VOLUME III

1975 PIPELINE BORROW INVESTIGATIONS
FORT GOOD HOPE, N.W.T. TO LATITUDE 60° N

Northern Engineering Services Company Limited

CALGARY ALBERTA



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VOLUME III
1975 PIPELINE BORROW INVESTIGATIONS - FORT GOOD HOPE, N.W.T. TO LATITUDE 60° N

Prepared For

Canadian Arctic Gas Study Limited

By

Northern Engineering Services Company Limited
Calgary, Alberta

T2P 0T5

July, 1977

Project: 13011

Northern Engineering Services Company Limited

635 - 6TH AVENUE S.W., CALGARY, ALBERTA T2P 0T5 — TELEPHONE (403) 265-8500-TELEX 038-24868-TWX 821-2283

29 July, 1977

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

ATTENTION: A.W. Wirth
Vice President
Engineering & Construction

REFERENCE: Volume III; 1975 Pipeline Borrow Investigations
- Fort Good Hope, N.W.T. to Latitude 60° N.

Dear Sirs,

We are pleased to submit this report which contains information on 32 borrow deposits along the Mackenzie Valley from Fort Good Hope to Latitude 60° N. in the Northwest Territories.

This work was undertaken as part of budget item 13011.

Yours truly,

NORTHERN ENGINEERING SERVICES COMPANY LIMITED

P.H. Dau, P.Eng.,
President

JKW:gj

PROJECT 13011

CANADIAN ARCTIC GAS STUDY LIMITED
CALGARY ALBERTA

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LATITUDE 60°N

DATE JULY 1977

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LATITUDE 60° N.

DATE JULY 1977

1. SUMMARY

Granular materials in the order of one (1) billion cubic yards have been identified and investigated along the proposed Canadian Arctic Gas Prime Route with the East of Fort Simpson realignment in the Fort Good Hope to Latitude 60° N. portion of the borrow investigation. It should be noted, however, that a great amount of this total volume occurs within a very few large deposits. This still leaves stretches along the pipeline route for which granular material is scarce. A total of 32 deposits were investigated during the summer of 1975 by Northern Engineering Services Company Limited between Fort Good Hope, N.W.T. and Latitude 60° N. of which 30 were investigated in detail by geophysics, test pitting and drilling. One of the detailed sites was investigated by additional ground and airborne geophysics (see Section 6). The remaining 2 were investigated by geological field reconnaissance only. Geological and biological reconnaissance was used to obtain information on the location and extent, quantity, quality, biological factors, and development parameters for each of the 32 borrow deposits. Archaeology, land use, land availability and socio-economic factors were not included in the scope of the study.

This report contains the field and laboratory results that pertain to each borrow deposit that was investigated. The detailed site specific information for each borrow deposit is presented as a complete package in the respective "Individual

Site Report" under Section 11. Separate sections describing the regional geological and biological setting of the Fort Good Hope to Latitude 60° N. area, the geophysical methods used to investigate the borrow deposits, and the logistics of this portion of the borrow investigation are included in this report.

As a result of this study, thirteen new granular and three non-granular material borrow deposits were located. These deposits, not documented in the DIAND Granular Materials Inventory, or the Mackenzie Highway investigations, represent approximately 535 of the 1005 million cubic yards of available granular material between Fort Good Hope and Latitude 60° N. The non-granular (till and/or bedrock) deposits are considered to contain unlimited quantities of material that could be acceptable for construction purposes. Processing may be required for these materials.

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DATE JULY 1977

2. INTRODUCTION

During the summer of 1975 a borrow investigation 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° N in Canada.

Territory covered by the program included the Yukon coastal plain portion of the Coastal Route, the Cross Delta Route and the Prime Route including the East of Fort Simpson realignment.

The program obtained preliminary site specific information on potential granular borrow deposits along the pipeline route (for location of individual deposits see Appendix B). 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 CAGPL application and further information was gathered on surface and subsurface aspects of the terrain along the pipeline.

Prior to the field study, airphotos, published surficial geology maps, and DIAND Granular Materials Inventory reports were assessed to obtain information on potential borrow sources. Preliminary choices of borrow sources for the pipeline and its

facilities are shown in the pipeline application and in two NESCL reports entitled: "Pipeline Related Borrow Studies" (July, 1974); and "Pipeline Related Borrow Studies Cross Delta Alternative Route and East of Fort Simpson Realignment" (November, 1975).

The 1975 field investigation provided preliminary information on the location and nature of potential borrow deposits and a rough estimate of the insitu quantities of each deposit. For final design and contractual purposes this program will have to be followed by further detailed investigations. Data obtained during the 1975 field investigation are contained in this report which is preliminary and not intended for final design or contractual purposes.

The borrow field program consisted of a geological and biological reconnaissance of granular material sources followed by ground geophysical investigation, test pitting and drilling of promising deposits selected during the reconnaissance. Archaeology, land use, land availability and socio-economic factors were not included in the scope of the study. The borrow investigation from Richards Island to Latitude 60° N was carried out concurrently with the 1975 wharf investigation to optimize the use of helicopters, tugboats, and fuel barges.

Organization, management, and supervision for this project were provided by NESCL. Engineering field support, field geophysical activities, and the geological reconnaissance from Fort Good Hope to Latitude 60° N were carried out 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 Limited, Ottawa, Ontario. Biological reconnaissance was conducted by Mr. D. R. Wooley, Wildlife Biologist,

of Renewable Resources Consulting Services Limited, Edmonton, Alberta. Samples collected in the field were tested by R. M. Hardy and Associates Limited, Calgary, Alberta. Drilling crews and equipment were supplied by Kenting Big Indian Drilling, Calgary, Alberta. Helicopter support in the lower Mackenzie Valley area was provided by Kenting Aviation Limited, Calgary, Alberta, Alpine Helicopters Limited, Norman Wells, N.W.T., and Buffalo Airways Limited, Fort Simpson, N.W.T. Barge facilities were supplied by Northern Transportation Company Limited (NTCL), Hay River, N.W.T. Other groups that provided support for the borrow field program are listed in the Equipment and Personnel section of this report.

The 1975 field investigation started at the Alaska/Yukon border July 12, 1975, and continued to the Fort Simpson, N.W.T. area, where it was completed September 21, 1975. The report on this program has been divided into the following three volumes:

Volume I:	1975 Pipeline Borrow Investigations - Yukon Coastal Plain. (Published May, 1976).
Volume II:	1975 Pipeline Borrow Investigations - Richards Island to Fort Good Hope, N.W.T. (Published November, 1976).
Volume III:	1975 Pipeline Borrow Investigations - Fort Good Hope, N.W.T. to Latitude 60° N.

Volume III describes the borrow investigation in the southern Mackenzie River valley portion of the pipeline route. A large portion of this area had been previously investigated during the DIAND Granular Materials Inventory. The DIAND inventory indicated that shortages of good quality granular borrow material exist in portions of this region. Areas where shortages had been identified were investigated in greater detail in order to identify additional borrow sources, to obtain

further information on previously explored deposits, or to locate alternative bedrock quarry sites. A total of 32 deposits were investigated during this phase of the borrow study. Thirty deposits were drilled and test pitted, and 2 were investigated on a reconnaissance basis. Subsequent to the field program additional ground and airborne geophysics work has been carried out on deposit 95H-B2, the results of which are included in Section 6.

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 the 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.

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

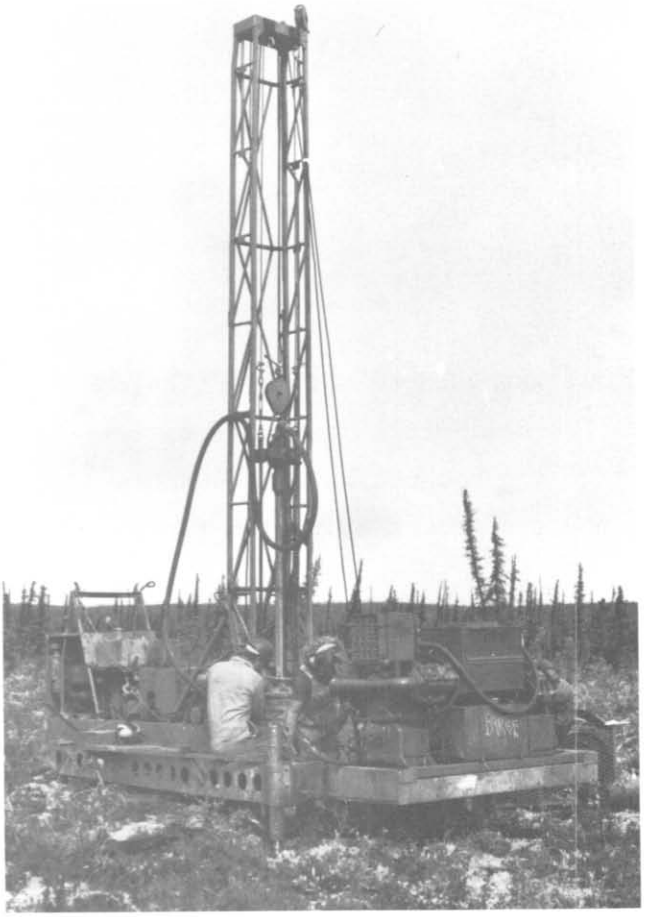


Photo 3.1.1

View of Kenting Big Indian Heli-Drill drilling by means of air-flush to prove out depth of granular material.

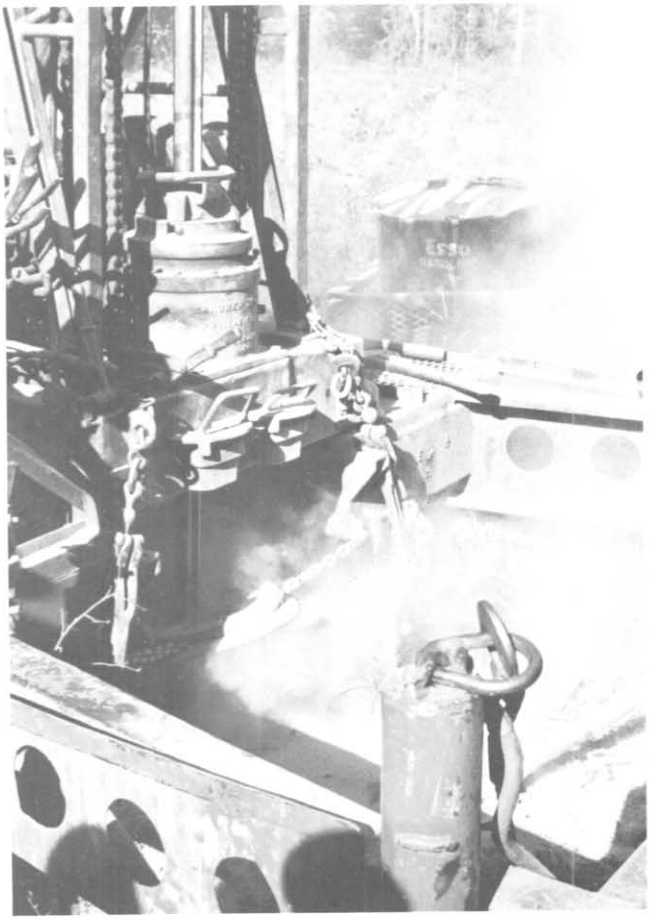


Photo 3.1.2

Close up view of drilling action while rig rotates on boulder.

Kelly and Sand line cables were modified by double lining to provide greater pulling capabilities in the event that either the drill bit or sampling tools became lodged during removal.

3.1.2 Test Pitting Equipment

The air compressors, described in the previous two volumes, were not used south of Fort Good Hope as deposits were either unfrozen or had deep active layers.

Each test pitting crew of four men was provided with long handled spades and picks.

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 Kenting Aviation Ltd. from its Inuvik, N.W.T. base was used for the geological reconnaissance down to the Willowlake River area. 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.

An Aerospatiale Gazelle SA341 helicopter, supplied by Buffalo Airways Ltd. from their Fort Simpson, N.W.T. base, was used by the geological reconnaissance crew south of the Willowlake

River area. This helicopter is turbine-powered and has a capacity to carry four passengers, or sling up to 1500 pounds of cargo. The same duties were performed by this helicopter as by the previously used 206B.

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, 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.



Photo 3.1.3

Kenting Aviation Ltd. Sikorsky S58E helicopter placing Heli-Drill mast onto the base.

In the Fort Simpson, N.W.T. area a Sikorsky S55T helicopter, contracted from the Norman Wells base of Alpine Helicopters Ltd., was used to position the clearing crews. This turbine-powered helicopter was obtained from another recently completed NESCL project in the Fort Simpson area. The seating capacity of 10 persons, enabled larger clearing crews to be positioned in a shorter period of time. This requirement was needed because the sites investigated in the Fort Simpson area were located relatively close to each other, enabling the drilling and test pitting operation to encroach on the clearing activity.

3.1.5 Sampling Equipment

Test pitting was the principal method used to obtain representative granular material samples. Drilling was carried out to establish or confirm the depths of granular material at selected deposits and as a result sophisticated sampling and coring tools were not used. The air return cuttings and observation of the drilling action were used to assess the downhole conditions and evaluate the quality of material being drilled.

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 co-ordination 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, the Motorola radio connected into the helicopter's intercom system became the field control centre for maintaining and coordinating the

daily field 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 II 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.

Fixed wing support facilities south of Fort Good Hope to just north of Fort Simpson were provided by Corridor Air Limited and Nahanni Air Limited of Norman Wells, N.W.T. in their respective Cessna 185 and Beaver aircraft. In the Fort Simpson area this support was not needed because of the close proximity of the borrow operations to the town.

3.2 Personnel

The following personnel were involved during the borrow source investigation from Fort Good Hope to Latitude 60° N.

Personnel	Affiliation
1 Project Manager	NESCL
1 Project Engineer	NESCL
1 Project Geologist	NESCL
1 Wildlife Biologist	Renewable Resources Consulting Services Ltd.
1 Junior Geologist	NESCL
2 Junior Geophysicists	NESCL
2 Geotechnical Engineers	NESCL
6 Test Pitting Northern Labourers	NESCL
1 Driller	Kenting Big Indian Drilling
1 Driller's Helper	Kenting Big Indian Drilling
3 Helicopter Pilots	Kenting Aviation Limited Alpine Helicopters Limited Buffalo Airways Limited
2 Helicopter Engineers	Kenting Aviation Limited Alpine Helicopters Limited
1 Cook	NTCL
1 Cook's Helper	NTCL
1 Camp Attendant	NTCL
1 Camp Mechanic/Radioman	NTCL
1 Tugboat Captain	Keen Industries Limited
3 Tugboat Deckhands	Keen Industries Limited

The entire field party, with the exception of the tugboat crew, the geological reconnaissance crew and the clearing crew, was billeted on the NTCL Camp Barge for the duration of the field program. The tugboat crew had quarters on their tugboat. The geological reconnaissance crew and the clearing crew travelled in advance of the barge camp staying at various

camps along the valley. These included the PeBen trailers at Norman Wells and the Hire North Camp at River Between Two Mountains. Once into the Fort Simpson area these crews were again accommodated on the barge camp until the end of the program.

4. LOGISTICS AND METHODOLOGY OF FIELD OPERATIONS

4.1 Logistics

The detailed criteria regarding the logistics for the Fort Good Hope to Latitude 60° N portion of the borrow investigation have been documented separately in a report entitled: "1975 Summer Wharf and Borrow Investigation Logistics Summary". The field operations for the borrow study were completely integrated with the 1975 wharf investigation on the Richards Island side of the Mackenzie Delta. The results of the 1975 wharf investigation have been recorded in a report entitled: "1975 Field Investigation - Wharf Report".

Although the detailed chronological documentation of the logistics for the borrow study has been compiled separately in the above captioned report, a brief description of the logistical planning and execution of the borrow source investigation for the Fort Good Hope to Latitude 60° N portion of the study is listed as follows:

(a) Following the completion of the field program for the borrow study in the Mackenzie Delta and along the northern Mackenzie Valley area on August 29, 1975 (Ref. Volume II - 1975 Pipeline Borrow Investigation - Richards Island to Fort Good Hope) the Fort Good Hope to Latitude 60° N portion of the borrow study was commenced on August 30, 1975.

(b) The Camp 702 borrow field operations were moved from Wharf Site 15 on August 30, 1975 and arrived at Norman Wells at 5.00 p.m. on September 2, 1975. A minor delay was caused by the fact that Sans Sault Rapids could not be navigated at night. During this move sites between Fort Good Hope and Norman Wells were investigated.

(c) Barge Camp 702 left Norman Wells on September 3, 1975 after replenishing supplies and fuel. With two short stops along the way to let off and pick up crews the camp was moved to Old Fort Point arriving on the morning of September 5, 1975. Field operations continued during this move and from the Old Fort Point location until September 7, 1975.

(d) Camp 702 was moved from Old Fort Point to the Fort Simpson area on September 7, 1975 with field borrow operations continuing as this move was in progress. The camp was moored a few times during this move to facilitate off-loading of equipment and on one occasion because of mechanical problems with the support tug. The camp arrived at the mouth of Spence River about noon on September 14, 1975.

(e) The remainder of field borrow operations were carried out from the Spence River location. The last site was completed on September 19, 1975. Preparations for de-mobilization were commenced this same day.

(f) Barge Camp 702 was fully demobilized by September 22, 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, the DIAND Granular Materials Inventory, pipeline alignment sheets, private industry reports, and previous NESCL project reports were compiled and assessed for the Fort Good Hope to Latitude

60° N portion of the study area. These served as background for airphoto mapping of prospective borrow material sources. 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 and the anticipated quality of the insitu material. Special efforts were made to locate borrow sources in areas previously identified as having shortages of good quality granular materials.

4.2.2 Geological Field Reconnaissance

The airphoto interpretation and office studies served as a basis 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 which had been selected by airphoto interpretation. The outlines of the prospective borrow sites were 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 specified and designated during this reconnaissance for each borrow site selected for additional investigation.

A project biologist accompanied the geological reconnaissance group to provide a biological assessment. A biological overview of the region 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 for the Fort Good Hope to Latitude 60°N study area, a total of 30 borrow deposits were selected for test pitting, drilling

and geophysics. This schedule was based on the completion of two borrow deposits each work day. An additional 2 borrow deposits were ground checked during the geological reconnaissance.

Generally, two to three test pits per borrow deposits 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. In those deposits which were frozen the test pits were selected in areas where the active layer was thought to be the deepest to eliminate the need for compressors. 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.

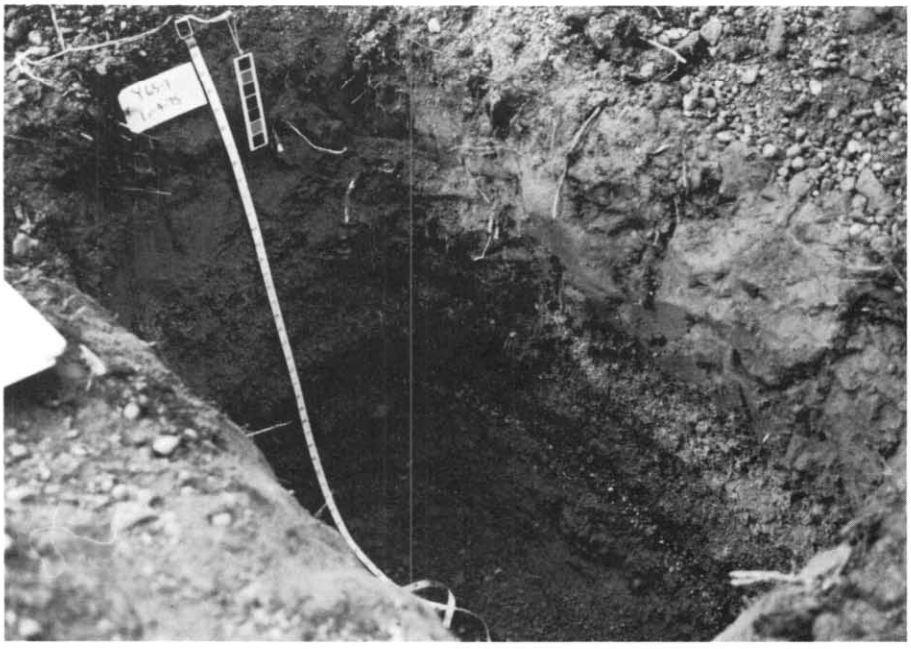


Photo 4.2.1

Typical view of a test pit excavation at Deposit 95H-B7.

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 were contained in six to ten sample bags. The 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 of one vertical face of the test pit was taken in a series of frames from the surface to the bottom of the pit. These photos are on file in the NESCL library.

The depth of selected borrow deposits were checked by drilling in areas that were representative of the deposit. A helicopter-portable "Heli-Drill", which is described in detail in Section 3 of this report, was used. In general, the drill holes were located 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 subsurface logging was conducted by observing the air flushed cuttings and the downhole drill action.

The ground geophysics conducted at each borrow deposit were carried out by a three-man crew. The details and the results of the geophysical investigation are included in Section 6 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 Limited, Calgary, Alberta. The following laboratory tests were carried out on selected samples:

(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 Limited by NESCL. The results of the laboratory tests are included in the individual site reports.

It should be noted that the drill hole logs are based on field classification only, as samples were not retained for testing.

4.2.5 Report Format

The site specific information for each potential borrow deposit is incorporated in the "Individual Site Reports", which is outlined in Section 11 of this report.

5. REGIONAL GEOLOGY AND GEOMORPHOLOGY OF THE FORT GOOD HOPE, N.W.T. TO LATITUDE 60°N AREA

5.1 General

The study area covers parts of the Interior Plains and Cordilleran physiographic regions. The following physiographic divisions are included in the Interior Plains region:

(a) the Anderson Plain, a low, flat lying plain 200 to 700 feet in elevation bordered on the south by the Franklin Mountains and on the east by the Mackenzie River. In the study area, south of Fort Good Hope, this plain is developed on Cretaceous shale, sandstone, and conglomerate;

(b) the Great Slave Plain, a flat plain encompassing the southern portion of the study area and developed mainly on Upper Devonian clastic rock. Isolated plateaux and hills within the plain are cored with Cretaceous shale and sandstone;

(c) the Alberta Plateau, a flat to sloping plateaux. Elevations in the study area reach 2500 feet. This physiographic division is underlain by Cretaceous shale, sandstone, and conglomerate.

Two parts of the Mackenzie Mountain area of the Cordilleran region also represented in the study area are:

(a) the Mackenzie Plain, a broad flat valley including land on both sides of the Mackenzie River. It is bordered by the Franklin and Mackenzie Mountains from Hanna River to Camsell Bend and is developed on Middle and Upper Devonian shale and limestone;

(b) the Franklin Mountains, a series of low ranges and ridges up to 500 feet in elevation that roughly parallel the Mackenzie River and are developed in resistant limestone and dolomite.

5.2 Bedrock Geology

Shallow, flat lying Cretaceous shale and sandstone underlies most of the Anderson Plain between Fort Good Hope and the Franklin Mountains. These units also occur in valleys which separate ridges of the Franklins.

The Franklin Mountains are thrusted and folded ridges of resistant cliff forming Middle and Upper Devonian limestone and dolomite. Some Devonian shale and anhydrite are also present. Ordovician and Silurian carbonates are exposed along the crest of the Franklins. In some localities within the mountains, e.g. south of Saline River, older units including Cambrian shales also appear.

The Mackenzie Plain is immediately south of the Franklin Mountains and is divided into two parts by the Mackenzie River. The plain is underlain by soft sandstone and shale of Devonian and Cretaceous age. Locally Devonian carbonates form resistant benches parallel to the Franklin Mountains. In a small basin near Great Bear River Tertiary sand and gravel was deposited unconformably on Lower Cretaceous to Middle Devonian strata.

The Great Slave Plain begins east of the Mackenzie River near River Between Two Mountains. This flat to rolling plain is underlain primarily by Upper Devonian shale, siltstone, and sandstone of the Fort Simpson Formation. Shallow gently dipping limestone of Upper Devonian age is also present on the south side of the Mackenzie River in the vicinity of the Mackenzie Highway. Plateaux within the Great Slave Plain, including the Ebbutt Hills and Horn Plateau, are made of Upper Cretaceous shale and sandstone which lies unconformably on Devonian formations.

The Alberta Plateau immediately south of Great Slave Plain is underlain by nearly flat lying shale and sandstone of Cretaceous age belonging to the Fort St. John Group.

5.3 Surficial Deposits

In the Anderson Plain, south of Fort Good Hope, bedrock is covered by 10 to 50 feet of silty clay till. The till is thinnest in the southern part of the Anderson Plain near the north edge of the Franklin Mountains. The surface of the till plain deposits is irregular and organic material fills low poorly drained areas. Near the Mackenzie River, west of the pipeline route, thick glaciolacustrine sediments overlie the till. Scattered glaciofluvial deposits consisting of silt, sand, and gravel are located within the Anderson Plain. The largest glaciofluvial deposit is an esker-kame complex on the south bank of the Hare Indian River near Fort Good Hope.

The Franklin Mountains lie south of Anderson Plain and north of Mackenzie Plain. In these mountains bedrock is close to the surface or covered by thin colluvium and till. Alluvial fans are also present where streams cut across bedrock ridges.

The Mackenzie Plain is located west and south of the Franklin Mountains and east of the Mackenzie River. Thin to thick till, glaciolacustrine, and alluvial deposits mantle bedrock throughout this area. During glaciation till was deposited on bedrock. Lakes associated with melting glaciers reworked till into both fine grained glaciolacustrine deposits and discontinuous coarse grained beach ridges. The beach ridges mark the edge of the glacial lakes and are found at about 500 feet elevation near Norman Wells, and at 800 feet elevation at the south end of Mackenzie Plain near Willowlake River. Glaciolacustrine deposits from 30 to 200 feet thick are located

between these beach ridges and the Mackenzie River. Glaciofluvial deposit associated with rivers leading from melting ice were also deposited during glacier retreat. Most of these deposits are located upslope of the glaciolacustrine deposits and overlie till plain sediments.



Photo 5.3.1

Aerial view of Deposit 95J-B1. Note the well-drained nature of the esker itself as compared to the immediate vicinity.

After the glacial lakes were drained, the Mackenzie River reworked some of the glaciolacustrine and till deposits into alluvial terraces. Also glaciolacustrine deposits near Old Fort Point were reworked by wind into dunes.

Bedrock in the Great Slave Plain is covered by surficial deposits of morainal and glaciolacustrine origin. Till in moraine plain deposits covers much of the study area between River Between Two Mountains and the Mackenzie River. It is

also the most common material south of the east-west segment of the Mackenzie Highway in the vicinity of McGill Lake. Till is from 10 to 80 feet thick and in some areas contains concentrations of boulders. Locally thick organic deposits have formed in depressions on the surface of the till plain.

Between the south side of the Mackenzie River and the Mackenzie Highway and McGill Lake glaciolacustrine silts, sands, and clays deposited in Glacial Lake McConnell cover till deposits. These materials range in thickness from 20 to 80 feet. Most of the glaciolacustrine plain is poorly drained and covered with thick organic deposits. Winds have reworked these fine grained materials into sand dunes that are 20 to 30 feet high. Coarse granular beach deposits which mark the edge of Lake McConnell are present at 700 to 800 foot elevations along the bedrock escarpment which is followed by the Mackenzie Highway. On the north side of the Mackenzie a thin veneer of these glaciolacustrine deposits are also present.

Alluvial and glaciofluvial terraces containing silt, sand, and gravel are located along the banks of the Liard and Mackenzie Rivers and Jean Marie Creek.

The Alberta Plateau extends from north of Trout Lake to south of the 60th Parallel. Only the area north of the 60th Parallel was included in this study. In this area morainal deposits cover bedrock. Silty clay till in these moraine plain and drumlin deposits ranges from 12 to 40 feet in thickness. A veneer of ablation till with a higher per cent of sand and gravel is sometimes found associated with drumlins. Crevasse fillings of till, silt, sand, and gravel overlie till plain deposits at some localities. Organic deposits 4 to 12 feet thick are found in low areas on the surface of the moraine plain. Minor glaciofluvial deposits containing gravel and sand are located near Trout and Kakisa Rivers.

5.4 Permafrost and Ground Ice

The study area lies entirely within the discontinuous permafrost zone. South of the Ebbutt Hills permafrost is not widespread and its occurrence is related to the presence of organic cover, poor drainage, low elevations and fine-grained materials. North of, and including, the Ebbutt Hills permafrost is widespread and unfrozen areas are associated with old burns, well drained terrain, water courses and springs.

The Anderson, Mackenzie and part of the Great Slave Plains and Franklin Mountains are within the zone of widespread discontinuous permafrost. Permafrost is present in fine grained materials and occurs at variable depths in coarse, granular deposits. The active layer ranges from 1 to 3 feet, but may reach 12 feet or more in coarse-grained material. South of Wrigley the active layer is substantially thicker on south facing slopes than in surrounding terrain. Ground ice is common in both till and glaciolacustrine sediments, especially if they are insulated by organic material and are poorly drained. Till may contain ground ice as irregular seams up to 25% by volume in the top 5 to 10 feet. Ice contents in till generally decrease with depth. South of Wrigley permafrost may be sporadic in till overlain by less than 4 feet of organic cover. Glaciolacustrine sediments are generally ice-rich and are very sensitive to thermokarst degradation, especially where the organic material is thin or has been disturbed.

Outcropping bedrock in the Norman and McConnell Ranges of the Franklin Mountains has minimal ice content while debris overlying bedrock may exhibit low to medium ice content. Permafrost is also present in talus slopes, alluvial fans and rock glaciers found at the bases of mountain slopes.

The Great Slave Plain, south of the Ebbutt Hills, and the Alberta Plateau both lie in that part of the discontinuous permafrost zone in which unfrozen areas are more widespread. Permafrost is generally restricted to morainal and glaciolacustrine areas that are poorly drained and underlie boglands, although ground ice has also been found in well drained glaciolacustrine sediments. Boglands include elevated organic terrain that contains ground ice in contrast to fenlands which are unfrozen. South of the Ebbutt Hills many areas of bogland are undergoing thermokarst erosion and becoming fenland. Throughout this area material in till ridges and hummocks is generally free of permafrost.

5.5 Regional and Local Drainage

Throughout the study area from Fort Good Hope to 60° North Latitude, all drainage is toward the Mackenzie River. In most cases granular deposits are better drained than the surrounding terrain.

South of Fort Good Hope on the Anderson Plain major drainage is provided by the Hare Indian and Tsintu Rivers. Poor drainage is characteristic of flat lying terrain with thick organic cover or thermokarst lakes. Such areas are located close to the east bank of the Mackenzie River.

The Great Bear, Blackwater, Ochre, River Between Two Mountains and Willowlake Rivers dissect the Franklin Mountains and provide major drainage to the Mackenzie Plain. Many of the creeks rising on the east slopes of the Franklins drain into the rivers listed above while the majority of creeks from the west slopes flow directly into the Mackenzie River, e.g. Bosworth Creek. Poorly drained areas on the flat-lying portions of Mackenzie Plain are similar to those on the Anderson Plain.

The sections of the Great Slave Plain and Alberta Plateau which fall within the study area are drained by the Liard, Trout and Kakisa Rivers and Jean Marie Creek. Much of the Great Slave Plain and Alberta Plateau are poorly drained because terrain is flat-lying and thick organic cover and fine-grained soils are common. In many areas water flows along fen filled shallow drainageways. The Ebbutt Hills and Alberta Plateau also exhibit a perched watertable as their upper surfaces are concave and underlain by impervious bedrock.

5.6 Granular Material and Bedrock Sources

Granular material and crushable bedrock in the study area can be found in the following geological settings from north to south:

(1) Eskers at isolated locations on the southern part of the Anderson plain.
(2) Exposed cabonate bedrock throughout the Franklin Mountains.
(3) Eskers, kames and outwash plains along the base of the western slopes of the Franklin Mountains and at scattered locations on the Mackenzie Plain near the Mackenzie River.
(4) Alluvial foodplain, terrace and fan deposits associated with streams crossing the Mackenzie Plain from the Franklin Mountains.
(5) Beach ridges south of Norman Wells.
(6) Sand dunes developed on the glaciolacustrine plain near Old Fort Point.
(7) Alluvial terraces of the Mackenzie River south of Blackwater River.
(8) Scattered eskers and kames between the Willowlake River and the Ebbutt Hills.
(9) Sand dunes developed on the glaciolacustrine plain, east of Fort Simpson.

(10) Beach ridges and outwash deposits northeast of Deep Lake and adjacent to the Mackenzie Highway.

(11) Shallow shale and limestone adjacent to and south of the Mackenzie Highway.

(12) Shallow shale bedrock on the Alberta Plateau, and

(13) Alluvial terraces of the Kakisa River.

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 6.1.1 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.

The relatively simple situation, shown in Figure 6.1.1, becomes considerably more complex in permafrost regions. Figure 6.1.2 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 when the ground is in the frozen state. However, in addition to temperature the ice content of the ground influences resistivity, as is illustrated in Figure 6.1.3. High resistivity (> 5000 ohm-m) in permafrost regions can, therefore, be due to low ground temperatures, high ice content and frozen gravel.

Thus, the resistivity of gravel deposits depends, in addition to soil type, on temperature and ice content. The value of resistivity over a frozen deposit can, therefore, not be used as a criterion for soil type without correlation to borehole data.

Often the best use of geophysics in borrow inventory programs is in delineating the extent of granular deposits and extrapolating subsurface information between boreholes. This requires that many geophysical soundings are made, so that a clear indication is obtained of the relative values of resistivity

on and around granular deposits. During this investigation only a few (1 to 3) measurements were made near or on a deposit, and the results of geophysical surveys were, therefore, often inconclusive.

Resistivity surveys, particularly in the Arctic, require electromagnetic rather than electrical methods. In electrical methods, the contact resistance of probes inserted in the ground has to be kept low. Establishing low contact resistance is difficult on permafrost. Also very small lateral variation in depth of active layer can have very large effects on electrical resistivity measurements. Electromagnetic methods have significant advantages over electrical methods in resistivity surveying in the Arctic. Electromagnetic methods for shallow exploration ($\sim$ 30 ft) were still under development at the time of the borrow program. Non-contact electromagnetic methods for shallow exploration became available shortly after the conclusion of the borrow investigation.

6.2 Resistivity Results

During the borrow investigation, two types of geophysical measurements were made:

(a) vertical soundings with four probes (galvanic) in a Schlumberger array,
(b) VLF radiohm resistivity measurements.

Because vertical soundings with probes is a relatively slow process, there was only time for a few soundings. From these data it has been difficult to draw a reliable interpretation about soil types at granular deposit sites.

After completion of the field work for the borrow investigation several geophysical field trials were conducted with

magnetic induction equipment between Fort Good Hope, N.W.T. and Zama, Alberta. The purpose of these field trials was to delineate permafrost and measure its thickness.

On several occasions surveys were also performed over sand and gravel deposits along the route. Also, an airborne resistivity survey with the Dighem system was conducted at sites between Fort Simpson, N.W.T. and Zama, Alberta. The ground and airborne electromagnetic surveys over deposit 95H-B2 will be discussed in this section. These surveys are typical of the manner in which geophysics may be used during final exploration of borrow sites. Furthermore, the results of tests in five existing granular deposits in the Calgary area are given in Volume II, Appendix C.

Figure 6.2.2 shows resistivity profiles over deposit 95H-B2 with magnetic induction equipment (Geonics EM31) and with VLF radiohm equipment (Geonics EM16R). Also shown on the lower half of Figure 6.2.2 is the thickness of granular deposits derived from the geophysical data, and the information from three boreholes along the geophysical traverse. The EM31 data show a marked resistivity high at the location of the thickest gravel. The VLF radiohm methods, because of its large effective depth of exploration, looks through the gravel and shows only a slight increase in resistivity over the deposit. In deposit 95H-B2, resistivity mapping delineated the granular deposit and provided an estimate of its thickness. The quality of these data is typical of what can be expected over deposits south of Fort Simpson, N.W.T. The deposits in this area are, in general, unfrozen and resistivity differences can be attributed to differences in material type, rather than to the frozen or unfrozen state of the ground.

Deposit 95H-B2 was also covered by the Dighem airborne survey, and the solid circles on Figure 6.2.2 are the apparent resistivity data obtained in the airborne survey. Because the

resolution of airborne systems (due to flight altitude) is much less (300 feet) than ground systems (15 feet), the resistivity high anomaly is a smooth curve over the deposit. The agreement in actual values of resistivity is quite good. The airborne survey in this instance also delineated the gravel deposit as is illustrated on a section of the contour resistivity map of Figure 6.2.1. The solid bar represents the location of the ground traverse. One can expect to locate granular material within the 178 ohm meter contour.

In general, however, we can not recommend the use of airborne resistivity surveys for the purpose of locating gravel deposits for the following reasons:

(a) The majority of granular deposits can be identified from surface features on photographs. The detailed surveying, necessary before mining, can best be performed by ground geophysics, test pitting and drilling.

(b) Airborne resistivity surveys may identify resistivity high anomalies not associated with surface features of granular deposits. However, every resistivity high can have several causes such as: granular deposits with shallow overburden, competent bedrock close to the surface, or permafrost. To determine the cause of the anomaly, each resistivity high must be determined by further ground work. This is an expensive task for the few deposits that may be located in this manner.

(c) Granular deposits only occur in areas where the geological history is favourable to their formation. Blanket airborne surveys, therefore, seldom come up with enough positive surprises to warrant their cost.

Ground surveys, on the other hand, particularly with the non-contact magnetic induction equipment, can be of considerable use, particularly in the area south of Fort Simpson, N.W.T.



Photo 6.2.1

Geonics EM 31 magnetic induction instrument.



Photo 6.2.2

Geonics EM 16R (VLF Radiohm) resistivity instrument.

where the granular deposits are generally unfrozen. The data in Figure 6.2.1 are one example of the ability of geophysical methods to delineate the extent of the deposit. Other examples are shown in Volume II, Appendix C.

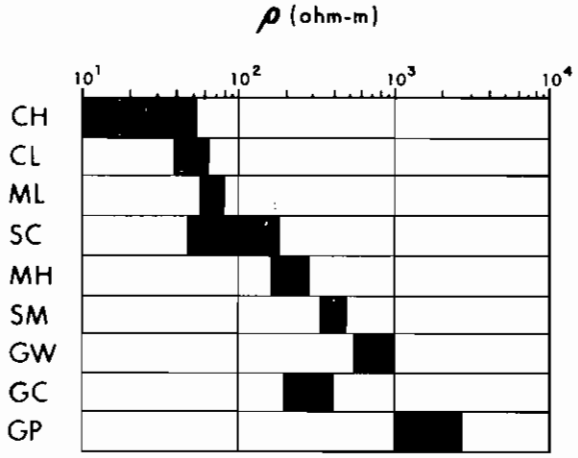


FIGURE 6.1.1.
THE RANGES IN RESISTIVITY ASSOCIATED WITH THE SOIL TYPES OF UNIFIED ENGINEERING CLASSIFICATION SYSTEM. (CH - FAT CLAY; ML - SILTY CLAY; SC - SANDY CLAY; MH - SILT; S - SAND; GW - WELL SORTED GRAVEL; GC - GRAVEL WITH CLAY; GP - POORLY SORTED GRAVEL).

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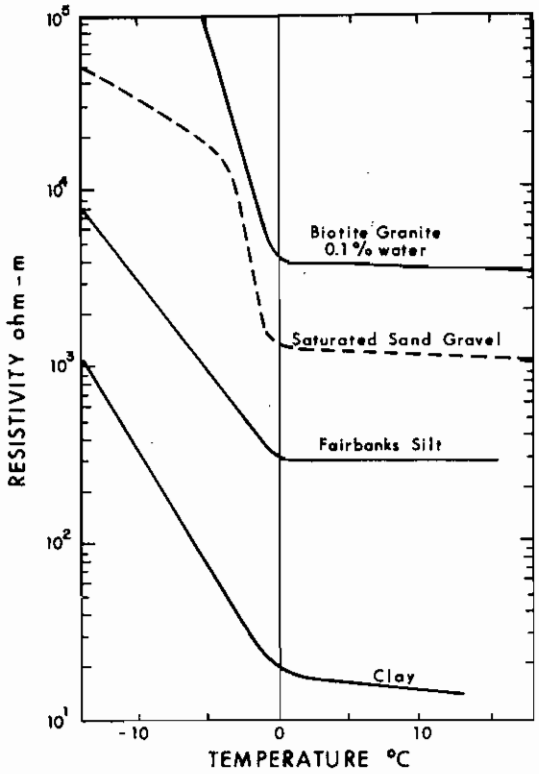


FIGURE 6.1.2.
THE RESISTIVITY OF SEVERAL SOILS AND ONE ROCK TYPE AS A FUNCTION OF TEMPERATURE (HOEKSTRA ET AL.,1975)[2]

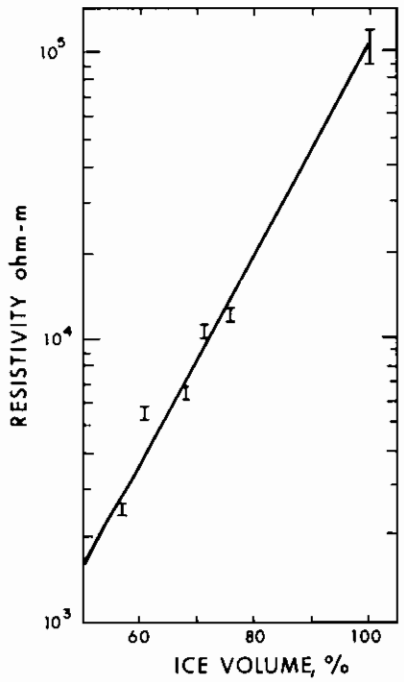


FIGURE 6.1.3.
RESISTIVITY OF FROZEN SILT AS A FUNCTION OF ICE CONTENT (HOEKSTRA ET AL., 1975)[2]

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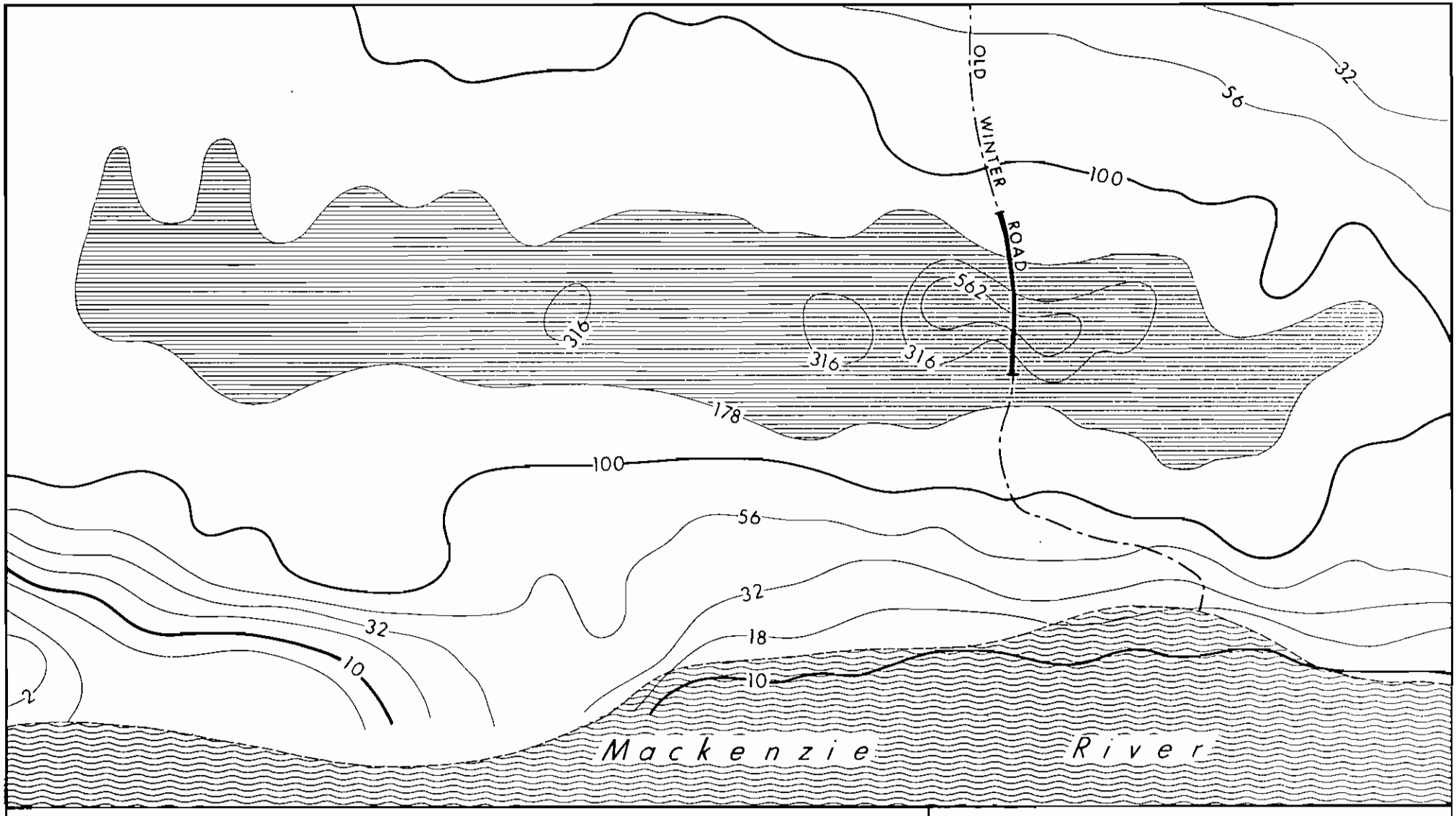


FIGURE 6.2.1

CONTOUR RESISTIVITY MAP
DIGHEM AIRBORNE SURVEY
DEPOSIT 95H-B2

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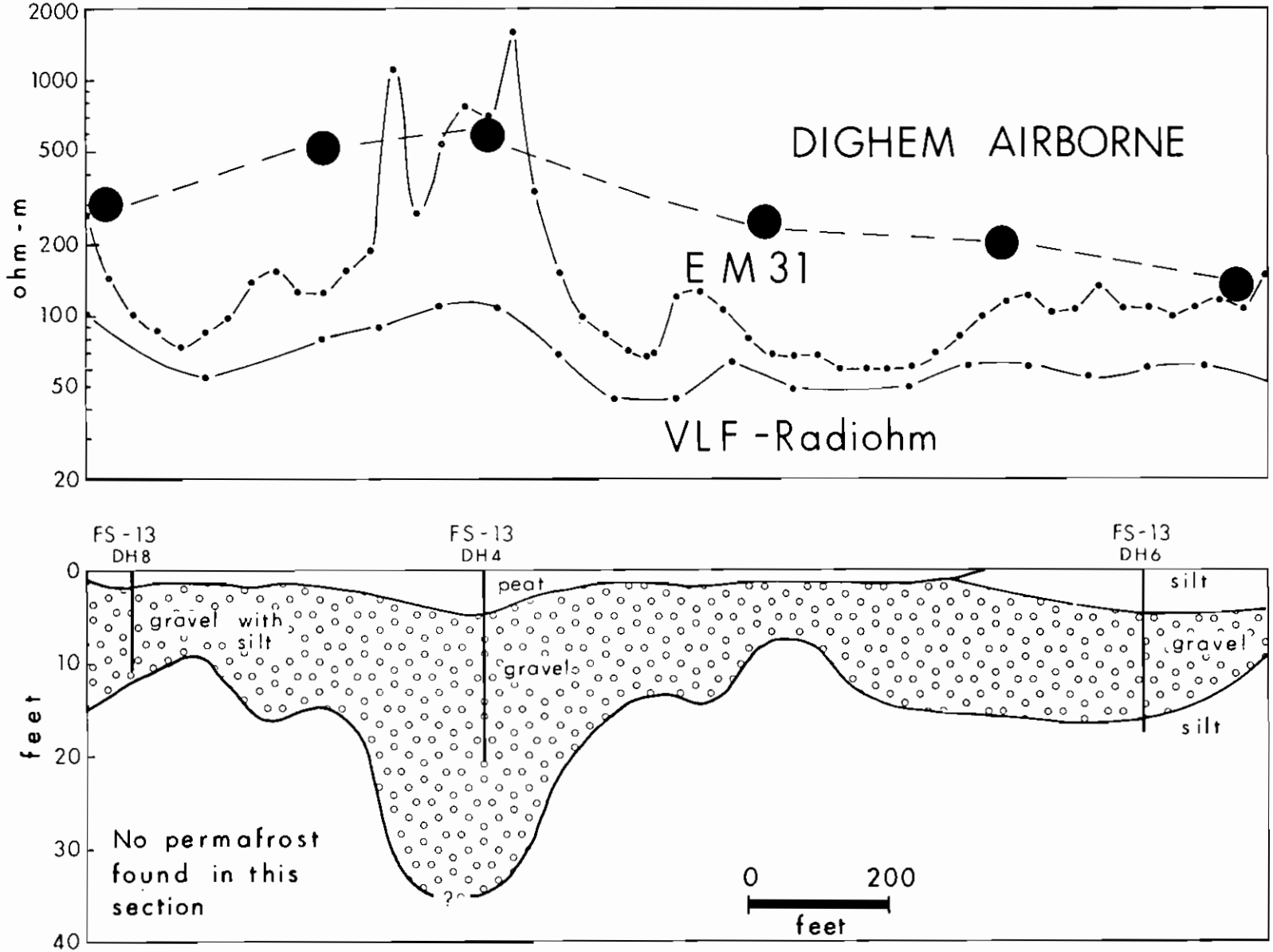


Figure 6.2.2
Top: RESISTIVITY PROFILES WITH GROUND AND AIRBORNE ELECTROMAGNETIC METHODS, (95H-B2)
Bottom: INTERPRETED GROUND PROFILE, (95H-B2)

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7. BIOLOGICAL OVERVIEW - FORT GOOD HOPE TO LATITUDE 60° N

7.1 Vegetation

The vegetation in the area between Fort Good Hope and 60° N consists primarily of closed coniferous and deciduous forest in the Mackenzie Valley, with extensive open coniferous forest on peatlands south of Fort Simpson. A more detailed description of the forest regions can be found in Rowe (1972), and detailed descriptions of the major vegetation types are found in Reid (1974) and Reid and Janz (1974).

A closed, often coniferous forest is characteristic south from Fort Good Hope to Norman Wells. On some well drained soils on the banks and islands of the Mackenzie River, white spruce attains sawlog size, but in general, stunted white and black spruce with alder and Labrador tea prevail over large areas of poorly drained soils. White birch and occasionally aspen are found on well drained upland soils. Non-forested land is made up of bogs, fens and recently burned areas.

The vegetation south from Norman Wells to Jean-Marie Creek includes a large part of the riverine forest of the Mackenzie Valley. The valley environment is much more favourable to tree growth than the adjacent uplands, and provides some of the best timber-producing land in the Northwest Territories. White spruce, aspen, white birch and pine form the main cover types on the river banks and adjacent well drained uplands. Large areas of sandy soils on the plains south of Fort Simpson are occupied by lodge-pole pine, jack pine and aspen, and in the wet to moist positions where organic soils are common, black spruce and tamarack are found. Non-forested areas, largely made up of bogs and fens, are common.

An open black spruce forest dominates the land from Jean-Marie Creek to 60° N. This forest is growing primarily on frozen peat plateaus, which are interspersed by tamarack, bog birch, sedge and moss covered fens. Well drained mineral soils are covered by lodgepole pine, jack pine or their hybrids and occasional aspen and white spruce.

7.2 Mammals

Prescott et al. (1973) delineated areas of Class 1 (good) and 2 (fair) moose winter range east of the Mackenzie River. Most of the good to fair moose winter range along the pipeline route between Fort Good Hope and Fort Simpson occurs on the floodplains and islands of the Mackenzie River. Relatively few areas of good to fair moose winter range are intersected by the pipeline route or occur at proposed borrow sites.

Between Fort Good Hope and Fort Simpson, woodland caribou range generally occurs within and to the east of the Franklin Mountains which are east of the pipeline route. The Franklin Mountains and Horn Plateau are used as summer range. Caribou then radiate out to the surrounding lowlands in winter (Watson et al., 1973). South of Fort Simpson, woodland caribou range occurs in the vicinity of the Redknife Hills and Redknife and Kakisa rivers (Prescott et al., 1973).

Class 1 (best) and 2 (intermediate) beaver habitat have been identified in some lake-studded lowland areas crossed by the route (Dennington et al., 1973). Productive beaver habitat also occurs along most of the slow-moving streams.

Several other mammals including mink, red fox, marten, black bear, otter, muskrat, wolf, ermine and wolverine are found in the area crossed by the proposed route. Most are wide-ranging species and low in numbers. During the denning period which

includes the winter dormancy period for bears and the maternal denning period for most other species, the animals are restricted in mobility. This could lead to conflicts where dens are located in potential borrow sites or along rights of way.

7.3 Birds

A discussion of the species of birds which utilize the Mackenzie Valley is lengthy and is provided in the CAGSL application (1974). Only those groups susceptible to potential impact from borrow development will be discussed here.

Waterfowl most commonly found breeding in the Mackenzie Valley region include pintail, green-winged teal, American widgeon, common goldeneye, bufflehead, oldsquaw, and scoters. Several additional species utilize the area during the spring migration, summer moulting, fall staging and fall migration periods. The two species most prone to disturbance during these periods are snow geese and whistling swan.

The most important waterfowl habitat in the vicinity of the route is found on the islands and the sandbars in the Mackenzie River and at the mouths of tributary rivers. These are particularly important during spring migration for feeding, resting and breeding. Other important areas for waterfow, including lakes and other wet land complexes, are delineated by Posten et al. (1973).

The Mackenzie Valley region provides important habitat for several rare and endangered species including bald eagle and peregrine falcon. Other raptor species that occur in the Mackenzie Valley are generally at the northern limit of their range, and except for the goshawk, are not numerous. Raptors tend to use traditional nest sites in trees or cliffs which could lead to conflict in the development of certain types of borrow sources.

Several other species including shorebirds and passerines are widely distributed throughout the region, and will not be adversely affected by borrow development.

7.4 Fish

Available fisheries information is provided in the site reports based on McCart et al. (1974). All major streams and rivers crossed by the route and in the vicinity of borrow sources support fish populations throughout the year. Many of the smaller ponds, lakes, and streams may support fish populations during the summer months, but during the winter period are incapable of supporting fish. Other small water bodies do not support fish populations.

8. DATA PRESENTATION

8.1 Individual Site Reports

8.1.1 General

The data have been presented so that all information related to a given borrow deposit 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

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

8.1.3 Site Report

All pertinent data and assessments which have been compiled for the potential borrow deposits investigated from Fort Good Hope to 60° N 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 geological setting. Drainage is given (ref. Appendix A) as well as geomorphology, ice contents and organic soil cover.

(b) Biological Setting - A general description of vegetation, observed and recorded mammal and bird use of the area, and fisheries potential of adjacent waterbodies are given for each site. These data were used to make an initial biological assessment pertaining to the development of the site and will be used to identify sites requiring further investigation.

(c) Material - description of soils in the deposit according to the test hole logs which are classified according to the Terms and Symbols Section in Appendix A. In the Materials and the Development and Rehabilitation sections the materials are indicated as being sources of excellent, good, fair and poor quality granular material. These terms are based upon the definitions as found in "Appendix A" pp A-16 and A-17.

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

(e) Development and Rehabilitation - the sections on Physical Setting, Biological Setting, Materials, and Volumes were used to describe the potential development of the deposit. A brief general plan for development of the deposit was formulated with the understanding that additional environmental and deposit information may alter final design.

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 entitled: "Summary of Laboratory Tests to Determine Aggregate Suitability in Concrete". In those cases where the fine aggregate was also tested, the results are similarily tabulated and cross-referenced to the coarse aggregate results. 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 from Fort Good Hope to Latitude 60° N 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 and are presented in Appendix B.

9. CONCLUSIONS

The 1975 CAGSL-NESCL borrow field program has shown that adequate construction materials are present along the pipeline route between Fort Good Hope and 60°N. Granular deposits and shallow bedrock are not evenly distributed along the route, especially in the area south of Fort Simpson. Careful consideration in allocation and development of all construction material resources will be needed to ensure that requirements by northern communities, highways, and industry can be met.

Thirty-two deposits were investigated in this area of the Mackenzie Valley during the summer of 1975. Sixteen of these deposits had not been documented in the detailed site investigations for the DIAND Granular Materials Inventory. Of these new deposits, 12 which contain granular material, and 2 which contain non-granular material are recommended for potential development based on material quality.

A total in the order of approximately one (1) billion cubic yards of fair to excellent quality granular borrow material were found in the deposits investigated in 1975 (see Table I, page 54) for the area from Fort Good Hope to Latitude 60°N. The non-granular (Till and/or Bedrock) deposits are considered to contain unlimited quantities because they cover extremely large areas.

The DIAND Granular Materials Inventory covered the area from Fort Good Hope to Fort Simpson. The CAGSL-NESCL study has provided further detail on certain deposits described in the DIAND Granular Materials Inventory, and has added site specific information on the above sixteen sites which were not included in the DIAND inventory.

Crushable bedrock and granular deposits from Fort Good Hope to 60° N are concentrated in outwash deposits (including esker and kame complexes), fluvial terraces, beach ridges, sand dunes, and carbonate and shale bedrock. Till deposits, when dry and unfrozen, have properties that make them suitable for certain construction uses. These unfrozen till deposits are common south of Fort Simpson in an area where granular deposits are in short supply.

Granular deposits were investigated by airphoto interpretation, field reconnaissance, geophysics, test pitting and drilling. The results, excluding geophysics, appear in the individual site reports which make up Section 11 of this volume.

Geophysical investigations were done to supplement information obtained from airphoto interpretation, field reconnaissance, and subsurface exploration of the individual borrow deposits. Electrical resistivity measurements were made at most borrow deposits investigated. The resistivity of the ground was determined by vertical soundings with probes in a Schlumberger array and with VLF radiohm. Resistivity methods were found to be of little use in helping to delineate the extent of frozen deposits.

Shortly after completion of the field portion of the borrow investigation specially designed electromagnetic equipment for shallow exploration became available. This equipment was tested on 5 existing borrow pits in the Calgary area (see Volume II, Appendix C); the results show this equipment to perform well for delineating unfrozen granular deposits.

The airborne survey with the Dighem System yielded good quality resistivity contour maps. The interpretation of these data in terms of granular deposits is difficult and costly because resistivity variations caused by permafrost or bedrock

close to the surface can give similar signatures. Each resistivity anomaly must, therefore, be explored further to identify its nature. It appears unlikely that many deposits will be detected that have not been identified by surface features on air photographs.

Following the field reconnaissance of borrow sources and an office review of other available information, no biological factors were identified which would preclude development of the deposits recommended in this report. Final design field studies may identify other environmental, archaeological, land use and socio-economic factors which would restrict or preclude development of certain sites.

TABLE 1 SUMMARY TABLE OF DEPOSITS INVESTIGATED
FORT GOOD HOPE TO LATITUDE 60° N

DEPOSIT NO. (R) - denotes reconnaissance site only	DIAND DEPOSIT NUMBER	GRANULAR MATERIAL (NESCL Volume) x 10^6 cu. yd.	NON-GRANULAR MATERIAL		SITES NOT RECOMMENDED (Major reasons)
			Till	Bedrock	
N75-106I-B13	P315	2.4			
N75-106H-B1	EBA Hwy	1.3			
N75-106H-B2(R)	P319, EBA Hwy	-		x	
N75-96E-B1	P303, 302	20.4			
N75-96E-B2	P279	3.9			
N75-96E-B3(R)	P304	-		x	
N75-96C-B1	FN19	290.0			
N75-96C-B2	-	38.3			
N75-96C-B3	-	6.6			
N75-96C-B4	P242	3.6			
N75-96C-B5	P197	25.7			
N75-96C-B6	UM Hwy	2.3			
N75-95N-B1	P191	29.0			
N75-95O-B1	W9	14.7			
N75-95O-B2	W1, W2	32.2			
N75-95J-B1	P142	35.6			
N75-95J-B2	-	65.5			
N75-95J-B3	-	3.0			
N75-95J-B4	-	6.6			
N75-95J-B5	-	0.5			
N75-95H-B1	FS 12	6.7			
N75-95H-B2	FS 13	1.3			
N75-95H-B3	-	7.7			
N75-95H-B4	-	17.8			poor quality, others closer.
N75-95H-B5	-	137.8			
N75-95H-B6	-	8.6			
N75-95H-B7	-	1.4			
N75-95H-B8	-	210.9			
N75-95H-B9	-	-		x	
N75-95A-B1	-	-	x	x	
N75-85D-B1	-	-	x		non-granular and long haul distance.
N75-85D-B2	-	31.0			
TOTAL Granular Material		1004.8			
- TOTAL Not Recommended Granular Material		17.8			
= TOTAL		987.0			

NOTE: The DIAND deposit number refers to the number assigned to each deposit that was investigated during the granular materials inventory as outlined in the following report.
Pemcan Services "72", 1972. Granular Materials Inventory.
The deposits indicated by EBA Hwy and UM Hwy were investigated during the centerline and borrow drilling done for the proposed Mackenzie Highway in 1972-73. These respectively indicate EBA Engineering Consultants Limited and Underwood McLellan and Associates Limited. R.M. Hardy and Associates Ltd. and Acres Consulting Ltd. also did centerline and borrow drilling for the proposed Mackenzie Highway.

10. RECOMMENDATIONS

The 1975 CAGSL-NESCL borrow field program and previous granular material inventory programs have shown the distribution and characteristics of borrow deposits along the pipeline route through the Mackenzie Valley and the Yukon Coastal Plain. As the location of the pipeline and facilities and decisions on construction modes are finalized, a more accurate determination of borrow requirements should be made. Also in preparation for final design a detailed field and office study of specific borrow deposits chosen to supply these and additional requirements should be undertaken.

Final design field studies should obtain information on the quantity, quality, and stratigraphy of materials available in each deposit. This data should be collected by on-site geological and engineering observations and by drilling and test pitting. Geophysical methods should be used where feasible, i.e. in unfrozen deposits, to provide subsurface information between drill holes. Also at this time, additional data should be collected on the occurrence of permafrost in the borrow materials, the position of the water table in the deposit, access from the deposit to the pipeline route, and engineering aspects which might be useful during development of the borrow source.

Airborne resistivity surveys are not recommended for detection of granular deposits. The few deposits without surface features visible on air photographs that may be detected by airborne surveys do not warrant the cost.

Final design studies should include further biological, archaeological, land use, land availability, and socio-economic field investigations of each deposit. This information is required for final location, scheduling, development and restoration planning. A list of preliminary environmental design guidelines is given in Table II (see page 56).

TABLE II

PRELIMINARY ENVIRONMENTAL DESIGN GUIDELINES

1. Development activity in the vicinity of borrow deposits may be rescheduled during certain periods of the year to minimize disturbance of: migrating waterfowl (April-June) (August-October), wintering moose (December-April), staging waterfowl (August-September), spawning or migrating fish populations (April-September), whelping fox and wolf (May-June), denning grizzly and black bears (October-May), and raptors (May-October).

2. In the final location of borrow deposits and facilities, productive forest land and merchantable stands of timber should be avoided, where possible, in favour of locations in lower productivity forest land.

3. Topsoil and/or the organic layer from all disturbed areas should be salvaged and stockpiled for use in deposit rehabilitation. Trees and shrubs may be salvaged either 'as cut' or chipped for use in erosion control or as dimension lumber for other project requirements.

4. A buffer strip should be maintained between waterbodies and the borrow deposit or support facilities such as roads, camps, etc. to minimize impact on aquatic ecosystems and to preserve important riparian wildlife habitat. The location and width of the buffer strip should be based on site-specific investigations.

5. Storage facilities for petroleum products or other toxic materials should be located so as to prevent the introduction of toxic materials into any waterbody inhabited by fish, waterfowl, and aquatic mammals, or any water course emptying directly into such water.

6. No borrow pits are proposed on active flood plains. Where ancillary facilities such as haul roads cross active streams, design measures should be implemented to protect stream banks and vegetation and to limit siltation.

7. Borrow deposits frequently represent prime denning habitat for bear, fox, wolf, and other denning species. During the final design field studies, active den sites and optimal potential denning habitats will be located. These areas should be protected where necessary from borrow development.

8. Blasting programs at borrow deposits should be developed following den surveys of the site, to prevent adverse impact on denning species. Hibernating species should be relocated or taken by resident trappers if found in the proposed borrow deposit.

9. The likelihood of encountering archaeological sites is proportionately greater in well-drained areas than in low-lying, poorly-drained areas. Archaeological surveys will be conducted at all proposed borrow deposits prior to final design. Development activities will be monitoried by an archaeologist in the event that archaeological sites are encountered during development of the borrow deposit.

11. The following is a list of individual site reports that are contained in this section.

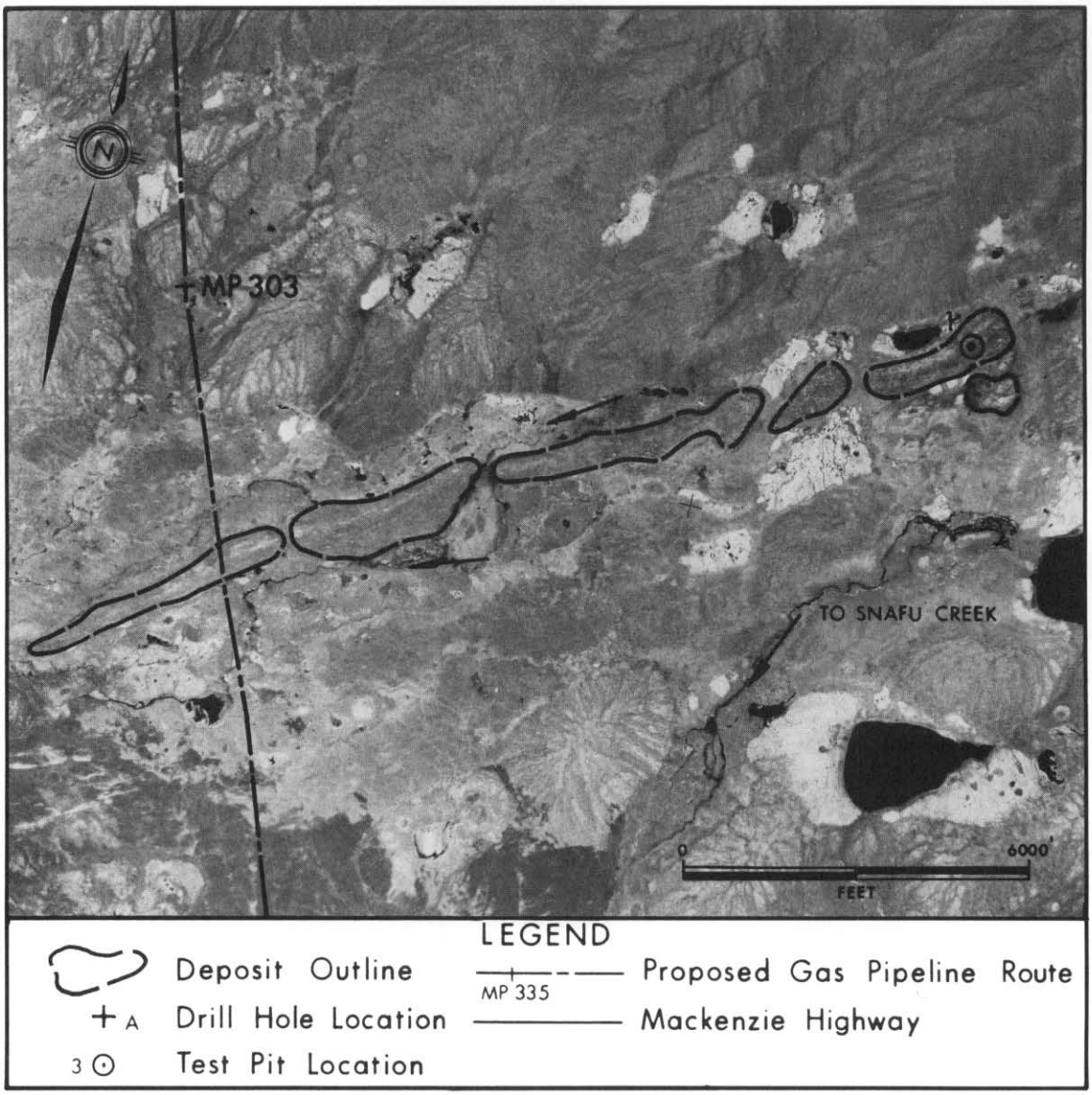
DEPOSIT	PAGE
106I-B13	59
106H-B1	65
106H-B2(R)	73
96E-B1	79
96E-B2	89
96E-B3(R)	103
96C-B1	107
96C-B2	125
96C-B3	133
96C-B4	141
96C-B5	151
96C-B6	159
95N-B1	167
95O-B1	179
95O-B2	193
95J-B1	203
95J-B2	213
95J-B3	225
95J-B4	235
95J-B5	247
95H-B1	257
95H-B2	269
95H-B3	285
95H-B4	293
95H-B5	301
95H-B6	315
95H-B7	323
95H-B8	341
95H-B9	361
95A-B1	367
85D-B1	375
85D-B2	381

Physical Setting: Deposit 106I-B13 is a discontinuous esker ridge 17 miles SSE of Fort Good Hope and 2 miles north of Snafu Lake. The proposed pipeline crosses the esker at M.P. 302.

Material: GRAVEL - well graded, little sand and silt, occasional cobbles and boulders.

Volume: 2,400,000 cubic yards.

Assessment: Deposit 106I-B13 is a source of good quality granular material suitable for general fill, embankment fill, and building pads.



Airphoto No. A12602-233
Approximate Scale: 1' = 3200'

Latitude: 66° 04' N.
Longitude: 128° 17' W.

DEPOSIT 106I-B13

PHYSICAL SETTING

Deposit 106I-B13 is a discontinuous esker ridge located 17 miles south-southeast of Fort Good Hope and 2 miles north of Snafu Lake. The proposed gas pipeline crosses the western end of the esker. The deposit corresponds to source number 315 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The esker is 200 to 500 feet wide at its base and varies from 5 to 25 feet in height. The surface is fairly flat and 3 to 6 feet of peat, silt, and organic silt overburden cover granular material in the deposit. The east end of the esker appears to have more coarse granular material and more vertical relief. Ice contents are low in the gravels and sands.

The esker is the only well drained feature in this portion of the Anderson Plain. It has been superimposed on till plain sediments. Fairly thick organic cover and higher ice contents are characteristic of this till plain.

BIOLOGICAL SETTING

Black spruce, white birch, alder and lichen occur on this site. The area provides potential woodland caribou habitat. The site is low quality raptor and waterfowl habitat. Adjacent streams do not appear to provide suitable fish habitat.

MATERIAL

The esker contains areas of good quality material. The gravel is well graded, fine to coarse, with little sand and silt, the occasional cobble and boulder, and predominantly composed of limestone and quartzite pebbles. Stratified sand, gravel and silt are present in some test holes.

VOLUME

Assuming an average esker height of six feet over a deposit area of 248 acres, the total volume of material comprising the esker is about 2.4 million cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 106I-B13 is a source of good quality granular material suitable for general fill, embankment fill and building pads. Gravels may be usable in concrete and asphalt subject to further investigation and testing.

Access would probably be via the trail along the esker ridge. Snow roads would be constructed to minimize environmental damage and to protect thermally sensitive terrain adjacent to the esker.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Development should begin at the eastern end of the esker where greater quantities of granular material have been located. Initially vegetative cover would have to be cleared in accordance with existing land use regulations. Peat cover and overburden would then be stripped and stockpiled near the pit area. Material should be removed only to a level just above the water table to insure that a relatively dry and free draining area remains. This would promote revegetation and animal usage of the area.

Standard excavation techniques and equipment should be adequate for the removal of material from this site.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

TEST HOLE LOG

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
0	ML	SILT - clayey, trace fine to coarse sand, low plastic, brown, damp, occasional cobbles (3")		UF								No samples taken
1.0	CL-CI	CLAY - silty, trace fine to coarse sand, grey, damp to wet, infrequent pebbles										
2.0		wet										
2.3	CL	CLAY - some fine to coarse sand, grey to brown, wet, scattered pebbles										
3.0	SC	SAND - fine to coarse, clayey, trace gravel, brown, saturated, occasional cobbles to 6"										
3.5												
3.8	CL	water from test pit wall, pebbles subrounded to subangular									4	
4.0		CLAY - silty, little fine to coarse sand, occasional cobbles to 6", grey, wet										
		Bottom of pit										

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: G.W.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 66°03'40"N. 128°17'00"W	ELEVATION:		N75-1061-B13-1	
DRWN. BY: A.M.	AIRPHOTO No.: A 12602-233	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA		
CHKD: J.K.W.	RIG:	AIR TEMP: Approx. 21°C			
	METHOD: TEST PIT		ENGINEERS FOR		
START: D 31 M 08 Y 75 TIME: —	FINISH: D 31 M 08 Y 75 TIME: —		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	

PC-9SK373

64

TEST HOLE No. N75-1061-B13-1

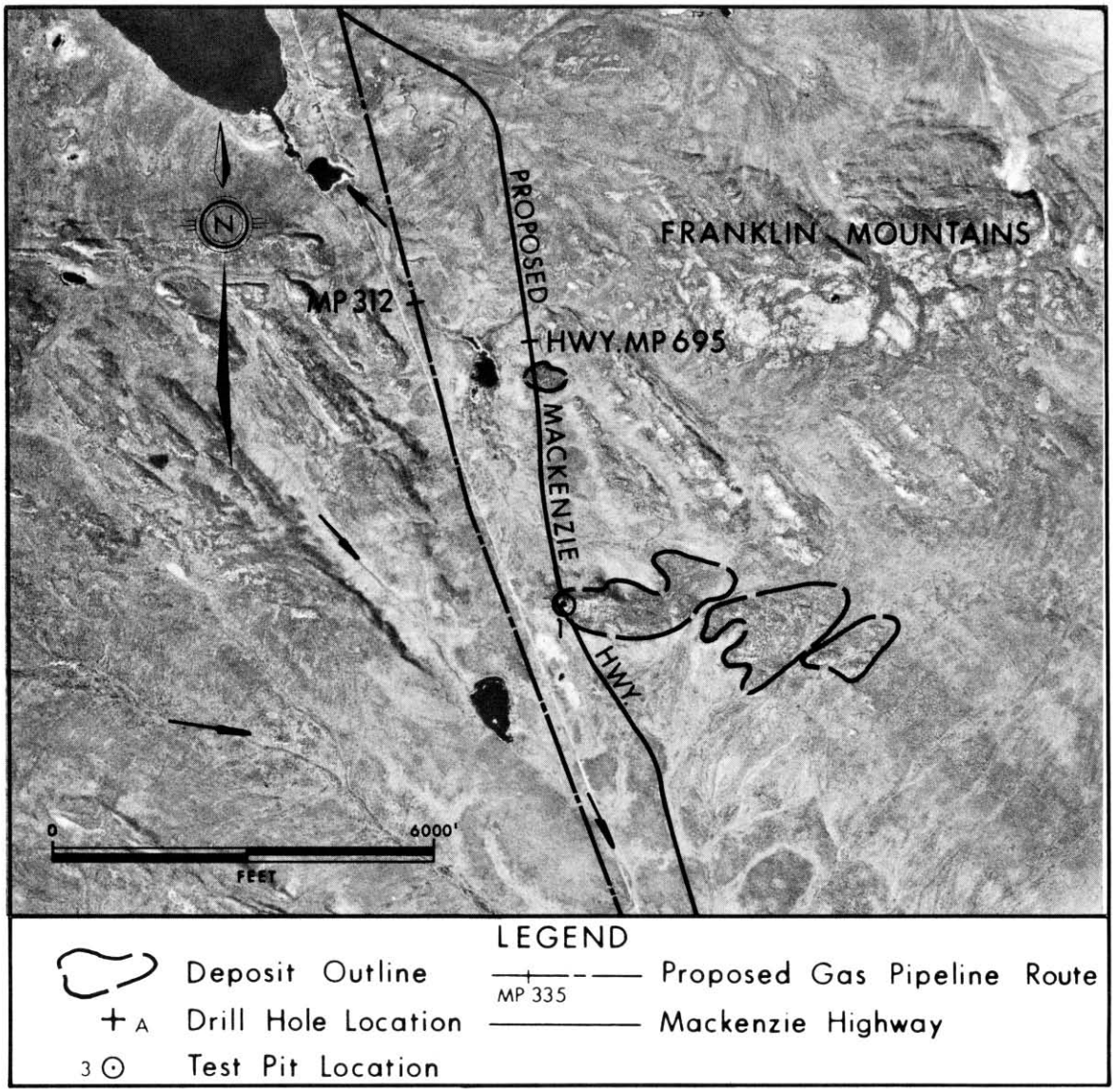
DEPOSIT 106H-B1

Physical Setting: Deposit 106H-B1 is a kame deposit located 3 miles northwest of Chick Lake. Milepost 312 of the proposed pipeline route is close.

Material: SAND and GRAVEL - wellgraded with cobbles and a trace fines.

Volume: 1,330,000 cubic yards.

Assessment: Deposit 106H-B1 is a source of good quality granular material suitable for general fill, backfill, building pads, and concrete and asphalt aggregate subject to further testing.



Airphoto No. A22848-14
Approximate Scale: 1" = 2900'

Latitude: 65° 56' N.
Longitude: 128° 16' W.

DEPOSIT 106H-B1

PHYSICAL SETTING

Deposit 106H-B1 is a kame deposit located near the northern end of the Norman Range in the Franklin Mountains 3 miles northwest of Chick Lake. The proposed Mackenzie Highway crosses the deposit and the proposed pipeline route is 1000 feet to the east. This deposit is adjacent to bedrock ridges described as deposit 106H-B2(R). This deposit corresponds to part of source 319 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The kames are about 85 feet high and are superimposed on shale which is exposed at the base of one kame. The deposit is flat to sloping, well drained and ice content is low to nonexistent in test pits and drill holes.

BIOLOGICAL SETTING

Black spruce, aspen, white birch, alder and willow dominate the moderate to steep slopes of this site. The area provides marginal moose winter range but good marten habitat. Tracks of moose, woodland caribou and wolf were observed. Black bears occur in the area. No dens were observed. There is no suitable waterfowl or fish habitat in the vicinity of the site. The site provides low quality raptor habitat.

MATERIAL

The material in this deposit consists of well graded sand and gravel with cobbles and a trace fines. The gravel is grey-brown, rounded to subangular, partially carbonate coated and composed of limestone, subordinate quartzite and altered fine grained silicates, and minor granite.

Concrete suitability tests indicated that the gravel would be a fair to good quality aggregate for concrete.

VOLUME

The DPW test holes have penetrated 9 feet of gravel. An average thickness of 6 feet over an area of 137 acres was used to calculate the total volume of 1,330,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 106H-B1 is a source of good quality granular material. Location of areas to be exploited will be dictated by haul distances, insitu material quality, and material requirements. Granular material from this deposit may be used for general fill, backfill, building pads, and concrete and asphalt aggregate. The gravel requires further testing before being used in concrete.

Access to the deposit with equipment may be achieved via the Mackenzie Highway centerline or via the pipeline right of way. Snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Following the removal of vegetative cover the organic topsoil would be stripped from the area to be excavated and stockpiled around the edge of the excavation area. Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so as to maintain good drainage. Natural mixing during excavation will be

adequate to obtain good gradations. Crushing and/or screening of the material may be required to produce quality construction aggregates. The excavated material may have to be stockpiled, thawed, and drained before use, if it is found to contain ice.

Standard excavation techniques and equipment should be adequate for the removal of material from this site.

A progressive rehabilitation plan will be developed for each segment of the deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	GM		GRAVEL - fine to coarse, silty, some fine to coarse sand, brown, dry.		UF							0	
1.0												1	
1	GP-GM		GRAVEL - coarse to fine and fine to medium sand, trace silt, grey-brown, fairly clean, infrequent cobbles to 8", moist, gravel subangular to rounded, rootlets to depth 3.0'.				MA, combined samples 1 - 4 G = 52% S = 43% F = 5%	B1				1	
2								B2				2	
3								B3				3	
4								B4				4	
5.0												5	
5	SW		SAND - fine to coarse, and fine to coarse gravel, clean, moist, grey-brown, occasional cobbles to 4".				MA, combined samples 5 & 6 G = 45% S = 50% F = 5%	B5				6	borderline sand/gravel (GW-SW)
6								B6					
6.8			Bottom of pit									6.8	

LOGGED BY: G.M.H.	FACILITY:		PROJECT: 1301 1	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 65°55'42"N, 128°15'50"W		ELEVATION:		N75-106H-B1-1
DRWN BY: N.L.	AIRPHOTO No.: A 22848-14		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP: Approx. 24°C		
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 31 M 08 Y 75 TIME: —	FINISH: D 31 M 08 Y 75 TIME: 18:00				

TEST HOLE No. N75-106H-B1-1

PC-9,SK373

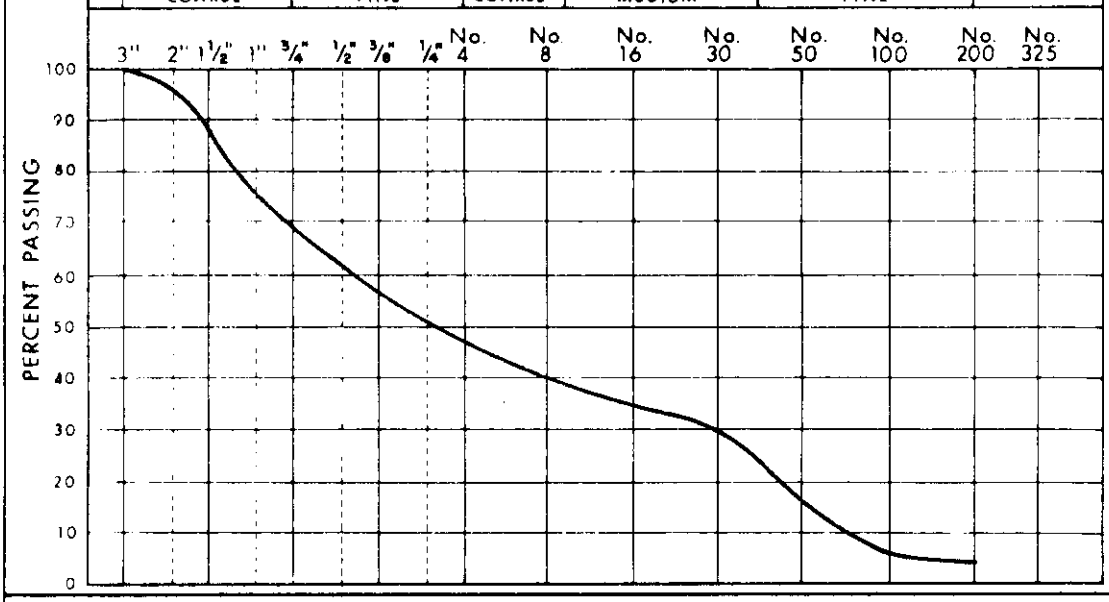
SIEVE ANALYSIS REPORT

SAMPLE N75-106H-B1-1 DEPTH 1.0-5.0

DATE SAMPLED August 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 226

GRAVEL SIZES		SAND SIZES			FINES
30%	22 %	8%	16 %	19 %	5%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.0
1½"	89.9
1"	76.6
¾"	70.0
½"	62.7
⅜"	57.8
¼"	
No. 4	47.5
No. 8	40.8
No. 16	36.1
No. 30	30.1
No. 50	17.3
No. 100	6.8
No. 200	4.7

COMMENTS

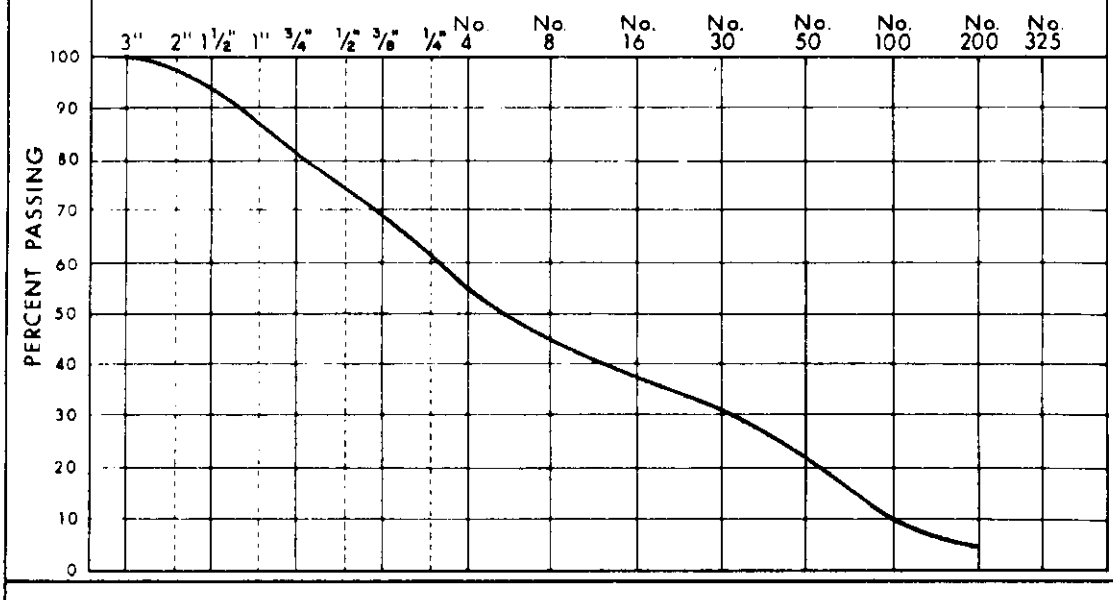
OVERSIZE (>3") = 0.0 %

SAMPLE N75-106H-B1-1 DEPTH 5.0-7.5

DATE SAMPLED August 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 227

GRAVEL SIZES		SAND SIZES			FINES
18%	27%	12%	17 %	21 %	5%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.2
1½"	93.9
1"	86.2
¾"	81.9
½"	74.9
⅜"	69.2
¼"	
No. 4	54.5
No. 8	46.1
No. 16	37.9
No. 30	31.3
No. 50	21.6
No. 100	9.8
No. 200	5.3

COMMENTS

OVERSIZE (>3") = 0.0 %

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-106H-B1-1 DATE SAMPLED : August 31, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-5 DATE TESTED : March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 6.36 %
FINE AGGREGATE : LOSS = 10.07 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 26.3 %

ORGANIC IMPURITIES TEST

NUMBER : 3+
COAL REMOVED : 2+
COAL & ROOTLETS REMOVED : 2+
COAL CONTENT : Trace
SIGNIFICANCE :

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	12.3
Granite		4.35
Sandstone	Medium strong, Good	1.6
Siltstone		1.5
Limestone	Slightly weathered, Medium strong, Good	17.0
Fine-grained silicate altered rocks		9.1
Chert	Potentially reactive, Fair	0.05
Flint		1.35
Soft Sandstone	Soft, Weak, Poor	0.75
Ironstone	Soft, Weak, Deleterious	0.6
Clay		0.4
PN = 133	INTERPRETATION : Fair	49.0

COMMENTS : Organic impurities test satisfactory.

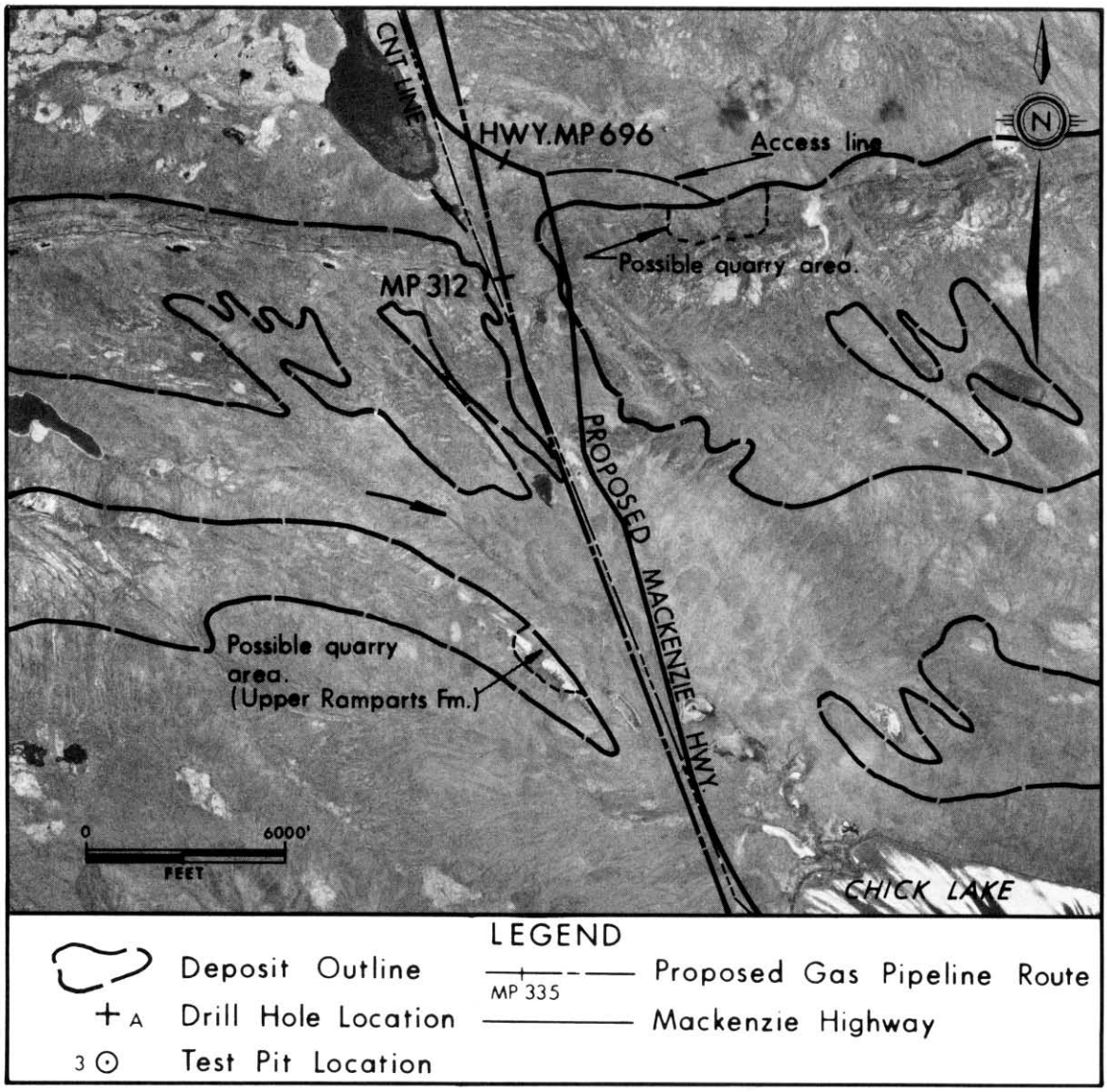
DEPOSIT 106H-B2(R)

Physical Setting : Deposit 106H-B2(R) is a series of carbonate ridges forming the north end of Norman Range, close to pipeline M.P. 313.

Material : LIMESTONE and DOLOMITE - thick bedded.

Volume : Unlimited.

Assessment : Deposit 106H-B2(R) is a source of good quality bedrock material suitable for general fill, backfill, building pads, and concrete aggregate.



Airphoto No. A22420-237
Approximate Scale: 1" = 5700'

Latitude: 65° 56' N.
Longitude: 128° 14' W.

PHYSICAL SETTING

Deposit 106H-B2(R) is a series of carbonate ridges forming the north end of the Norman Range between Snafu and Chick Lakes. The old CNT line, the proposed Mackenzie highway, and the proposed gas pipeline pass through a gap in these ridges. This bedrock materials site corresponds to source number 319 in Pemcan Services DIAND Granular Materials Inventory (1972) report. This site has also been investigated by EBA Engineering in connection with the Mackenzie Highway.

The limestone and dolomite ridges stand 750 feet above the surrounding till plain. They are part of the west plunging Beavertail Anticline. A major east-west trending thrust fault borders the north side of the ridges. Kames of deposit 106H-B1 are adjacent to these bedrock ridges. Colluvium forms a discontinuous cover over the bedrock.

BIOLOGICAL SETTING

Dominant tree cover consists of white spruce and white birch. A burn (1969) occurs south of the southern-most ridge. The burned area is utilized by moose in early winter. Woodland caribou occur in the area. Although marten utilize the unburned areas in the ridges, they are most abundant in the small stream valleys between the ridges. Black bear are common near Chick Lake and utilize the area at the proposed borrow site. The denning potential of this site is not known but it may be used by black bears. The area provides low quality raptor habitat. There is no suitable fish or waterfowl habitat adjacent to the site, however the small intermittent streams adjacent to the site flow into Chick Lake and the Donnelly River.

MATERIAL

The bedrock ridges are made of dolomite of the Mount Kindle and Franklin Mountain Formations, brecciated dolomite of the Bear Rock Formation, and limestone of the Hume and Ramparts Formations.

The Ramparts limestone would probably provide the best quarried material. This scarp-forming limestone is homogeneous, thick bedded and free of chert. The community of Norman Wells to the south has used this rock type successfully for construction purposes. Fossiliferous limestone of the Hume Formation is resistant to weathering but is not as resistant as the Ramparts limestone.

The Mount Kindle and Franklin Mountain dolomites are siliceous and contain chert. Concrete reactivity tests are suggested, if these dolomites are used with cement.

Dolomites of the Bear Rock Formation would probably yield good material from fresh exposures. Rock from this unit is brecciated and may fragment to finer sizes when blasted during quarry operations. Gypsum is also present in this formation.

VOLUME

There is an unlimited supply of bedrock material in these ridges.

DEVELOPMENT AND REHABILITATION

Deposit 106H-B2(R) is a source of good quality bedrock material suitable for general fill, backfill, building pads and concrete aggregate. Areas to be exploited would be dictated by haul distances, overburden thickness, insitu material quality and material requirements. Two areas are indicated on the aerial photograph as possible quarry sites but further

work will be required to assess these prior to quarry development. The northern site is on the north slope of a dolomite cored ridge at the end of an access line from the highway. The second site is a limestone scarp of the Ramparts Formation. This exposure is located approximately 2000 feet west of the proposed pipeline. A minor stream separates the ridge from the pipeline right of way.

No biological factors were identified during the field reconnissance, which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Standard quarrying techniques and equipment would be required to develop this source.

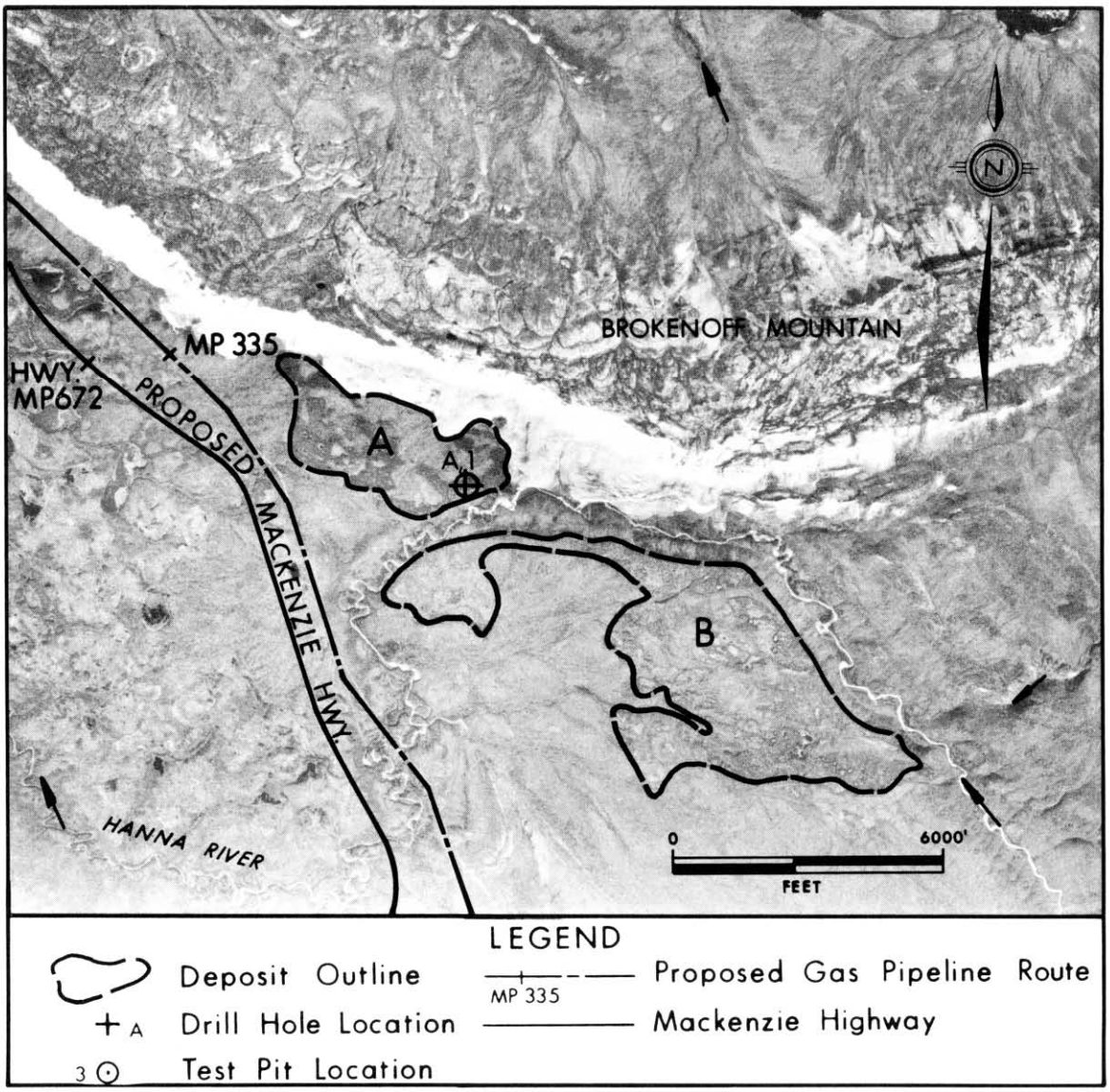
Before abandonment, the quarry walls would be scaled and the pit floor graded to promote drainage from the site. The quarry area would be inspected for unacceptable residual environmental impacts and remedial measures taken.

Physical Setting: Deposit 96E-B1 is an outwash plain bissected by Hanna River. The proposed pipeline right of way passes near the deposit between M.P. 335 and 337.

Material: SAND and GRAVEL - poor to well graded, silty, gravel discontinuous.

Volume: 20,400,000 cubic yards.

Assessment: Deposit 96E-B1 is a source of fair to good quality granular material suitable for general fill, backfill, building pads and possibly concrete aggregate with further testing.



Airphoto No. A22387-67
Approximate Scale: 1" = 4050'

Latitude: 65° 40' N.
Longitude: 127° 47' W.

DEPOSIT 96E-B1

PHYSICAL SETTING

Deposit 96E-B1 is a gently sloping glaciofluvial outwash plain that has been bisected by Hanna River. The deposit is located just south of Brokenoff Mountain on the west flank of the Franklin Mountains. The proposed gas pipeline, the proposed Mackenzie Highway and the CNT line are within 500 feet of both the northern (Part A) and southern (Part B) segments of the deposit.

The two portions of this deposit have been drilled by DPW and Pemcan Services (12 holes total) and were identified as deposit numbers 303 (northern, Part A) and 302 (southern, Part B) in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The surface of the deposit is irregular because the outwash sands and gravels have been eroded after deposition. Small wet depressions are present on the eastern and southern sections of Part B. Higher well treed areas of the deposit generally represent thicker, better quality granular material. Test holes completed to date show that gravel layers within the deposit are discontinuous. These holes also indicate that the north end of Part A has the best potential for providing gravel.

The deposit has low ice content and overburden of silt and organic silt that ranges in thickness from 2 to 7 feet.

BIOLOGICAL SETTING

Vegetation on well-drained portions of the site consists of aspen, birch and white spruce (up to 80 feet high) with a dense understory of shrubs. Bare patches of mineral soil are present on steep slopes. The Hanna River valley provides poor moose winter habitat. The site is located near potential raptor habitat. Several species of fish including

grayling, walleye, burbot, and suckers utilize the river. A spawning and rearing area for grayling, slimy sculpin and possibly pike occurs downstream of the site. Open water in winter also suggest possible overwintering areas.

MATERIAL

This deposit is a source of fair to good quality granular material. The outwash plain is mostly sand with large discontinuous gravel layers. The sand is poorly graded, fine to coarse, silty, brown to gray, and contains small amounts of detrital coal. The gravel is well to poorly graded, fine to coarse, rounded to angular, brown to grey, and is composed of limestone, quartzite, chert, shale, siltstone and igneous rock.

VOLUME

Assuming a 15 foot depth of material over an area of 843 acres a total deposit volume of 20.4 million cubic yards can be calculated.

DEVELOPMENT AND REHABILITATION

Deposit 96E-B1 is a source of fair to good quality granular material suitable for general fill, backfill, and building pads. The gravel portions may be suitable for base or surface course and possibly concrete aggregate. Location of areas to be exploited would be dictated by haul distance, insitu material quality, material requirements and environmental concerns.

Access to the deposit would be via a short cutline from the right of way to the western edge of both portions of the deposit. The east half of Part B requires a 1 to 2 mile haul road to reach the pipeline right of way. Care should be taken at any crossings of Hanna River as the banks are steep.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between development areas and the Hanna River to prevent siltation. Further raptor investigations may indicate that areas near Brokenoff Mountain be avoided.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Development would involve the use of conventional earthmoving techniques along with blasting and/or ripping if required. Extraction would follow the dugout pit style for level areas or horizontal quarries for side slopes.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
0	SM		SAND – fine to medium, very silty, rust brown, moist.		UF
2					
3.0 / 3.5			med. grain, silty, grey-brown, damp		
4	CL		CLAY – slightly silty, grey, damp.		
4.5				4.5	
4	SM		SAND – fine to medium, trace coarse, silty, (slight clayey) trace fine gravel.		Nb
6					
8.0				8.0	
8	SW		SAND – cmf. trace fine gravel, fairly clean, grey.		Vx
10					
12.0					
12	SP-SM		SAND – fine to medium, trace coarse, trace silt, grey.		
14					
16.0					
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	DEPTH (FT.)	REMARKS
					16	19:30 3 7/8" Walmac bit.

LOGGED BY:	G.M.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	65°40'05"N, 127°47'28"W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 22387-67	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD:	J.K.W.	RIG:	HELI-DRILL	AIR TEMP.:	Approx. 16°C
		METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 01 M 09 Y 75 TIME: 19:30 FINISH: D 01 M 09 Y 75 TIME: 20:10

TEST HOLE No. N75-96E-B1-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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SP-SM		16.0 SAND - fine to medium grey-brown, fairly clean.		Vx							16	
18												18	17:50
20													
22			22.0 22.0										
	ML		SILT - some fine sand, grey.		Nb								
24			24.5										
	SM		SAND - fine, silty, grey.										
26													
			27.0 fine to medium grained, grey, sulphurous odour from approx. depth 27.0 to 28.0									27	20:00
28													
			29.0 fine grained, silty, grey									29	20:05
30													
36			36.0 End of hole									36	

LOGGED BY:	G.M.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	65°40'05"N, 127°47'28"W	ELEVATION:	
DRWN. BY:	A.W.	AIRPHOTO No.:	A 22387-67	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	J.K.W.	RIG:	HELI-DRILL	AIR TEMP.: Approx. 16°C	ENGINEERS FOR
		METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 01 M 09 Y 75 TIME: 19:30		FINISH: D 01 M 09 Y 75 TIME: 20:10			TEST HOLE No. N75-96E-B1-A; SHEET 2 OF 2

TEST HOLE No. N75-96E-B1-A

PC-9,SK373

TEST HOLE LOG

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
1	SM	SAND – fine grained, very silty, some fine to coarse gravel, light rust brown, moist.	UF							
1.5										
2	SP-SM	SAND – fine to medium, trace fines, (trace gravel) brown to grey-brown, damp. (fairly uniform)		MA, combined samples 1-4	B1				2	2.5 horizontally stratified
3		1.9' - 2.1' black organic layer soft coal or ash, powdery, occasional hard chunks, no odour, "burnt" taste.		G = 3% S = 88% F = 9%	B2				3	
4		3.0' - 1" black layer, infrequent pebbles to ¾"			B3				4	
5		3.3' - 4" coal layer, fairly hard, occasional brown woody patches			B4				5	4.9 infrequent pebbles to 1"
6		6.2 Bottom of pit							6.2	

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: G.M.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 65°40'05" N, 127°47'28" W	ELEVATION:			
DRWN. BY: D.J.M.	AIRPHOTO No.: A 22387-87	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96E-B1-1	
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 16°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 01 M 09 Y 75 TIME: 19:30	FINISH: D 01 M 09 Y 75 TIME: 20:35				

TEST HOLE No. N75-96E-B1-1

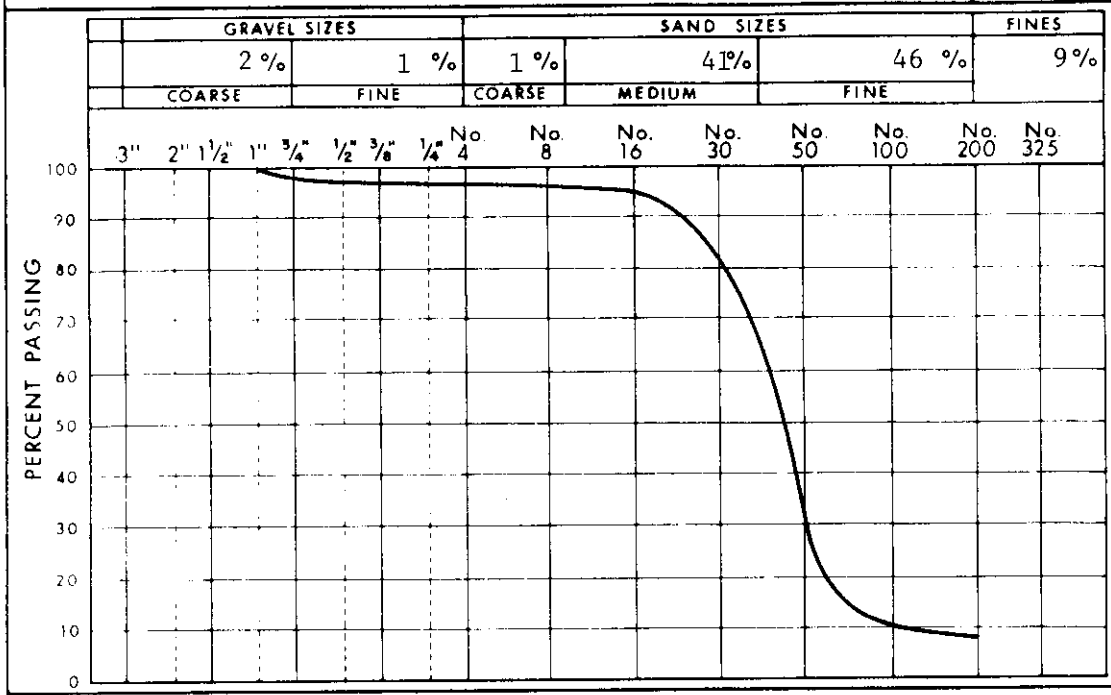
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-96E-B1-1 DEPTH 2.0-6.0

DATE SAMPLED September 1, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 191



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	100.0
¾"	98.2
½"	97.2
⅜"	97.2
¼"	
No. 4	97.0
No. 8	96.8
No. 16	95.6
No. 30	81.1
No. 50	32.0
No 100	10.9
No. 200	8.6

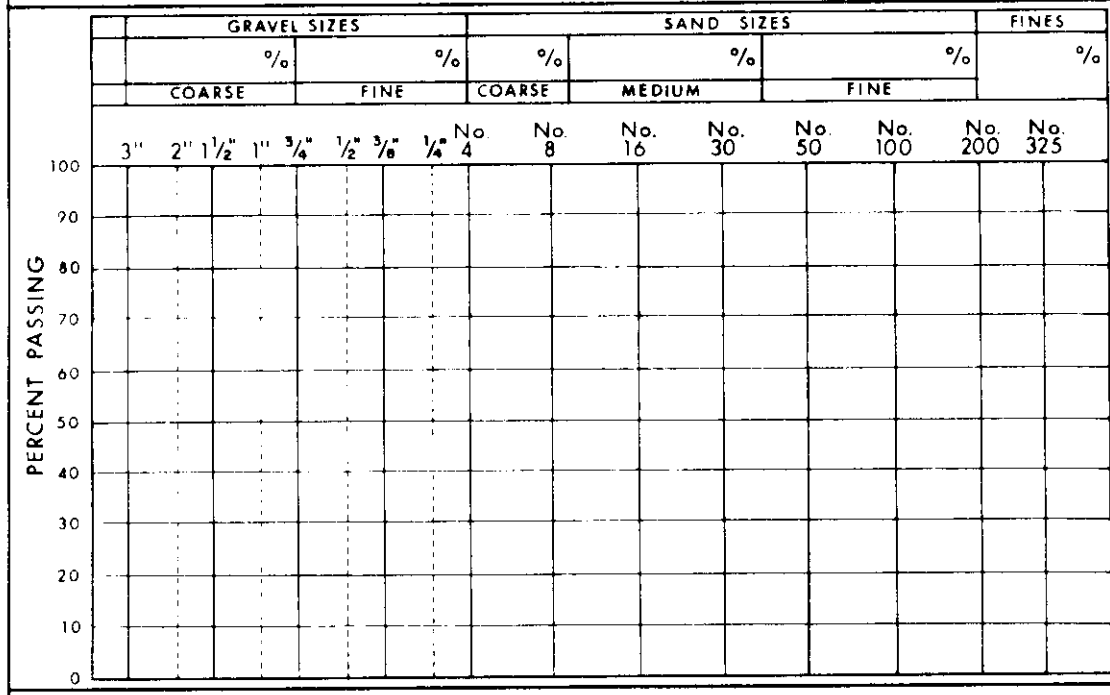
COMMENTS Moisture contents range from 4.5 to 6.9%

OVERSIZE (>3") = 0.0 %

SAMPLE _____ DEPTH _____

DATE SAMPLED _____ SAMPLED BY _____

R.M.HARDY REPORT NUMBER _____



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

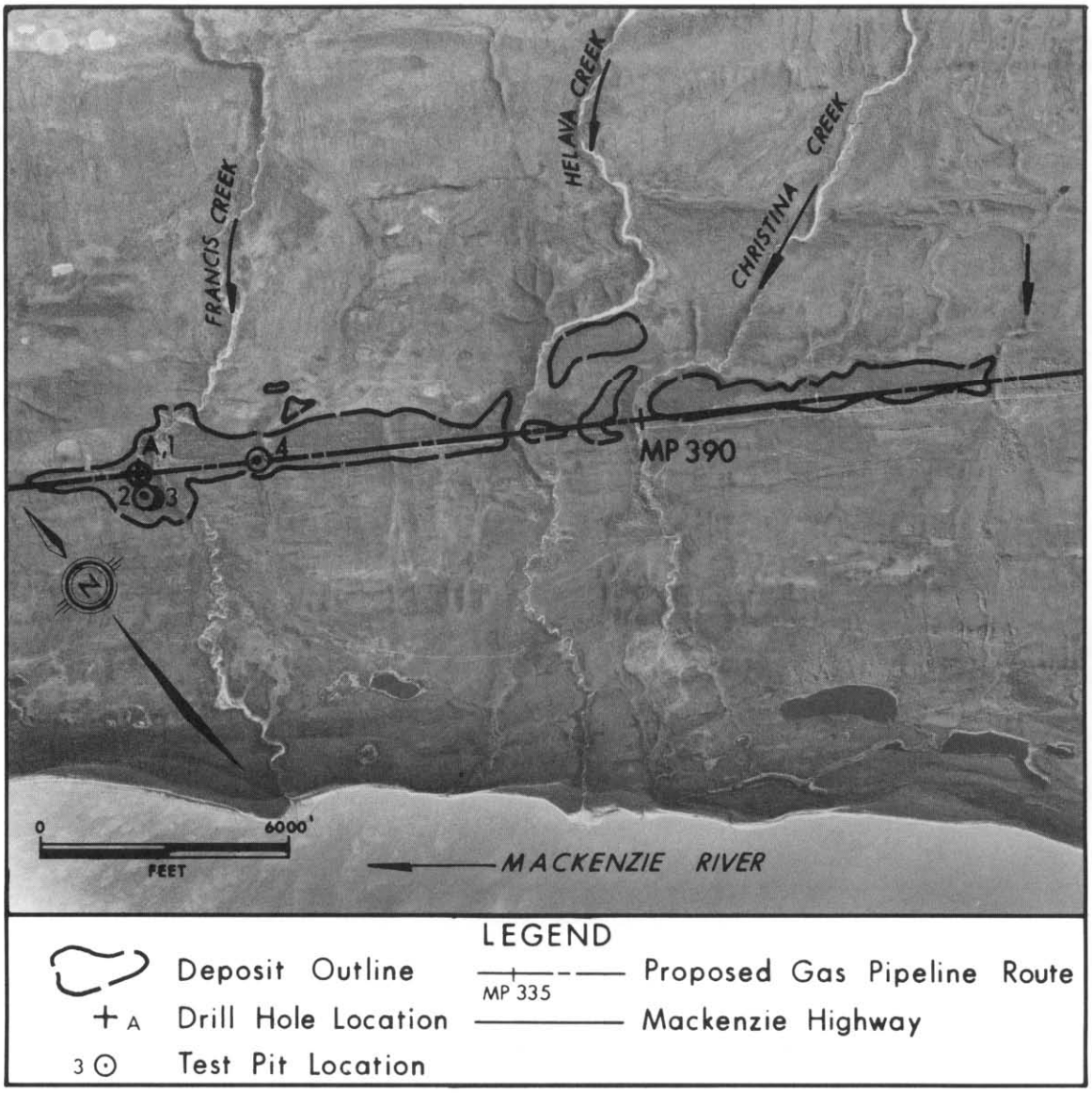
DEPOSIT No. N75-96E-B1

Physical Setting: Deposit 96E-B2 is a beach ridge located between Francis and Prohibition Creeks.

Material: SAND - well graded, with well to poorly graded gravel layers.

Volume: 3,900,000 cubic yards.

Assessment: Deposit 96E-B2 is a source of fair to good quality granular material suitable for general fill, backfill, building pads, and concrete and asphalt aggregate.



Airphoto No. A22387-183
Approximate Scale: 1" = 4250'

Latitude: 65° 13' N.
Longitude: 126° 27' W.

DEPOSIT 96E-B2

PHYSICAL SETTING

Deposit 96E-B2 is the most prominent beach ridge in a series of glacial lake beaches located on the east side of the Mackenzie River between Francis and Prohibition Creeks. The north end of the beach ridge has been reworked, by flowing water, into an alluvial fan. This portion of the deposit corresponds to source numbers 279 and 273 in Pemcan Services DIAND Granular Materials Inventory (1972) report. R.M. Hardy and Assoicates Ltd., consultants to DPW, have also drilled the alluvial fan portion of 96E-B2.

The beach ridges of 96E-B2 were deposited along the shoreline of a glacial lake that occupied the Mackenzie Valley. The position of the beach ridges was probably controlled by the underlying bedrock topography.

Drainage on the beach ridges is good. Ice content of beach materials is low to medium.

BIOLOGICAL SETTING

Aspen, white spruce and balsam poplar dominate the beach area. Black spruce is common in adjacent low-lying areas. The old CNT line has been revegetated by grasses and shrubs since abandonment. The region is moose summer range and good furbearer habitat. Moose pass through the area in early winter and early spring enroute to and from islands in the Mackenzie River. Moose and bear tracks and snowshoe hare sign were seen during the 1975 survey. Raptors possibly use the area but none were observed. Francis, Helava and Cristina creeks are minor grayling and slimy sculpin spawning and rearing areas, but probably not overwintering areas. Helava and Cristina creeks are generally dry by late July-early August. The site occurs in the Norman Wells hunting and trapping area.

MATERIAL

Well graded sands and well to poorly graded gravels are present in the beach ridges. Most of the beach material is sand but gravel layers are found at some locations. The gravel is fine to coarse, subrounded to flat to semi-spherical shaped. The gravel is made up of mostly granite and limestone. Quartzite, siltstone, and altered fine-grained silicate rocks and sandstone are also present. The aggregate quality is very good to excellent for use in concrete. More extensive drilling is required to determine a more complete granular material inventory of this deposit.

VOLUME

Assuming an average thickness of 4.5 feet over the deposit area of 537 acres, a total volume of 3.9 million cubic yards is estimated for this deposit.

DEVELOPMENT AND REHABILITATION

Deposit 96E-B2 is a source of fair to good quality granular material suitable for general fill, backfill in pipeline construction and building pads, and concrete and asphalt aggregate. Location of areas to be exploited will be dictated by haul distances, insitu material quality, material requirements and environmental considerations.

Access to the deposit may be achieved by barge to Francis Creek and overland from there to the deposit. Alternatively, the equipment may be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, existing cut lines and the CNT line should be utilized whenever possible. If needed, snow roads could be built to transport borrow material to points of use on the right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between creeks and areas of borrow development.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas to maintain adequate drainage. The alluvial fan portion of the deposit might require a cut and bench system parallel to the natural contours. Either type of development could be accomplished using blasting or conventional earthmoving techniques. The excavated material may have to be stockpiled, and possibly, where frozen, thawed before it is used. Natural mixing during excavation would help to obtain good gradations. Excavation of the better pockets or layers would provide better quality material.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
0	Pt		PEAT – light brown, dry fibrous roots, and wood chips.		UF
1.0					
2	ML		SILT – some fine sand, little fine – medium gravel, trace organics (fibrous roots), low – non plastic, light brown, dry.		
4					
6					
7.0					
	SP		SAND – fine, light brown, dry, loose, trace fine gravel.		
(8.0)					F
8					
10					
12					
14					
16					
16.0					

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

LOGGED BY: K.J.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 65°12'51"N, 126°37'05"W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 22387-183	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 20° C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: AIR		
START: D 03 M 09 Y 75 TIME: 14:30	FINISH: D 03 M 09 Y 75 TIME: 15:20		

TEST HOLE No. N75-96E-B2-A

TEST HOLE No. N75-96E-B2-A

SHEET 1 OF 2

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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
18	GM		GRAVEL – fine, silty, little fine sand, loose, light brown		F	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙							
20			(21.0)										
22	SM		SAND – fine, silty, little fine gravel, dry, loose, light grey.										
24													
26			(26.0)										
28	ML		SILT – clayey, light grey, rounded lumps.										
32			33.0 End of hole									33	End of hole

LOGGED BY: K.J.H	FACILITY: BORROW	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 65°12'51"N, 126°37'05"W	ELEVATION:			
DRWN. BY: A.M.	AIRPHOTO No.: A 22387-183	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96E-B2-A	
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 20°C	ENGINEERS FOR		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2	
START: D 03 M 09 Y 75 TIME: 14:30	FINISH: D 03 M 09 Y 75 TIME: 15:20				

TEST HOLE No. N75-96E-B2-A

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION
0	GW	GRAVEL – fine to coarse, some medium to fine sand, trace silt, pebbles subrounded, roots.
1		boulder 8" x 4" x 4"
		some coarse sand.
2		gravel becoming angular.
		subangular.
		2.5
	SP	SAND – medium to coarse, some coarse gravel,
3	(3.0)	grey, brown.
	SM	SAND – some silt, trace coarse gravel, grey.
4		4.0
	ML	SILT – some fine sand, grey.
5		5.0 Bottom of pit

ICE GRAPHIC LOG

NRC ICE TYPE VISUAL ICE %: UF

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

MA, combined samples 1–4

G = 36%
S = 40%
F = 24%
(SM)
(borderline GM-SM)

SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)
				0
B1				1
B2				2
B3				3
B4				4
				5

REMARKS

By Francis Creek, south of Norman Wells.

boulder 12"x 6" x 6"

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	65°12'51"N, 126°37'05" W	ELEVATION:	
DRWN. BY:	D.J.M.	AIRPHOTO No.:	A 22387-183	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 15°C
		METHOD:	TEST PIT		

START: D 04 M 09 Y 75 TIME: 11:35 FINISH: D 04 M 09 Y 75 TIME: 13:30

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-96E-B2-1

SHEET 1 OF 1

PC-9,SK373

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TEST HOLE No. N75-96E-B2-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION
0	OL		PEAT - 2'' thick SILT - some fine to coarse gravel, trace fine sand, gravel subrounded. light brown, fibrous, nonplastic
0.75			
1	GP		GRAVEL - coarse-grained, some medium to coarse sand, dark brown
2			
3			coarse gravel content increased 5 - 10%
3.5			
4	SP		SAND - fine to medium, some coarse gravel, occasional cobble
5			
5.5			Bottom of pit

ICE GRAPHIC LOG

NRC ICE TYPE VISUAL ICE %: UF

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

MA, combined samples 1 - 5
G = 31%
S = 62%
F = 7%
(SW-SM)

SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)
B1				1
B2	X			2
B3	X			3
B4	X			4
B5	X			5

REMARKS

Combined material = SAND, mfc, some fine to coarse gravel, trace fines

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	W.W.	LAT. & LONG:	65°12'47''N, 126°27'07''W	ELEVATION:	
DRWN. BY:	F.B.	AIRPHOTO No.:	A 22387-183	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP:	Approx. 15°C
		METHOD:	TEST PIT		

START: D 04 M 09 Y 75 TIME: 15:00 FINISH: D 04 M 09 Y 75 TIME: 17:45

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-96E-B2-2

SHEET 1 OF 1

PC-9,SK373

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TEST HOLE No. N75-96E-B2-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
1	GP	GRAVEL - coarse, little coarse sand, trace silt, roots		UF
2		2'' - 3'' layer of coarse gravel to coarse sand		
		2'' - 3'' layer of SILT, some fine sand, organics		
3		fine gravel 3.0		
	SW	SAND - fine to medium, trace coarse gravel		
4		4.0		
	GP	GRAVEL - fine to coarse, trace medium sand, poorly graded		
5		5.0		
		5.3 coarse gravel 5.0 - 5.3		
		5.7 coarse gravel 5.7 - 6.0		
6		6.0 Bottom of pit		

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	on C.N.T. right of way
MA, combined samples 1 - 4 G = 44% S = 53% F = 3% (SW)	B1				2	combined sample = SAND, cmf, and gravel to 3''
	B2				3	
	B3				4	
	B4				5	
					6	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 65°12'45''N, 126°27'00''W		ELEVATION:		N75-96E-B2-3
DRWN. BY: G.B.	AIRPHOTO No.: A 22387-183		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG:		AIR TEMP.: Approx. 20°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 04 M 09 Y 75 TIME: 13:45	FINISH: D 04 M 09 Y 75 TIME: 14:30				

TEST HOLE No. N75-96E-B2-3

PC-9,SK273

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1	SM		0.3 SAND – fine, some silt, light brown		UF		MA, – 3" material: Samples 1 - 3 G = 25% S = 37% F = 38%	B1				1	
	SW		SAND – fine to coarse, little gravel, well rounded, sand layered in 1" layers, occasional cobbles. 1.2										
	SP		1.5 SAND – fine to medium, light brown, poorly graded, trace root fibre.										
2	SM		SAND – fine, silty, trace fine gravel, well rounded, dense. 2.7					B2				2	
3	ML		SILT – clayey, trace coarse gravel, trace coarse to fine sand, low plastic, brown-grey, pebbles rounded. moist, very stiff.					B3				3	
4			4.3 Bottom of pit									4	

LOGGED BY: D.V.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 65°12'33"N, 126°26'09" W	ELEVATION:			
DRWN. BY: D.J.M.	AIRPHOTO No.: A 22387-183	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96E-B2-4	
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 20°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 05 M 09 Y 75 TIME: 11:30	FINISH: D 05 M 09 Y 75 TIME: 12:20				

66

TEST HOLE No. N75-96E-B2-4

PC-9,SK373

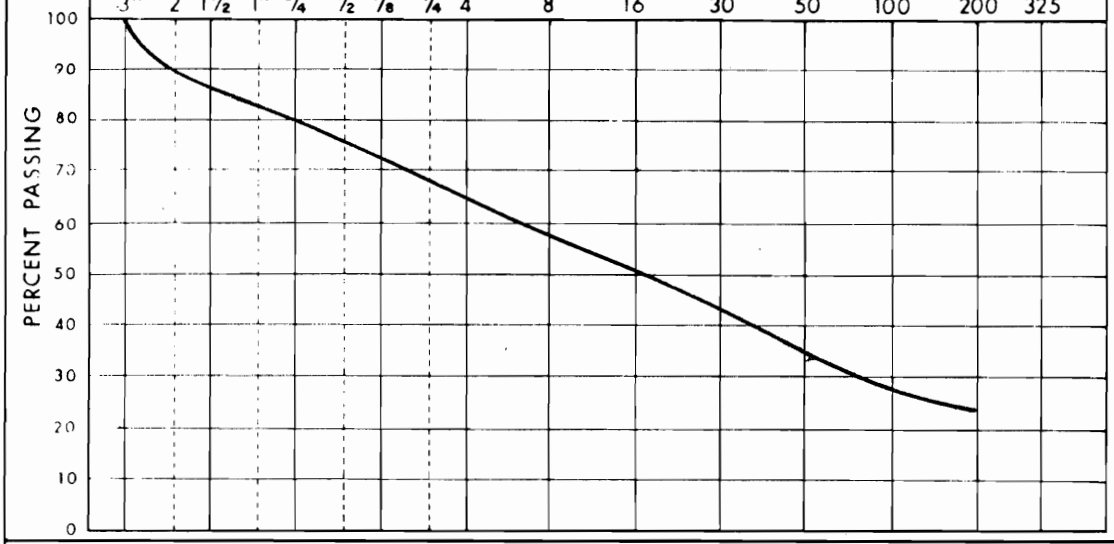
SIEVE ANALYSIS REPORT

SAMPLE N75-96E-B2-1 DEPTH 1.0-5.0

DATE SAMPLED September 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 196

GRAVEL SIZES		SAND SIZES			FINES
20 %	16%	8 %	17 %	15 %	24 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.0
1½"	86.0
1"	83.1
¾"	79.8
½"	75.1
⅜"	72.0
¼"	
No. 4	64.3
No. 8	58.0
No. 16	51.1
No. 30	43.4
No. 50	35.0
No 100	28.4
No. 200	24.2

COMMENTS

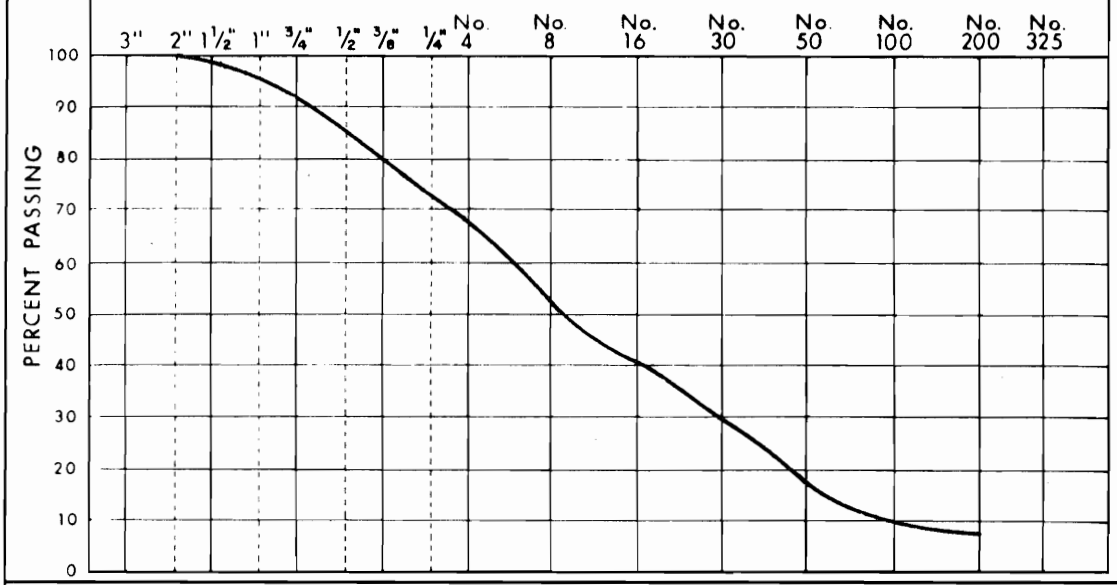
OVERSIZE (>3") = 0.0 %

SAMPLE N75-96E-B2-2 DEPTH 0.0-5.0

DATE SAMPLED September 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 23

GRAVEL SIZES		SAND SIZES			FINES
8 %	23 %	17 %	27 %	18 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	99.0
1"	94.3
¾"	91.8
½"	85.0
⅜"	79.2
¼"	
No. 4	68.5
No. 8	52.2
No. 16	40.4
No. 30	29.6
No. 50	17.1
No. 100	10.0
No. 200	7.4

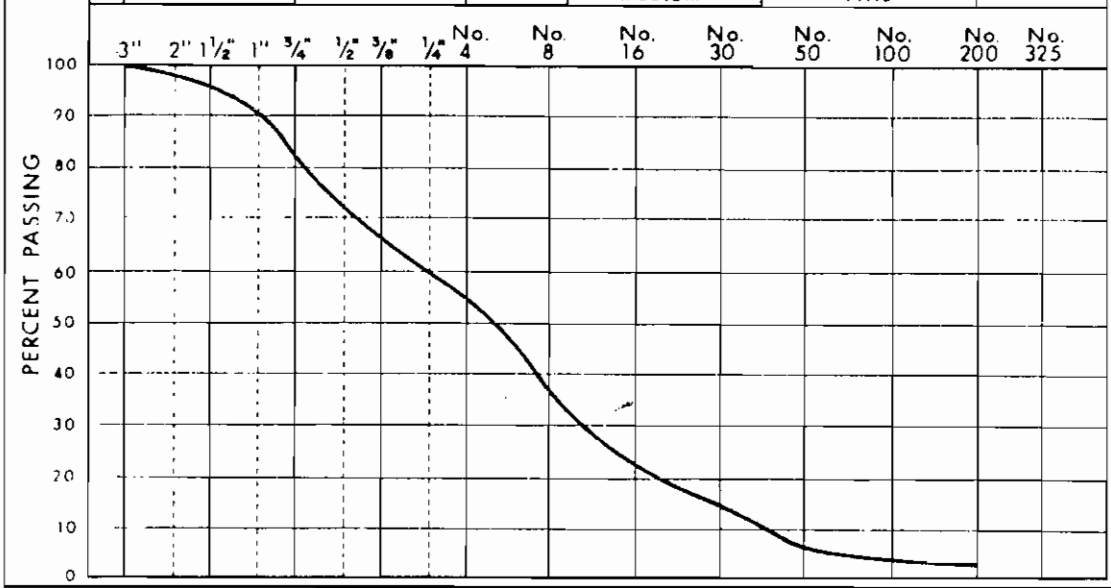
COMMENTS

OVERSIZE (>3") = 0.0 %

SIEVE ANALYSIS REPORT

SAMPLE N75-96E-B2-3 DEPTH 2.0-6.0
DATE SAMPLED September 4, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 9

GRAVEL SIZES		SAND SIZES			FINES
18 %	26 %	24%	22 %	7 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	

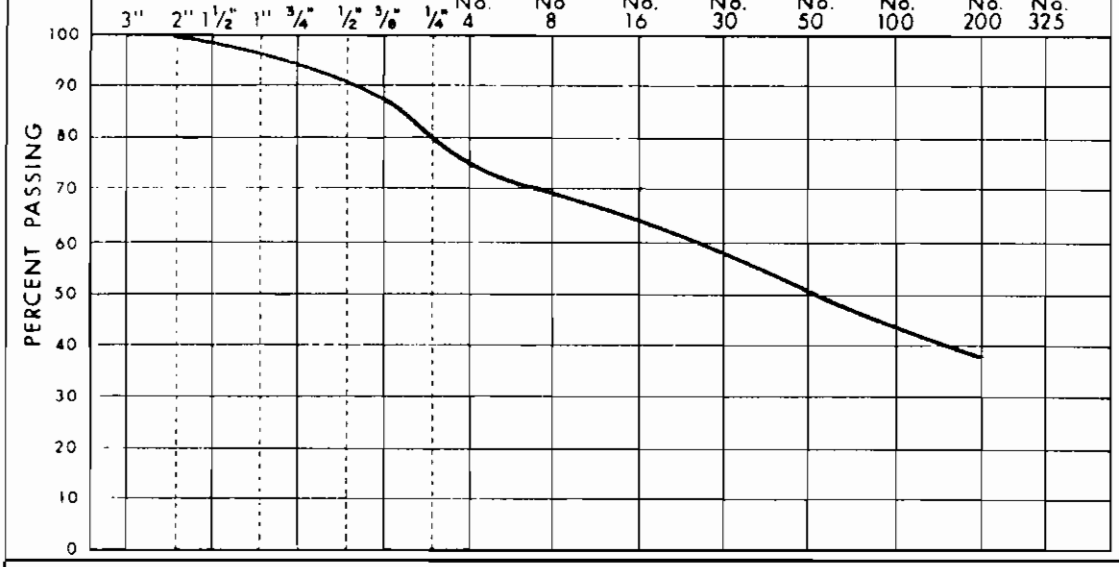


SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.2
1½"	96.1
1"	91.2
¾"	81.9
½"	72.7
⅜"	66.2
¼"	
No. 4	55.7
No. 8	36.5
No. 16	23.1
No. 30	15.1
No. 50	6.3
No 100	4.1
No. 200	3.3

COMMENTS OVERSIZE (>3") = 0.0 %

SAMPLE N75-96E-B2-4 DEPTH 1.0-4.0
DATE SAMPLED September 4, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 195

GRAVEL SIZES		SAND SIZES			FINES
6 %	19 %	7 %	13 %	17 %	38 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	98.1
1"	96.5
¾"	94.4
½"	90.5
⅜"	87.4
¼"	
No. 4	74.9
No. 8	69.3
No. 16	63.9
No. 30	58.0
No 50	51.3
No.100	45.2
No. 200	38.3

COMMENTS Moisture contents range from 7.6 to 15.7% OVERSIZE (>3") = 0.0 %

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-96E-B2-3 DATE SAMPLED September 4, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 2-6 DATE TESTED March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 5.55%
FINE AGGREGATE : LOSS = 16.29%

LOS ANGELES ABRASION TEST

PERCENT LOSS = 22.8%

ORGANIC IMPURITIES TEST

NUMBER : 5
COAL REMOVED : 4+
COAL & ROOTLETS REMOVED : 3
COAL CONTENT : Trace
SIGNIFICANCE :

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	6.10
Granite		11.42
Sandstone	Medium strong, Good	2.45
Siltstone		5.25
Limestone	Soft, Strong, Good	10.45
Altered fine-grained silicates		8.20
Flint	Potentially reactive, Fair	0.14
Ironstone	Friable, Weak, Deleterious	0.29
PN = 106	INTERPRETATION : Excellent	44.3

COMMENTS : Organic impurities test indicates additional tests required before using material for concrete aggregate.

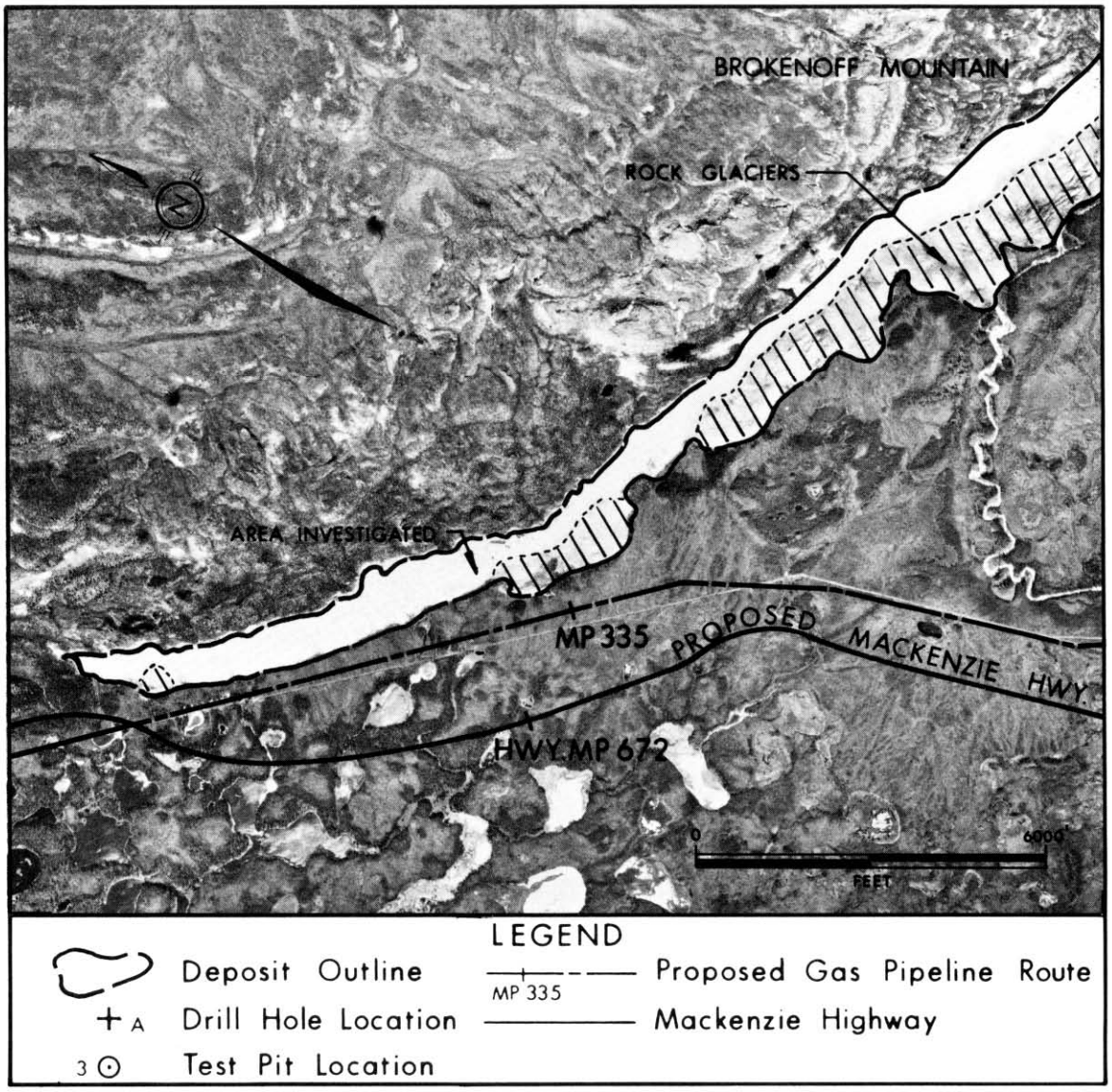
DEPOSIT 96E-B3(R)

Physical Setting: Deposit 96E-B3(R) is a talus slope of Brokenoff Mountain. Mile 335 of the proposed pipeline route is adjacent to the deposit.

Material: LIMTESTONE - talus, blocky, sand to boulder size.

Volume: Unlimited.

Assessment: Deposit 96E-B3(R) is a source of fair to good quality crushable rock suitable for subgrade, fill, building pads, and possibly aggregate. Further work is required.



Airphoto No. A22848-25
Approximate Scale: 1" = 3150'

Latitude: 65° 41' N.
Longitude: 127° 21' W.

DEPOSIT 96E-B3(R)

PHYSICAL SETTING

Deposit 96E-B3(R) is a talus slope deposit at the base of Brokenoff Mountain. The CNT line, the proposed Mackenzie highway and the proposed gas pipeline are adjacent to the deposit. This deposit corresponds to source number 304 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The talus slope is 100 to 300 feet high and the source rock for the talus dips away from the talus slope. Slope angles on the talus are as high as 45° with the average at 25°. Lobe-shaped rock glaciers are present along the southern section of the talus slope.

Bedrock of the cliff face consists of thinly bedded limestone and dolomite with fractures from 3 to 7 inches apart. The base of the talus slope rests on ice rich glaciolacustrine sediments. Ice contents in the talus slope areas are low but high in the rock glaciers.

BIOLOGICAL SETTING

The talus deposit does not support any vegetation except for occasional shrubs along the base of the slope. The associated cliffs provide potential raptor habitat. Further field work is required to document raptor use of the area.

MATERIAL

The talus material is composed of blocky limestone and dolomite which ranges from fine sand to boulder size.

VOLUME

A considerable volume of rock debris is present along the mountain front. More detailed investigation is needed to provide quantity estimates for this material.

DEVELOPMENT AND REHABILITATION

Deposit 96E-B3(R) is a source of fair to good quality crushable rock suitable for coarse subgrade, fill, building pads, and possibly as aggregate. Further work is required at this deposit to determine its characteristics with depth, including ice contents and material type. Slope stability will also need further work.

Access to the deposit is possible via the CNT line or the pipeline right of way. The terrain adjacent to the deposit is ice rich and thermally sensitive and care should be taken so as not to promote thermal degradation.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit. Development should avoid raptor nests if any are located in the immediate area.

Borrow areas should be located where ice rich rock debris is not evident. Toe excavations (with proper precautions) could commence immediately since there is no vegetative cover or overburden on the talus slopes. Excavation could be accomplished with conventional techniques and equipment. Crushing and screening equipment may also be needed to upgrade the aggregate quality.

Once controlled and organized borrow operations have finished at any one location along the talus slope the problems of rehabilitation are minor. It is expected that the continual addition of new material from the cliffs onto the talus slopes will eventually remove (i.e. cover) all traces of borrow operations.

DEPOSIT 96C-B1

Physical Setting : Deposit 96C-B1 is a large outwash plain located southwest of Fort Norman on the west side of the Mackenzie River near Little Bear River.

Material : GRAVEL - fine to coarse, poorly graded, sandy; some portions contain silty sand.

Volume : 290,000,000 cubic yards.

Assessment : Deposit 96C-B1 is a source of good quality granular material suitable for embankment fill, general fill, backfill, building pads and possibly concrete aggregate although chert is present.

AIRPHOTO SHOWN ON FOLLOWING PAGE



LEGEND

Deposit Outline

Drill Hole Location

Test Pit Location

Proposed Gas Pipeline Route

MP 335

Mackenzie Highway

Airphoto No. A21527-68, 69, 70

Approximate Scale: 1" = 5750'

Latitude: 64° 50' N.

Longitude: 125° 46' W.

DEPOSIT 96C-B1

PHYSICAL SETTING

Deposit 96C-B1 is a large outwash plain located 8 miles southwest of Fort Norman near Little Bear River on the west side of the Mackenzie River. The proposed pipeline is on the east side of the Mackenzie River about 10 miles north of the deposit. The deposit corresponds to source number FN-19 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The flat to gently sloping outash plain has been dissected by both a meltwater channel and the Little Bear River. The deposit has been divided into segments "a", "b", and "c" by the river and the meltwater channel. A gravel exposure in segment "a" shows 50 feet of gravel.

The deposit is well drained and drill holes indicate that it has low to medium ice contents. Silty sand overburden from 2 to 10 feet thick overlies the gravel.

Glaciolacustrine sediments are present both east and west of the deposit and till plain deposits are found immediately to the south.

BIOLOGICAL SETTING

A mixed forest of white birch, black spruce and aspen with alder, rose and sphagnum occur on this extensive site. The area provides poor to fair moose winter habitat. Moose tracks and beaver activity were observed during the 1975 survey. Waterfowl and raptor habitat occurs along the river valley and small lakes. The fisheries potential of the Little Bear River is not known.

MATERIAL

Large quantities of good quality gravel have been identified in segments "a" and "c" of the deposit. The gravel is fine to coarse, poorly graded, sandy, cobbly, rounded to subrounded, and composed of chert, quartzite, carbonate and granitic rock types. Segment "b" has no drill holes at present but is expected to contain gravel and sand similar in composition to segments "a" and "c". The sand which overlies the gravel in this deposit is silty, poorly graded, light brown and fine to medium grained.

VOLUME

The deposit covers 12,000 acres. A thickness of 15 feet was used in calculating the total volume of 290 million cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B1 is a source of good quality granular material suitable for embankment fill in berm construction, general fill, backfill in pipeline construction, building pads and possibly concrete aggregate. The high chert content may preclude its use as concrete aggregate. Location of areas to be exploited will be dictated by haul distance, insitu material quality and material requirements.

Access to the deposit from the pipeline is possible via barge or hauling on ice across the Mackenzie River. A cutline runs from just east of the mouth of the Little Bear River overland to segment "c" of the deposit. Other seismic lines cross segment "b". Access to segment "c" west of the Little Bear River is more difficult and would need to be looked at in some detail before development of this portion of the deposit.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use

and socio-economic information prior to final selection and development of the deposit.

Excavation in segments "a" and "b" should be kept away from the Little Bear River banks to avoid siltation and slope stability problems. A buffer zone should also be maintained between development areas and the lakes next to portions "b" and "c" of the deposit.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

The deposit is flat and a dugout type of development would probably be used to extract the borrow material. Conventional earthmoving techniques and equipment could be utilized, however, blasting and/or ripping might be required depending upon the degree of ice cementation.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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 – dark black, woody, fibrous, wet, odourous.		UF								
(1.0)													
1	SP		SAND – fine, trace organics, wet, quick, sensitive, light grey.										
(2.4)													
2	SP ?		SAND – fine, trace organics, bonded, light grey.		F ?								
4													
6													
8													
10													
12													
27													
28.0			End of hole									28	

LOGGED BY: K.J.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 64°51'02"N, 125°46'50"W	ELEVATION:			
DRWN. BY: K.J.H	AIRPHOTO No.: A 21527-68, 69, 70	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-96C-B1-A	
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 22°C			
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 05 M 09 Y 75 TIME: 12:20	FINISH: D 05 M 09 Y 75 TIME: 12:35				

TEST HOLE No. N75-96C-B1-A

114

PC-9,SK373

TEST HOLE LOG

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
0	Pt	0.3 PEAT, dark brown, roots, fibrous, wood chips.		UF	▲ Dry density (pcf) ⊙ Water content %							
2	SM	SAND, fine, silty, light yellow brown, dry, loose.			Plastic limit ⊢——⊣ Liquid limit							
		(3.0)			40 60 80 100 120 140 ▲							
4	SP	SAND, coarse, little fine gravel dark brown, damp, loose, clean.			0 20 40 60 80 100 ⊙							
6												
8												
10		(10.0)										Drill chattering & vibrating.
12	GP ?	GRAVEL, loose										Losing circulation
14		14.0 End of hole									14	End of hole — circulation loss

LOGGED BY: K.J.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 64°49'21"N, 125°49'22"W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No. A 21527-68, 69, 70	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 27°	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: AIR		
START: D 04 M 09 Y 75 TIME: 14:20	FINISH: D 04 M 09 Y 75 TIME: 14:55		

TEST HOLE No. N75-96C-B1-B

TEST HOLE No. N75-96C-B1-B

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	Pt		PEAT - light brown, woody, fibrous		UF								
			0.8										
	SM		SAND - fine, silty, light yellow brown, dry, loose										
2			(2.3)										
	SP		SAND - fine, little med sand, dark brown dry, loose. Becoming siltier with depth. moist to damp										
4													
6													
8													
			(9.0) 9.0										
10	GM		GRAVEL - fine, some coarse sand, dark brown-black, damp to wet.		F								
12												12	Losing circulation
14												14	
16													

LOGGED BY: K.J.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	64°48'30"N, 125°43'11"W	ELEVATION:		N75-96C-B1-C
DRWN. BY: A.M.	AIRPHOTO No.:	A 21527-68, 69, 70	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD:	RIG:	HELI-DRILL	AIR TEMP.: Approx. 22°C		
	METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2
START: D 05 M 09 Y 75 TIME: 10:40	FINISH: D 05 M 09 Y 75 TIME: 11:15				

TEST HOLE No. N75-96C-B1-C

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
	GM		GRAVEL, (continued)		F								
			(17.0)										
18	SW		SAND, fine, little medium–coarse sand. trace fine gravel, dark brown–black.										
20													
			22.0 End of hole									22	End of hole, lost circulation. No samples possible.
22													

LOGGED BY: K.J.H.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 64°48'30"N, 125°43'11"W		ELEVATION:		
DRWN. BY: K.J.H	AIRPHOTO No.: A 21527-68, 69, 70		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-96C-B1-C
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 22°C		
	METHOD: AIR				
START: D 05 M 09 Y 75 TIME: 10:40		FINISH: D 05 M 09 Y 75 TIME: 11:15		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2

TEST HOLE No. N75-96C-B1-C

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		0.3 PEAT - organic cover, moss + roots, black.		UF								
	SP		SAND - fine, poorly graded, light brown										
1			1.3 red brown, rootlets.				MA, combined Samples 1 to 4, & 6 G = 0% S = 95% F = 5%	B1				1	
			1.5 medium brown, roots, some organic streaking										
2								B2				2	
3								B3				3	
4								B4				4	
5								B5				5	
6								B6				6	
7			7.0 Bottom of pit									7	

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: D.V.	LAT. & LONG:	64°51'02"N, 125°46'50"W	ELEVATION:		
DRWN. BY: A.J.B.	AIRPHOTO No.:	A 21527-68, 69, 70	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96C-B1-1
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 23°C	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 05 M 09 Y 75 TIME: 14:30	FINISH: D 05 M 09 Y 75 TIME: 15:30				

TEST HOLE No. N75-96C-B1-1

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	ML		SILT - trace fine sand, light brown		UF		MA, combined samples 1 - 5 from 1' to 6' G = 29% S = 66% F = 5%					0	
1								B1				1	
1.8													
2	SW		SAND - fine to medium, little fine to coarse gravel, subrounded, loose					B2				2	
3								B3				3	
4								B4				4	
5								B5				5	
6.0			Bottom of pit									6	
6													

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	64°49'21"N, 125°49'22"W	ELEVATION:	
DRWN. BY:	F.B.B.	AIRPHOTO No.	A 21527-68, 69, 70	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 17°C
		METHOD:	TEST PIT		

START: D 05 M 09 Y 75 TIME: 10:30 FINISH: D 05 M 09 Y 75 TIME: 11:30

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-96C-B1-2

SHEET 1 OF 1

TEST HOLE No. N75-96C-B1-2

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	OL		SILT - trace fine sand, light brown, non-plastic, roots		UF							0	
1.0			1'' band fine gravel from 11''										
1	SW		SAND - medium to fine grained, (trace fine gravel), medium brown				MA, combined samples 1 - 6 G = 2% S = 91% F = 7% (SW)	B1				1	
2								B2				2	
2.9			occasional black horizontal bands, possibly organic, no organic odour (2.9' to 4.0')										
3								B3				3	
4.0			some fine to coarse gravel										
4								B4				4	
5								B5				5	
6			bands - fine sand, little silt and silt layers; silt layers moist									6	
7.0			Bottom of pit					B6				7	
7													

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	64°48'30''N, 125°43'11''W	ELEVATION:	
DRWN. BY:	R.J.S.	AIRPHOTO No.:	A 21527-68, 69, 70	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 17°C
		METHOD:	TEST PIT		

START: D 05 M 09 Y 75 TIME: 12:30 FINISH: D 05 M 09 Y 75 TIME: 13:45

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-96C-B1-3

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-96C-B1-3

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SP		SAND - fine, poorly graded, light brown, very dense, fibres		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙	%					0	
1												1	
2			2.6			⊙	4.8	B1				2	
3	SP-SM		SAND - fine, fairly uniform, trace silt, darker brown, dense				MA, combined samples 1 & 2 G = 0% S = 93% F = 7%					3	
4												4	
5						⊙	4.1	B2				5	
6			6.0 Bottom of pit									6	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	64°51'02"N, 125°48'58"W	ELEVATION:		N75-96C-B1-4
DRWN. BY: R.J.S.	AIRPHOTO No.	A 21527-68, 69, 70	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 17°C	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 04 M 09 Y 75 TIME: 19:00	FINISH: D 04 M 09 Y 75 TIME: 19:40				

TEST HOLE No. N75-96C-B1-4

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
	ML		SILT - little fine sand, non-plastic, dry, loose, light brown		UF								2" organic cover grasses, mosses, seedlings
1	CL		CLAY - dry, fractured										
			1.4 End of hole										

LOGGED BY:	K. J. H.	FACILITY:		PROJECT:	13011
CHKD:	R. H.	LAT. & LONG:	64°49'17"N, 125°54'20"W	ELEVATION:	
DRWN. BY:	A. M.	AIRPHOTO No.:	A 21527-68, 69, 70	PIPE MILEAGE:	
CHKD:	J. K. W.	RIG:		AIR TEMP:	Approx. 7°C
		METHOD:	TEST PIT		
START:	D 06 M 09 Y 75 TIME: 09:50	FINISH:	D 06 M 09 Y 75 TIME: 10:08		

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-96C-B1-5

SHEET 1 OF 1

TEST HOLE No. N75-96C-B1-5

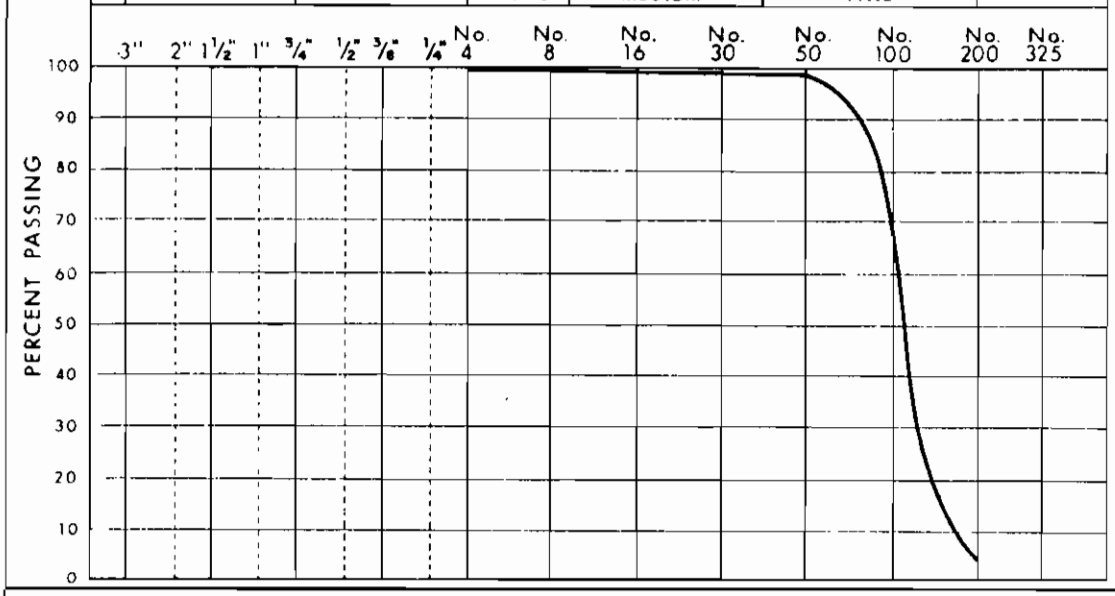
PC-9,5K373

SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B1-1 DEPTH 1.0-5.0 & 6.0-7.0
DATE SAMPLED September 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 218

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0 %	0 %	95 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	100.0
No. 8	99.9
No. 16	99.9
No. 30	99.8
No. 50	99.2
No 100	66.9
No. 200	5.0

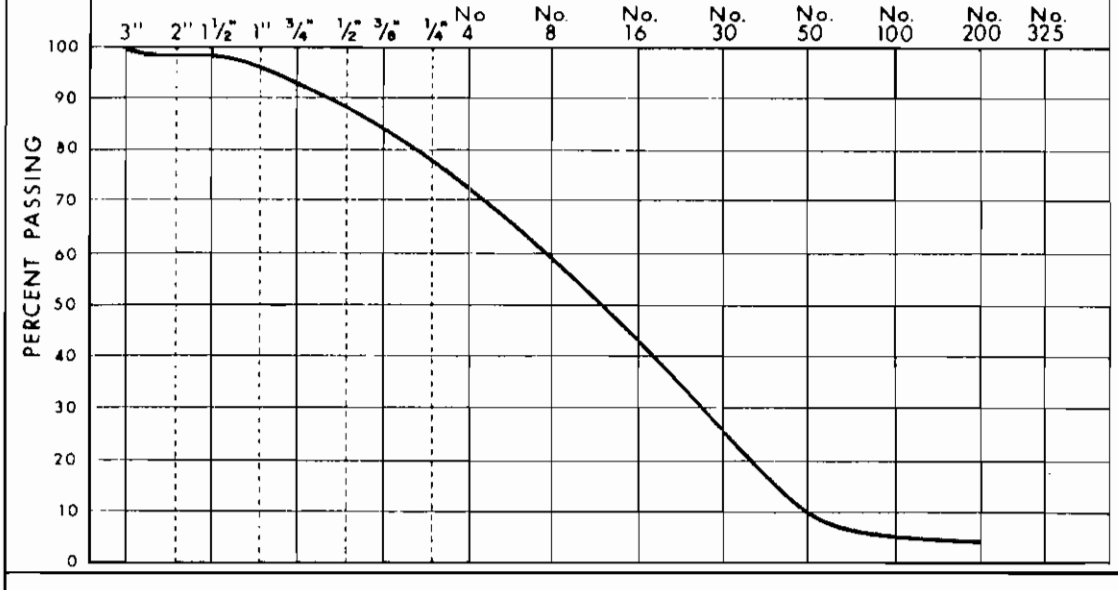
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-96C-B1-2 DEPTH 1.0-6.0
DATE SAMPLED September 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 175

GRAVEL SIZES		SAND SIZES			FINES
7 %	22%	15 %	37 %	14 %	5%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	98.4
1½"	98.4
1"	95.4
¾"	92.5
½"	88.0
⅜"	83.6
¼"	
No. 4	71.4
No. 8	58.1
No. 16	43.5
No. 30	26.3
No. 50	10.9
No.100	5.4
No. 200	4.6

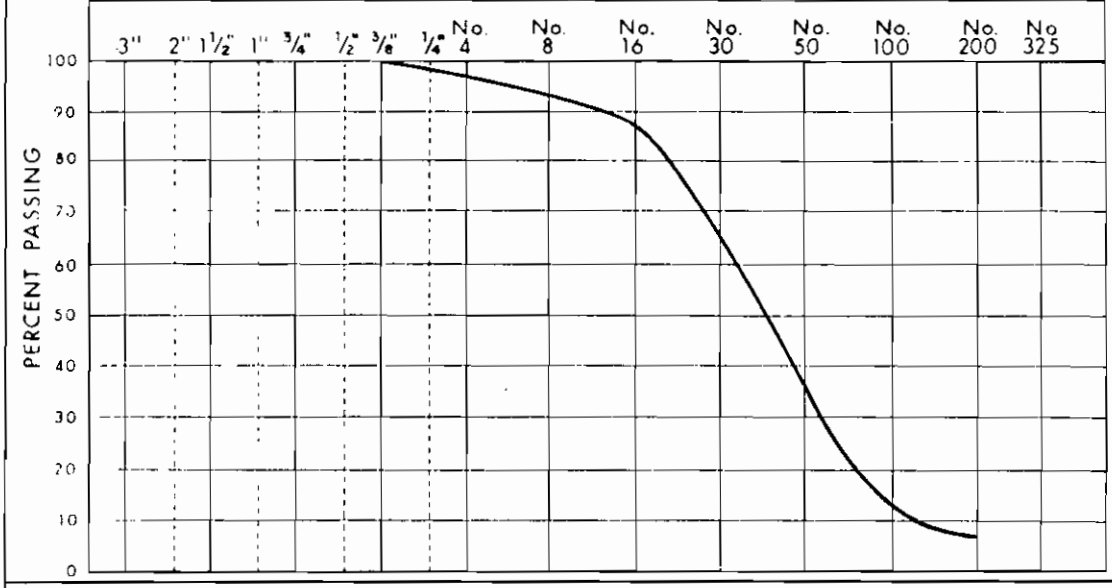
COMMENTS

OVERSIZE (>3") = 0.0 %

SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B1-3 DEPTH 1.0-7.0
DATE SAMPLED September 5, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 179

GRAVEL SIZES		SAND SIZES			FINES
0%	2%	5%	43%	43%	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	

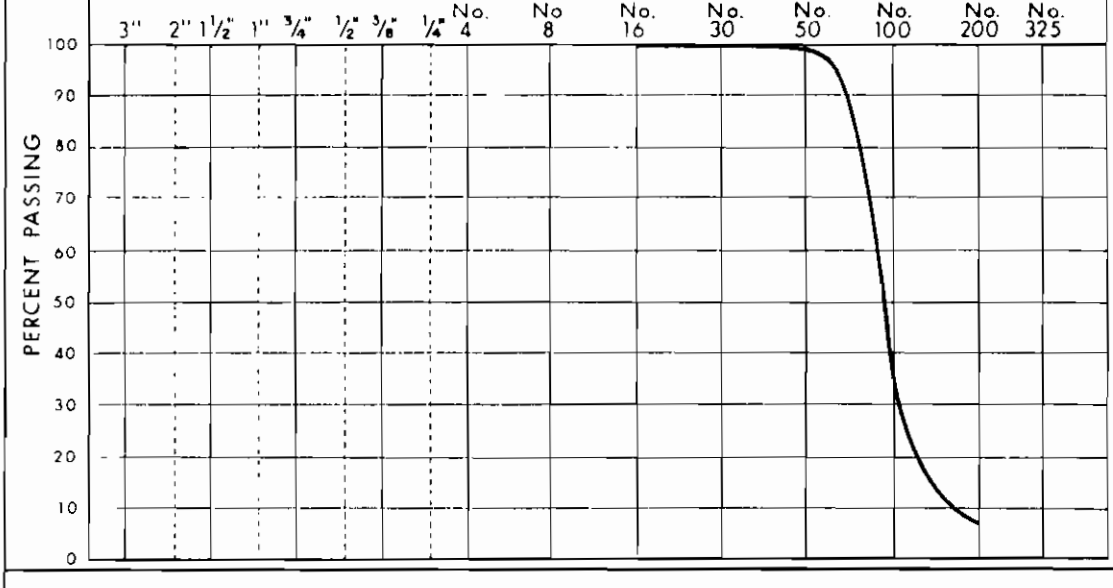


SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	98.3
No. 8	94.7
No 16	87.8
No. 30	66.3
No 50	34.7
No 100	13.8
No. 200	7.3

COMMENTS OVERSIZE (>3") = 0.0 %

SAMPLE N75-96C-B1-4 DEPTH 1.0-2.0 & 4.0-5.0
DATE SAMPLED September 4, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 185

GRAVEL SIZES		SAND SIZES			FINES
0%	0%	0 %	1%	92 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	100.0
No. 30	100.0
No. 50	99.4
No. 100	35.1
No. 200	6.9

COMMENTS Moisture contents range from 4.1 to 4.8%. OVERSIZE (>3") = 0.0 %

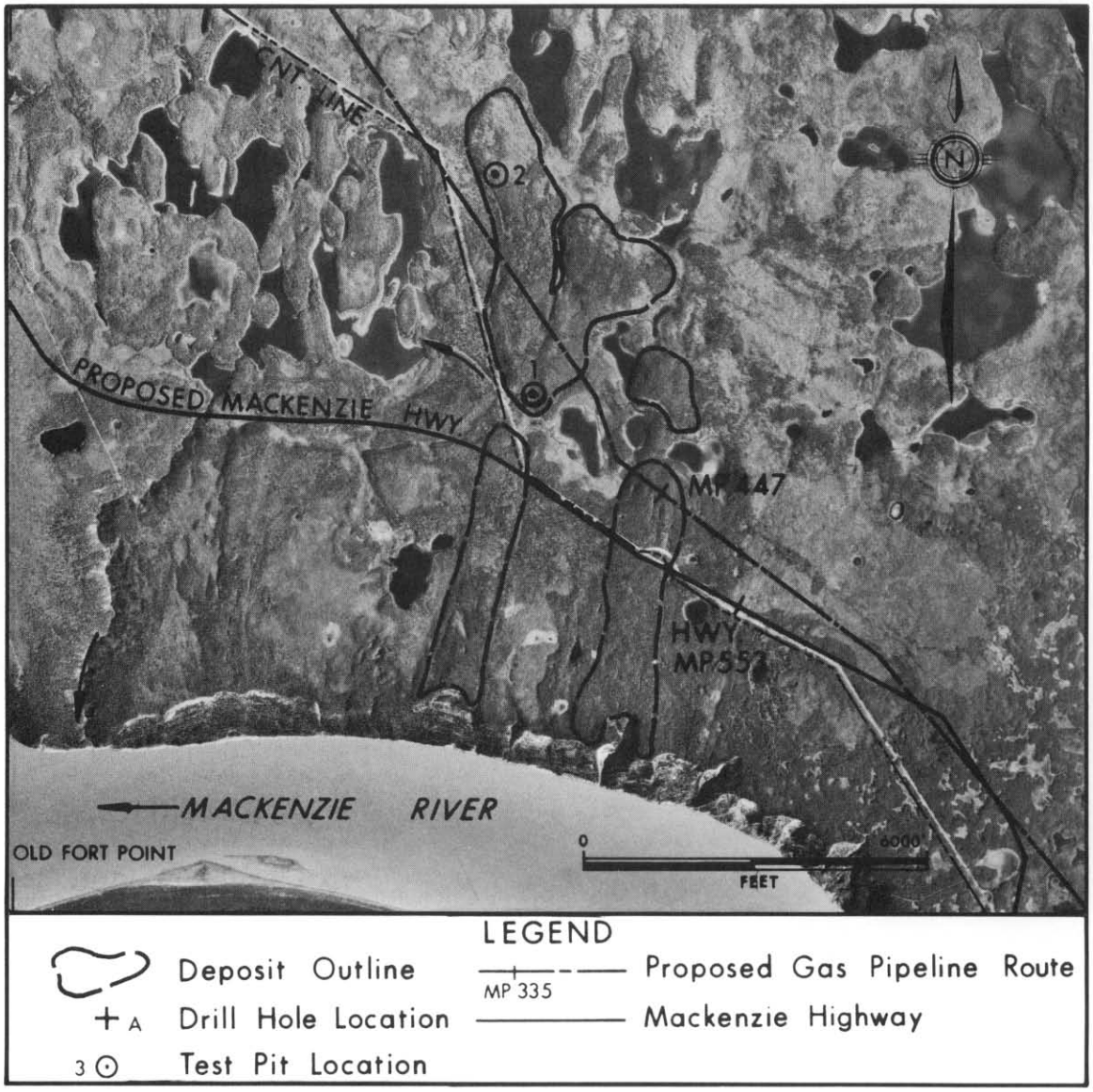
DEPOSIT 96C-B2

Physical Setting : Deposit 96C-B2 consists of sand dunes located on the north side of Mackenzie River across from Old Fort Point. The proposed pipeline right of way crosses the deposit near M.P.447.

Material : SAND - medium to fine grained, trace silt.

Volume : 38,300,000 cubic yards.

Assessment : Deposit 96C-B2 is a source of poor quality granular material suitable for general fill. Haul distances are short.



Airphoto No. A22933-21
Approximate Scale: 1" = 3100'

Latitude: 64° 43' N.
Longitude: 124° 55' W.

DEPOSIT 96C-B2

PHYSICAL SETTING

Deposit 96C-B2 includes some fairly large north-trending sand dunes located immediately north of the Mackenzie River across from Old Fort Point. The dunes are crossed by the old CNT line, the proposed gas pipeline, and the proposed Mackenzie highway. DPW has drilled in these dunes during borrow investigations for the Mackenzie highway. Northern Engineering has also drilled in one of the dunes (N75-OFP-1 drill hole) during other geotechnical investigations for the pipeline.

The dunes stand 60 to 100 feet above the surrounding deltaic plain. Side slopes on the dune are steep and the surface of the dunes are flat to undulating. Ice contents of dune sands are low.

Sands and silts underlying the dunes are deltaic in origin and are ice rich. Thermokarst collapse features are common.

The Mackenzie River has down cut 250 feet into the deltaic plain just south of the dune area. Gully erosion and slope failures are common along the river bank.

The dune investigated stands about 60 feet high with a 30¼ slope into the thermokarst collapse. This steep western slope is almost bare of overburden and has a few trees. Other parts of the dune have a thin top soil and fairly dense vegetation.

Ice content in the well drained dune is expected to be low.

BIOLOGICAL SETTING

The scattered site is generally well-drained and supports balsam poplar, white spruce, a dense alder understory and a ground cover of moss and low bush cranberry. Good moose winter habitat occurs on the islands

west of the site in the Mackenzie River, but the site provides only poor moose winter habitat. Migrating moose may move through the area in November-December and April-May enroute to and from islands or other winter habitat. The most important habitat for waterfowl is the island and river complex which is used extensively by migrating waterfowl in the spring. The site provides potential raptor nesting habitat. The Mackenzie River serves as year-round habitat for resident and migratory fish populations. The site lies within the Fort Norman hunting and trapping area.

MATERIAL

The dune sand is poorly graded, medium to fine grained, brown, with a trace of silt. The sand is expected to be uniform throughout the deposit as indicated by other drill holes in sand dunes in the area.

VOLUME

Several deep test holes (20-100 feet) from previous geotechnical investigations in the dunes have recorded thick, poorly graded sand. Large volumes of sand are therefore present. For the purpose of a volume calculation only the areas outlined on the airphoto were included. Assuming an average dune height of 100 feet and a triangular cross section over a deposit area of 475 acres, a total volume of 38.3 million cubic yards was calculated.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B2 is a source of poor quality granular material suitable for general fill.

Access to the deposit may be achieved via the CNT line or via the pipeline right of way which crosses the deposit. The proposed Mackenzie Highway also passes through the dunes. The southeastern dune ridge (B-28) has been delineated as a possible highway borrow source.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Terrain adjacent to the dunes is thermally sensitive and care will be taken during development to prevent degradation.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation. Development would consist of vertical side slope excavations or of removing material evenly from the top of the dunes. The excavated material may have to be stockpiled, and thawed before use. Conventional techniques and standard equipment including rippers would be adequate to develop this deposit.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SP		SAND - fine, trace organics, dry, loose, light red-brown		UF							0	2'' organic cover
2								B1	X			2	
3	SP		SAND - fine, dry, loose, light grey-brown				MA -3'' material G = 0.0% S = 96.8% F = 3.2%					3	
4								B2	X			4	
5												5	
6			6.0 Bottom of pit									6	

LOGGED BY: K.J.H.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	64°43'13''N, 124°55'02''W	ELEVATION:		
DRWN. BY: R.J.S.	AIRPHOTO No.:	A 22933-21	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96C-B2-1
CHKD:	RIG:		AIR TEMP.: Approx. 25°C	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 06 M 09 Y 75 TIME: -	FINISH: D 06 M 09 Y 75 TIME: -				

TEST HOLE No. N75-96C-B2-1

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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SP		SAND - fine, trace organics, dry, loose light red-brown		UF	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	MA -3" material G = 0% S = 96% F = 4%	B1				2	3" organic cover mosses, grasses, wild rose seedlings
3	SP		SAND - fine, dry, loose, light brown					B2				4	
6			6.0 Bottom of pit									6	

LOGGED BY: K.J.H.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 64°43'44"N, 124°55'19"W		ELEVATION:		N75-96C-B2-2
DRWN. BY: R.J.S.	AIRPHOTO No.: A 22933-21		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG:		AIR TEMP.: Approx. 25°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 06 M 09 Y 75 TIME: -	FINISH: D 06 M 09 Y 75 TIME: -				

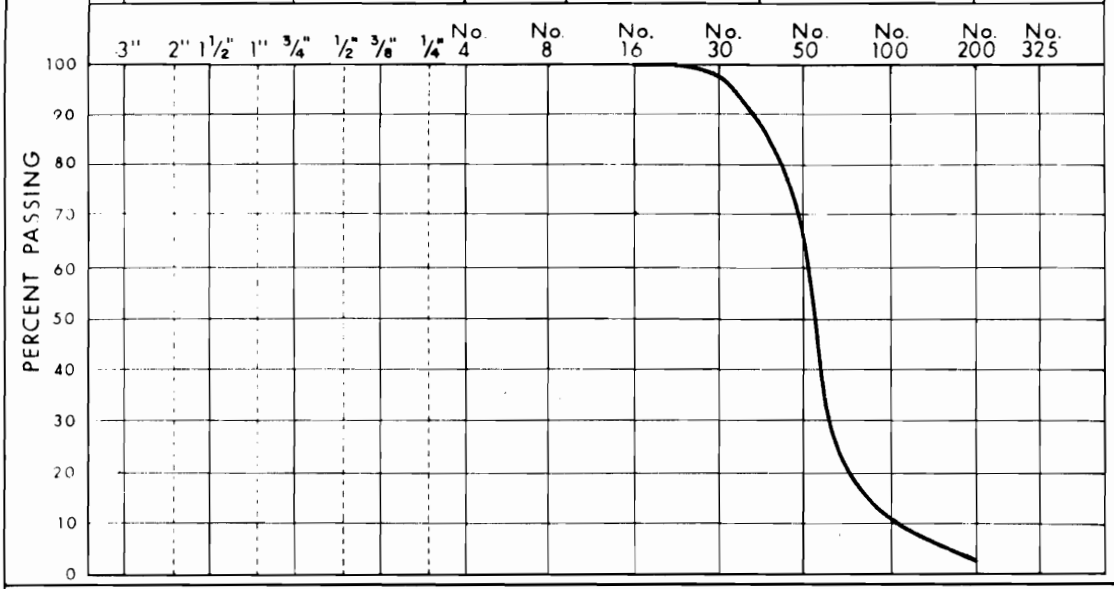
TEST HOLE No. N75-96C-B2-2

PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B2-1 DEPTH 2.0-3.0 & 4.0-5.0
DATE SAMPLED September 6, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 198

GRAVEL SIZES		SAND SIZES			FINES
0%	0%	0 %	18 %	79 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



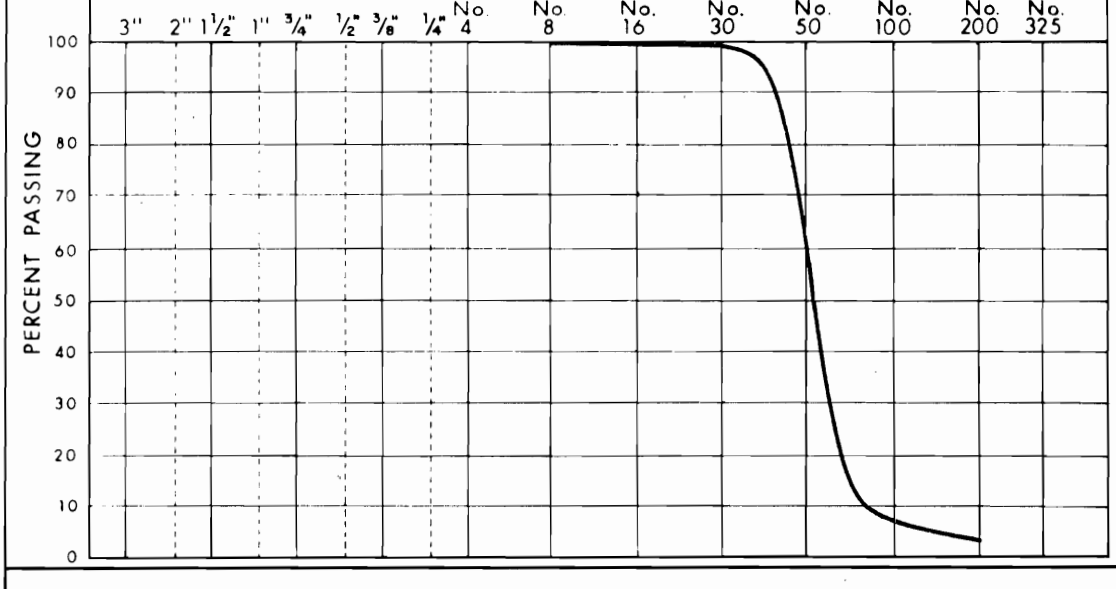
SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	100.0
No. 30	98.7
No. 50	65.2
No 100	11.6
No. 200	3.2

COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-96C-B2-2 DEPTH 2.0-4.0
DATE SAMPLED September 6, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 197

GRAVEL SIZES		SAND SIZES			FINES
0%	0 %	0%	19 %	77 %	4%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	100.0
No. 16	99.9
No. 30	99.7
No. 50	61.4
No. 100	7.8
No. 200	3.9

COMMENTS

OVERSIZE (>3") = 0.0 %

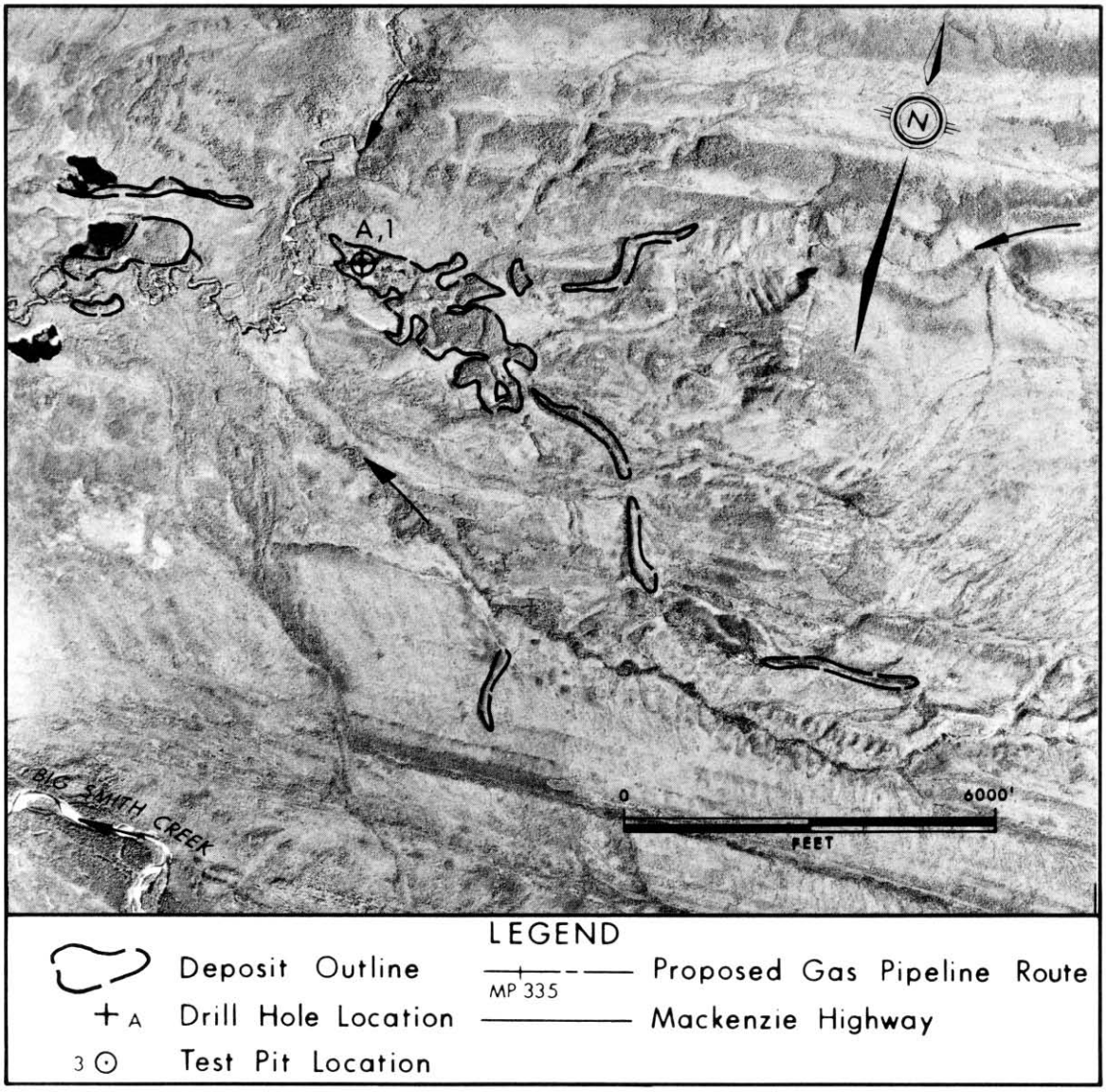
DEPOSIT 96C-B3

Physical Setting : Deposit 96C-B3 is a glaciofluvial complex located 2 miles north of Big Smith Creek and 9 miles east of the Mackenzie River.

Material : SAND - poorly graded, fine to medium, some gravel, trace fines. Gravel pockets expected.

Volume : 6,600,000 cubic yards.

Assessment : Deposit 96C-B3 is a source of fair quality granular material suitable for general fill, backfill or sub-base use. Haul distance is 8 miles. Further work is needed.



Airphoto No. A22422-22
Approximate Scale: 1" = 2950'

Latitude: 64° 43' N.
Longitude: 124° 34' W.

DEPOSIT 96C-B3

PHYSICAL SETTING

Deposit 96C-B3 is a glaciofluvial complex located about 9 miles east of the Mackenzie River and 2 miles north of Big Smith Creek. The proposed gas pipeline is approximately 8 miles west of the deposit and an old winter road leading to the Mackenzie River is a half mile to the south.

This glaciofluvial complex consists of discontinuous eskers and two kames. Meltwater channels are present near the eskers. The eskers are up to 100 feet high and have fairly steep sideslopes.

The deposit is well drained and the test pit and drill hole indicate that the top 7 feet of the deposit is unfrozen.

BIOLOGICAL SETTING

This scattered site is vegetated by a mixed white spruce-aspen forest on well drained areas with stunted black spruce on surrounding low-lying terrain. The area provides poor winter moose habitat. Bear tracks and spruce grouse were observed in the 1975 survey. No fish were observed in the creek which crosses the site.

MATERIAL

The portion of the deposit investigated was primarily poorly graded, fine to medium, light gray to light brown sand, with some angular to subangular gravel and a trace fines. Pockets or layers of well graded gravel are expected within the deposit.

VOLUME

Using an area of 164 acres and an estimated average thickness of 50 feet and triangular cross section, a total volume of 6.6 million cubic yards was calculated.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B3 is a source of fair quality granular material suitable for general fill, backfill or sub-base use. The 8 mile haul distance and the high sand content make this deposit not that attractive for providing quality granular to the pipeline. Further work is needed to determine if more gravel layers are present within the sands of this deposit.

Access may be achieved via the winter road with a snow road extension. The terrain between the pipeline and the deposit is flat, poorly drained and thermally sensitive. Care should be taken to avoid disturbing minor stream crossings.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially, vegetative cover would be removed in accordance with existing land use regulations. Any peat and/or overburden would then be stripped and stockpiled nearby for future replacement. Development of this deposit would involve excavating borrow material evenly from the higher well drained areas down to the apparent base of the esker-kame complex. This could be accomplished using conventional techniques and standard earthmoving equipment along with ripping to break up the frost layer.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the

abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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
2	GW		GRAVEL, coarse, well graded, light brown, pebbles subangular, 1" – 2" very dry.		UF								4¼" Walmac
4			4.0									4	
	SW		SAND, little coarse to fine gravel, well graded, light brown, pebbles to 1"										hole caving very dusty when cuttings returned up the hole.
6			6.5 End of hole									6	6.5 – loss of circulation due to caving of hole.

LOGGED BY:	D.A.O	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	J.K.W.	LAT. & LONG:	64°43'00"N, 124°33'41"W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 23422-22	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA
CHKD:		RIG:	HELI-DRILL	AIR TEMP.: Approx. 18°C	ENGINEERS FOR
		METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START:	D 06 M 09 Y 75 TIME: 16:35	FINISH:	D 06 M 09 Y 75 TIME: 16:55		

TEST HOLE No. N75-96C-B3-A

TEST HOLE No. N75-96C-B3-A

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
0	GW	GRAVEL - coarse to fine, angular to sub-angular, light brown, rootlets		UF
1.4	SP	SAND - poorly graded, layered, grey, rootlets, oxidized layer at 1.9'		
2.0	SW	SAND - well-graded, occasional gravel sizes, layered, grey, pebbles sub-angular to angular, rootlets		
3.7	SP	SAND - fine, light grey, layered, rootlets		
4.1	SW	SAND - well graded, light brown, layered, oxidized layer at 5.0'		
5.0	SP	SAND - fine, light brown, layered		
7.0		Bottom of pit		

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

MA, combined samples 1 - 6
G = 11%
S = 81%
F = 8%
(SP-SM)

SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)
B1				1
B2				2
B3				3
B4				4
B5				5
B6				6
				7

REMARKS

stratum dipping approx. 5 - 10° to slope of hill

Combined samples from 1.0' to 7.0'
"SAND, fine to medium, little gravel, trace fines"

LOGGED BY: D.A.O.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 64° 43' 00" N, 124° 33' 41" W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 23422-22	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 18°C	
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 06 M 09 Y 75 TIME: -	FINISH: D 06 M 09 Y 75 TIME: -		

TEST HOLE No. N75-96C-B3-1

SHEET 1 OF 1

TEST HOLE No. N75-96C-B3-1

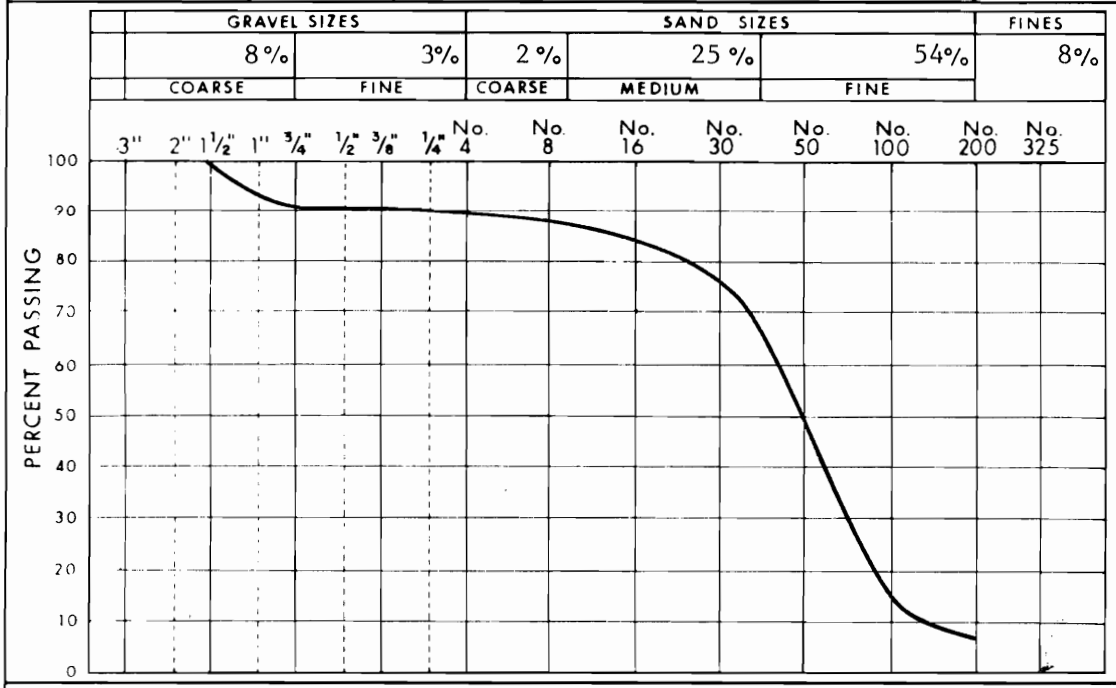
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B3-1 DEPTH 1.0-7.0

DATE SAMPLED ~~September 6, 1975~~ SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 184



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	93.4
¾"	91.7
½"	91.7
⅜"	90.5
¼"	
No. 4	88.9
No. 8	87.2
No. 16	84.3
No. 30	76.7
No. 50	49.9
No. 100	15.4
No. 200	7.4

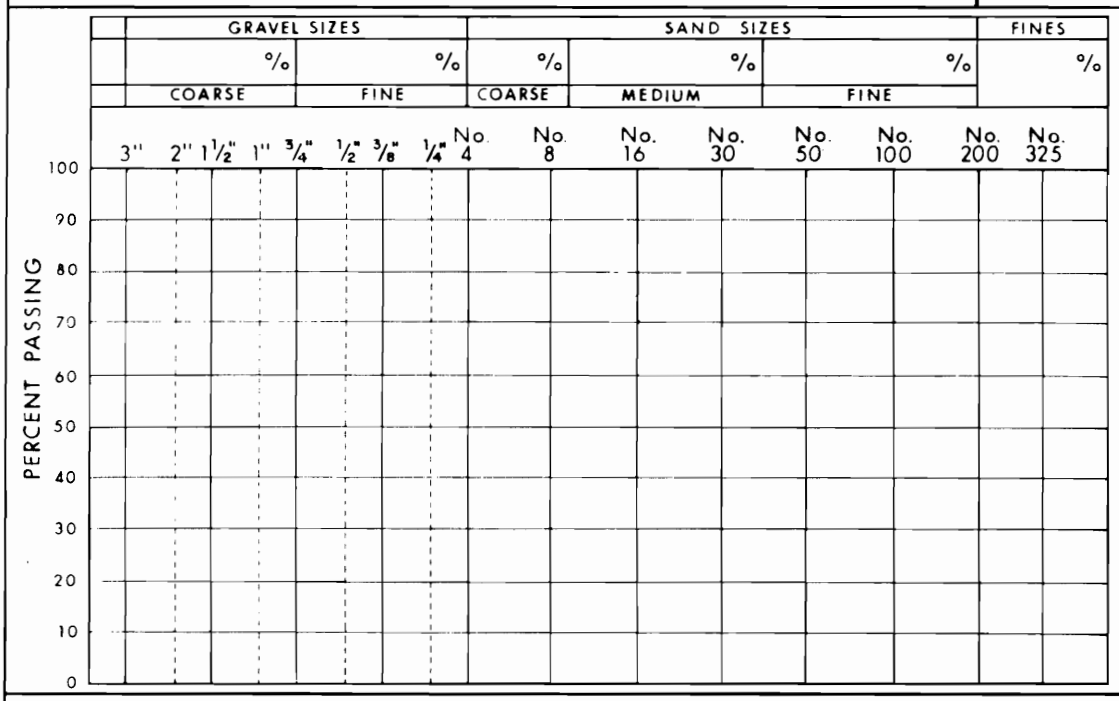
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER



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

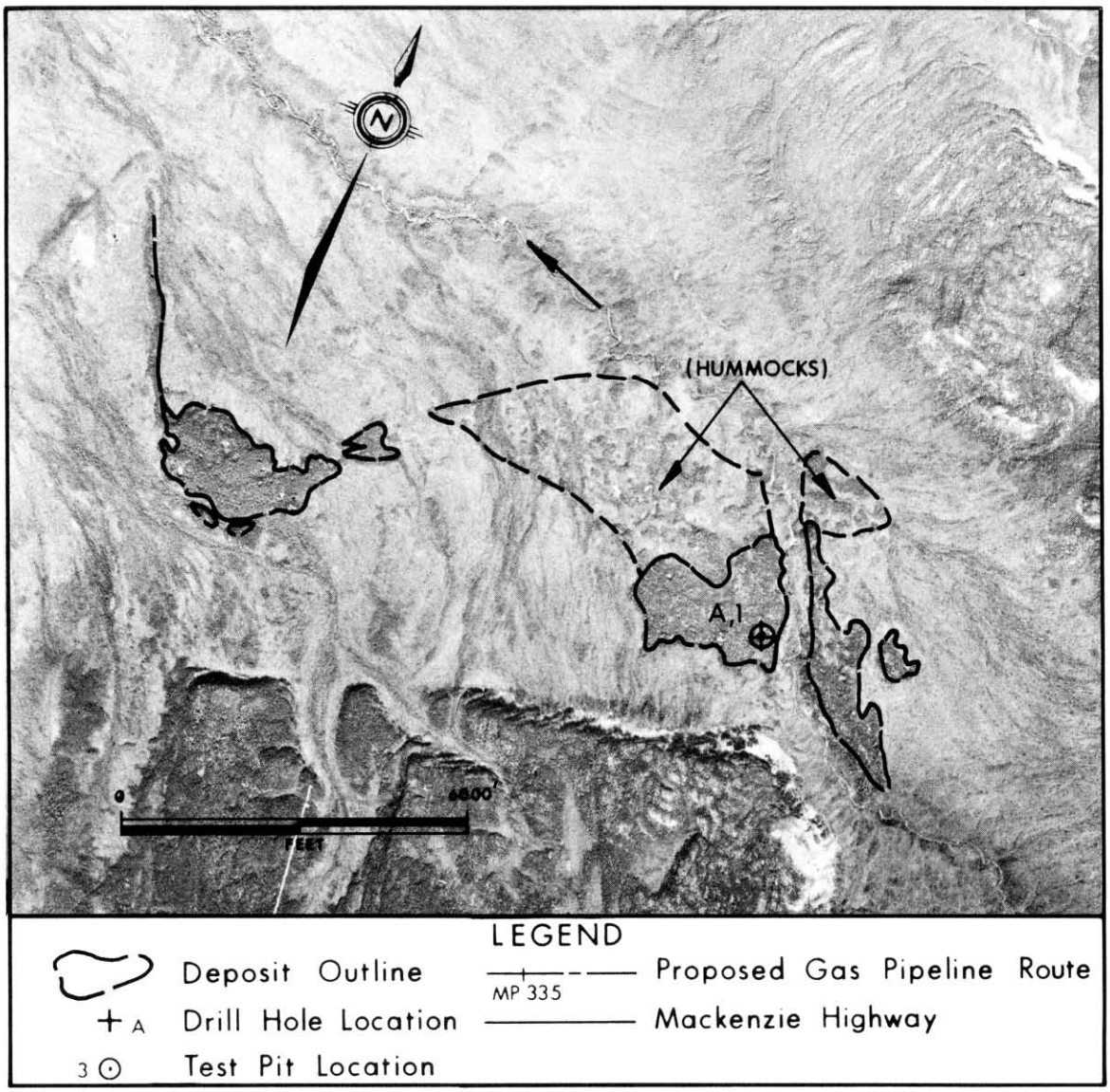
DEPOSIT No. N75-96C-B3

Physical Setting : Deposit 96C-B4 is a glaciofluvial complex on the west side of the McConnell Range about 10 miles southeast of Old Fort Point.

Material : SAND and GRAVEL - interbedded fine sand with a trace gravel and well graded gravel with sand.

Volume : 3,600,000 cubic yards.

Assessment : Deposit 96C-B4 is a source of good quality granular material suitable for general fill, embankment fill, building pads and possibly concrete and asphalt aggregate subject to further testing.



Airphoto No. A22886-9
Approximate Scale: 1" = 3150'

Latitude: 64° 35' N.
Longitude: 124° 39' W.

PHYSICAL SETTING

Deposit 96C-B4 is a glaciofluvial complex on the west side of the McConnell Range about 10 miles southeast of Old Fort Point near tributaries to Big Smith Creek. The pipeline right of way is 1½ miles west of the deposit. The western portion of this deposit corresponds to source numbers 242 and 236 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The deposit consists of a kame, esker, and terraces which overlie till and shallow bedrock. Small hummocks adjacent to the terraces are also part of the glaciofluvial complex but have not been included as part of the deposit because they contain only a limited amount of granular material.

The kame, esker, and terraces are well drained and have ½ to 2 feet of silt over the sand and gravel. A few small wet depressions exist on these outwash features. The test pit and drill hole indicates the sands and gravels in this deposit are unfrozen.

BIOLOGICAL SETTING

Dominant vegetation consists of dense black spruce forest with white birch and a thick moss ground cover. Stream channels support shrubs and alder along the banks. The area is not used as moose winter habitat. Raptor nests may be located near the site. The fisheries potential of the area is not known.

MATERIAL

The deposit contains interbedded sand and gravel. The sand is fine grained with a trace of gravel. The gravel is well graded, gray to brown, with sand and cobbles.

VOLUME

This volume calculation includes the kame, the terraces, and the eskers of this glaciofluvial complex. Assuming a 9 foot depth of material over 248 acres, the total volume of materials is 3.6 million cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B4 is a source of good quality granular material suitable for general fill, embankment fill in berm construction, building pads and possibly concrete and asphalt aggregate. Further testing is required before its use in concrete or asphalt. Location of areas to be exploited will be dictated by haul distances, insitu material quality, material requirements and environmental concerns.

A buffer zone should be maintained between areas of development and the tributary stream which flows through the area.

Access is possible via the pipeline right of way then over a 1½ to 3 mile snow road to the deposit. Terrain to be crossed consists of gently sloping till plain and slopewash deposits.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, would then be stripped and stockpiled around the edges of the excavation. Development would involve removing material evenly from the higher areas to a level which would maintain adequate drainage. This could be accomplished using conventional techniques and standard equipment including rippers.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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 – light brown, damp fibrous odourous		UF								
	ML		SILT – trace fine sand non plastic light yellow brown, dry										
2			2.0										
	SP		SAND – fine, trace fine gravel, dry, loose, light brown										
4													
6													
8													
10													
12													
14													
16													

LOGGED BY: K.J.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 64°34'43"N, 124°39'19"W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 22888-9	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 25°C	TEST HOLE No. N75-96C-B4-A
	METHOD: AIR		SHEET 1 OF 2
START: D 06 M 09 Y 75 TIME: 18:50	FINISH: D 06 M 09 Y 75 TIME: 19:30		

TEST HOLE No. N75-96C-B4-A

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SP	SAND (cont'd)		UF								Drill clattering and vibrating
		17.0										
18	GP	GRAVEL									18	Changing to 3 7/8" Tricone
		18.5										
20	SP	SAND – fine, trace fine gravel, dry, loose, light brown										
22												
		23.0									23	Drill clattering and vibrating.
24	GP	GRAVEL										
26												
		28.0 End of hole									28	
28												

LOGGED BY: K.J.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	64°34'43"N, 124°39'19"W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.:	A 22866-9	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96C-B4-A
CHKD:	RIG:	HELI-DRILL	AIR TEMP.: Approx. 25°C	ENGINEERS FOR	
	METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2
START: D 06 M 09 Y 75 TIME: 18:50	FINISH: D 08 M 09 Y 75 TIME: 19:30				

TEST HOLE No. N75-96C-B4-A

147

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	SP		SAND - fine, trace silt, medium brown, moss cover		UF							0.5	
0.5	GW		GRAVEL - coarse to fine, some mfc sand, grey to brown, cobbles 3"-6" from 1.0 to 3.0, organic silt pocket to 2" at 1.6', clay pocket 2" at 1.6', damp.				MA, combined, samples 1 - 5 G = 65% S = 32% F = 3%	B1				1.5	
1.6								B2				2.5	
3.0			no cobbles below 3.0'					B3				3.5	
								B4				4.5	
5.4			Bottom of pit					B5				5.4	

LOGGED BY: D.A.D.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	64°34'43"N, 124°39'19"W	ELEVATION:		
DRWN. BY: R.J.S.	AIRPHOTO No.:	A 22886-9	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-96C-B4-1
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 16°C	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 06 M 09 Y 75 TIME: 17:00	FINISH: D 06 M 09 Y 75 TIME: 19:00				

TEST HOLE No. N75-96C-B4-1

PC-9,SK373

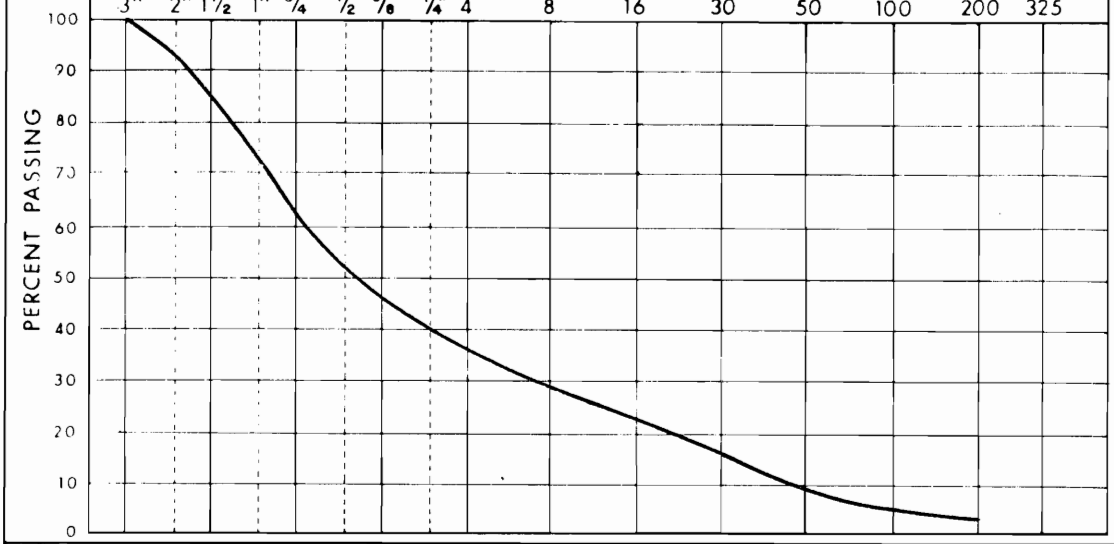
SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B4-1 DEPTH 0.5-5.4

DATE SAMPLED September 6, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 188

GRAVEL SIZES		SAND SIZES			FINES
36%	29 %	7%	15%	10 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.4
1½"	85.5
1"	71.8
¾"	63.8
½"	52.9
⅜"	46.6
¼"	
No. 4	35.4
No. 8	29.0
No. 16	23.6
No. 30	17.4
No. 50	9.2
No. 100	4.9
No. 200	3.4

COMMENTS

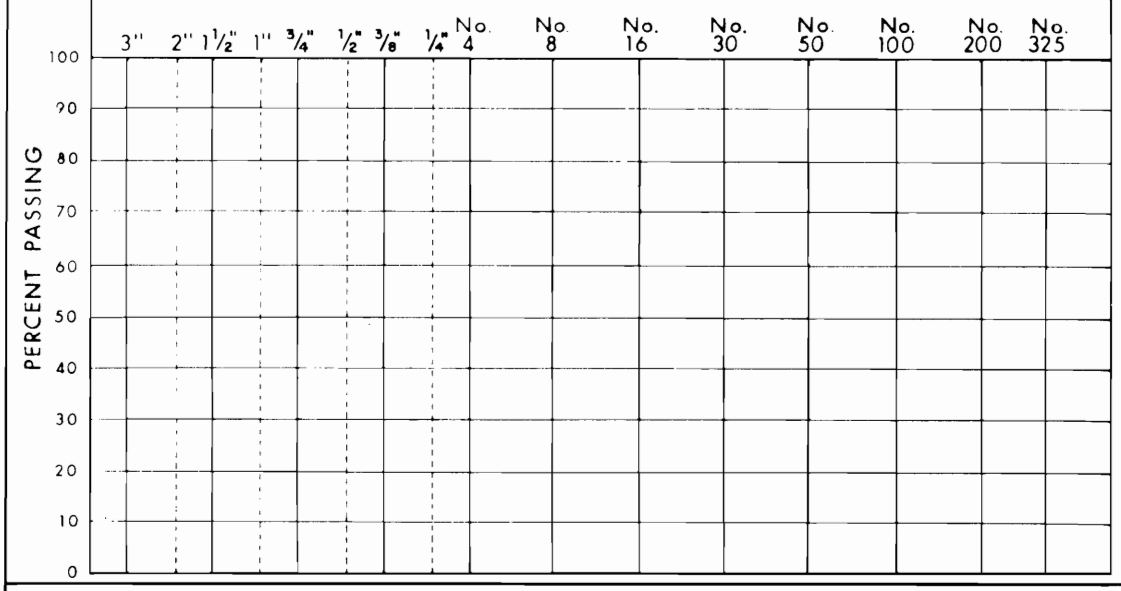
OVERSIZE (>3") = 0.0 %

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") = %

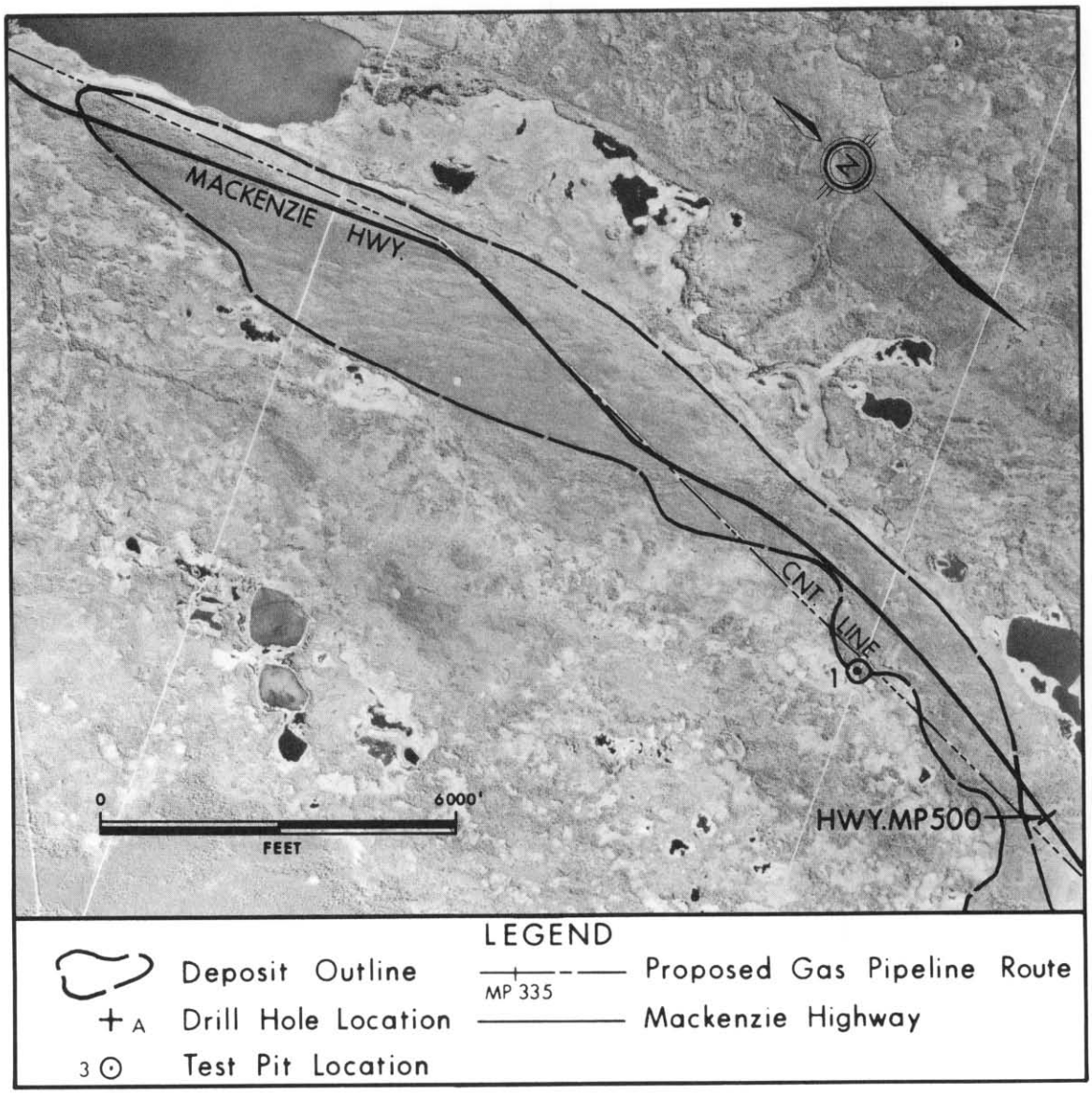
DEPOSIT 96C-B5

Physical Setting: Deposit 96C-B5 is an outwash plain located 7 miles north of Blackwater River. The proposed pipeline at M.P. 496 is 4 miles to the east.

Material: SAND and GRAVEL - poorly to well graded, stratified.

Volume: 25,700,000 cubic yards.

Assessment: Deposit 96C-B5 is a source of good quality granular material suitable for general fill, embankment fill, building pads and possibly concrete and asphalt aggregate subject to further testing.



Airphoto No. A22887-18
Approximate Scale: 1" = 3050'

Latitude: 64° 05' N.
Longitude: 124° 09' W.

DEPOSIT 96C-B5

PHYSICAL SETTING

Deposit 96C-B5 is a glaciofluvial outwash plain located about 7 miles north of Blackwater River. The proposed Mackenzie Highway crosses the site and mile 496 of the proposed gas pipeline is 4 miles to the east. This deposit has previously been investigated by DPW and Pemcan Services and corresponds to source number 197 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The deposit is about 5 miles long and up to 3000 feet wide. Its eastern boundary is marked by a meltwater channel and the western side is bounded by a glaciolacustrine plain which exhibits thermokarst features. Both the surface of the deposit and the surrounding terrain are flat.

Overburden is less than 1 foot over most of the deposit and drainage is good. Test holes done during the various investigations of this deposit seem to indicate that it is mostly unfrozen, or frozen with low ice content. Terrain between the pipeline right of way and the deposit has high ice content glaciolacustrine sediments.

BIOLOGICAL SETTING

A mixed pine-aspen forest covers this extensive site. The area is poor moose winter habitat. Moose droppings were observed during the 1975 survey. The area is used by black bear, snowshoe hare and red squirrel. A small shallow lake adjacent to the site provides limited waterfowl habitat. No suitable fish habitat was identified near the site.

MATERIAL

This deposit has good quality granular material. The sand and gravel is stratified. The sand is medium to coarse, and poorly to well graded.

The gravel is subrounded, fine to coarse, and composed of granitic rock, quartzite, limestone and dolomite with minor amounts of chert and mudstone.

VOLUME

Assuming an average depth of 15 feet and an area of 1064 acres, a total volume of 25.7 million cubic yards of material is calculated to be in this deposit.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B5 is a source of good quality granular material suitable for general fill, embankment fill in berm construction, building pads and possible concrete and asphalt aggregate. The gravel will require further testing before being used for concrete.

Access to the pipeline could be obtained via the CNT line, the Mackenzie Highway right of way and various seismic lines. The terrain between the deposit and pipeline is poorly drained and has high ice content soils. Winter development of this site would be best as snow roads could be used across this high ice content terrain.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A vegetated buffer zone should be maintained for aesthetic reasons between the highway and pits.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Since the deposit is flat lying, a dugout excavation would probably be used for borrow extraction. Conventional earthmoving techniques and equipment should be adequate as the overall ice content in the deposit during summer months was low to nonexistent.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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		0.2 PEAT		UF								White spruce, dense to 25' Grasses, rose, alder to 9'
	ML		0.5 SILT - trace fine sand, fibrous, rust brown										
1	GW		1.0 GRAVEL - well graded, subrounded to 2''									1	
	SW		SAND - coarse to medium, some gravel, subrounded to 2½'', average size 1½''				MA, combined, samples 1 - 6 G = 32% S = 66% F = 2% (SW)	B1					
2	SM		2.2 SAND - fine, silty, rust brown					B2				2	Combined samples from 1.0' to 7.0' = ''SAND, medium grain, some fine to coarse gravel''
	GW		GRAVEL - subrounded to 2'', and sand, medium										
3			3.2					B3				3	
	SP		SAND - medium grain, moist, loose										
4								B4				4	
5			5.3					B5				5	
	SW		SAND - some gravel to 2'', subrounded										
6								B6				6	
7			7.0 Bottom of pit									7	

LOGGED BY: R.H. - J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	64°05'10''N, 124°09'15''W	ELEVATION:		N75-96C-B5-1
DRWN. BY: F.B.B.	AIRPHOTO No.:	A 22887-18	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 08 M 09 Y 75 TIME: 13:00	FINISH: D 08 M 09 Y 75 TIME: 16:00				

TEST HOLE No. N75-96C-B5-1

PC-9,SK373

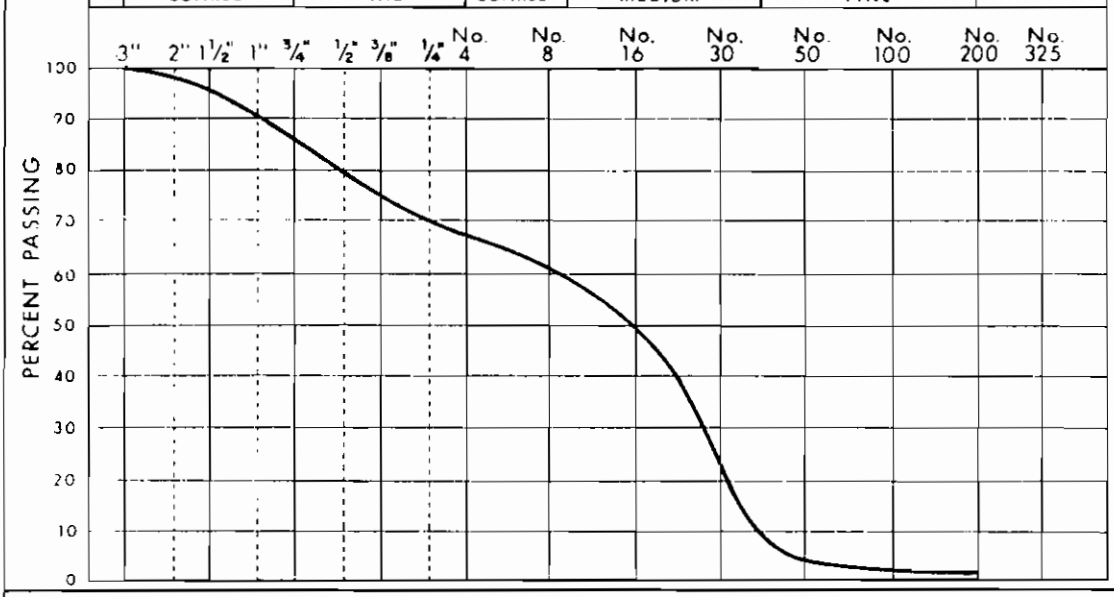
SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B5-1 DEPTH 1.0-7.0

DATE SAMPLED September 8, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 172

GRAVEL SIZES		SAND SIZES			FINES
15 %	17 %	8 %	48 %	10 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	98.8
1½"	95.5
1"	90.2
¾"	85.3
½"	79.5
⅜"	75.2
¼"	
No. 4	67.6
No. 8	61.9
No 16	49.2
No. 30	23.4
No. 50	4.1
No 100	2.6
No. 200	1.9

COMMENTS

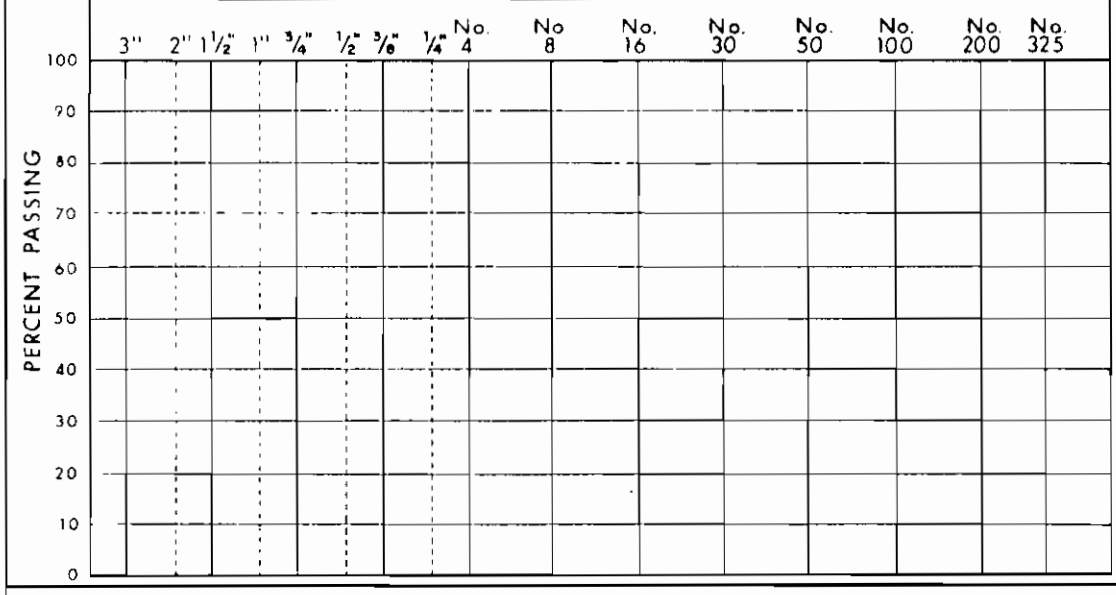
OVERSIZE (>3") = 0.0 %

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") = %

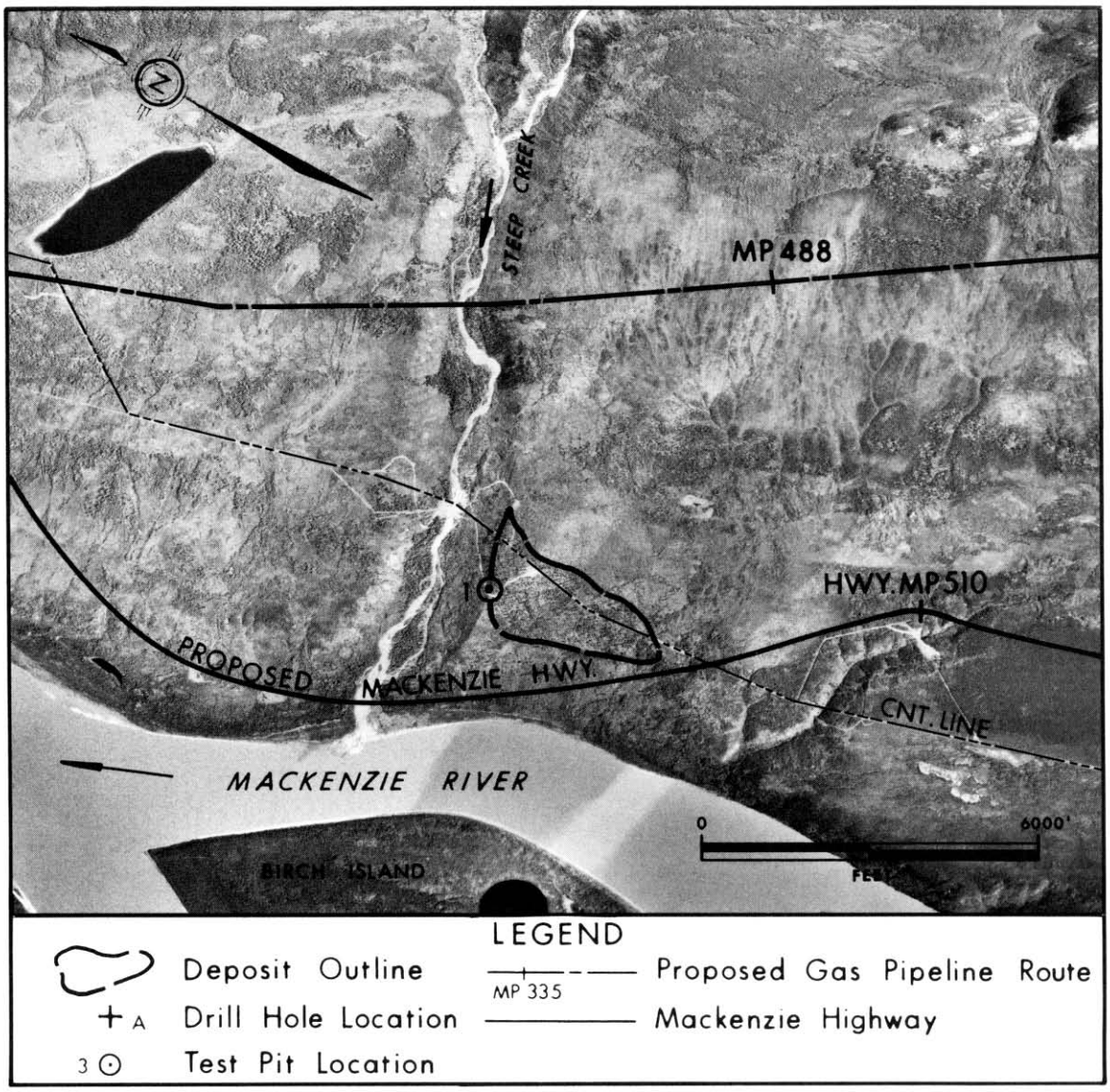
DEPOSIT 96C-B6

Physical Setting: Deposit 96C-B6 is an alluvial terrace located east of Birch Island near the east bank of the Mackenzie River. The proposed pipeline passes one mile to the east.

Material: SAND and GRAVEL - poorly to well graded, silty, stratified.

Volume: 2,300,000 cubic yards.

Assessment: Deposit 96C-B6 is a source of good quality granular material suitable for general fill, embankment fill, building pads and possibly concrete and asphalt aggregate.



Airphoto No. A22966-93
Approximate Scale: 1" = 3250'

Latitude: 64° 11' N.
Longitude: 124° 21' W.

DEPOSIT 96C-B6

PHYSICAL SETTING

Deposit 96C-B6 is an alluvial terrace located east of Birch Island and south of Steep Creek near the east bank of the Mackenzie River. The proposed Mackenzie Highway is near the western edge of the deposit and the proposed pipeline is one mile to the east. This site had previously been investigated by DPW for the Mackenzie highway.

The terrace is flat to sloping and is bounded on the north and west sides by steep banks. The deposit is a small portion of an alluvial terrace which extends for some distance north of the deposit along the east bank of the Mackenzie River. Immediately south and east of 96C-B6 are glaciolacustrine plain silts and clays.

The terrace is free of overburden except for a thin mat of vegetation. Drainage is good, and DPW drill holes indicate that the deposit is unfrozen to depths of 15 feet.

BIOLOGICAL SETTING

A white spruce forest covers this extensive site. Birch Island, adjacent to the site, is good moose winter habitat. The island-river complex is used extensively by migrating waterfowl in April-May. The stream is an important grayling spawning and rearing area and serves as a summer feeding area for grayling, slimy sculpin and lake chub. The stream may also serve as an overwintering area.

MATERIAL

This deposit consists of stratified silty sand and gravel. The sand is light brown, poorly graded, fine to coarse and contains varying amounts of silt. The gravel is well graded, light brown, loose, subround to subangular, fine to coarse with occasional cobbles, and some silt.

VOLUME

A total volume of 2.3 million cubic yards was calculated assuming a deposit thickness of 15 feet over an area of 94 acres.

DEVELOPMENT AND REHABILITATION

Deposit 96C-B6 is a source of good quality granular material suitable for general fill, embankment fill in berm construction, building pads and possibly concrete and asphalt aggregate. Location of areas to be exploited will be dictated by haul distance, insitu material quality, material requirements and environmental concerns.

Access could be achieved via a one mile snow road from the deposit to the pipeline right of way. Gently sloping, well drained, terrain is present between the deposit and the pipeline.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between excavation areas and the Mackenzie River and Steep Creek to protect these bodies of water.

Initially the vegetative cover would be cleared and disposed of according to existing land use regulations. Overburden, if any, would then be stripped and stockpiled around the edge of the excavation. Development of this deposit would involve a dugout pit because the terrace is relatively flat. Conventional earthmoving techniques should be adequate for developing this deposit.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to

prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SM		SAND - fine, silty, little organics, dry, light red-brown		UF		w%					0	2" organic cover
1	GM		GRAVEL - silty, little medium sand, rootlets, fibres, dry, light brown, occasional cobbles, rounded to 4"				4.2	B1				1	
2.0													
2	GW		GRAVEL - coarse to fine, some mcf sand, well graded, dry, loose, sub-rounded, occasional subangular, avg. size app. 2", light brown				1.8	B2				2	
3							4.8	B3				3	
4								B4				4	MA, combined samples 1 - 5 oversize = 4.3% G = 67% S = 30% F = 3%
5.0			occasional cobbles, rounded, to 7"				2.3					5	
5							2.1	B5					
6.0			Bottom of pit									6	
6													

LOGGED BY: R.H. - K.J.H.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 64°11'17"N, 124°21'12"W		ELEVATION:		N75-96C-B6-1
DRWN. BY: R.J.S.	AIRPHOTO No.: A 22966-93		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 5°C		
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 08 M 09 Y 75 TIME: 15:15	FINISH: D 08 M 09 Y 75 TIME: 15:15				

TEST HOLE No. N75-96C-B6-1

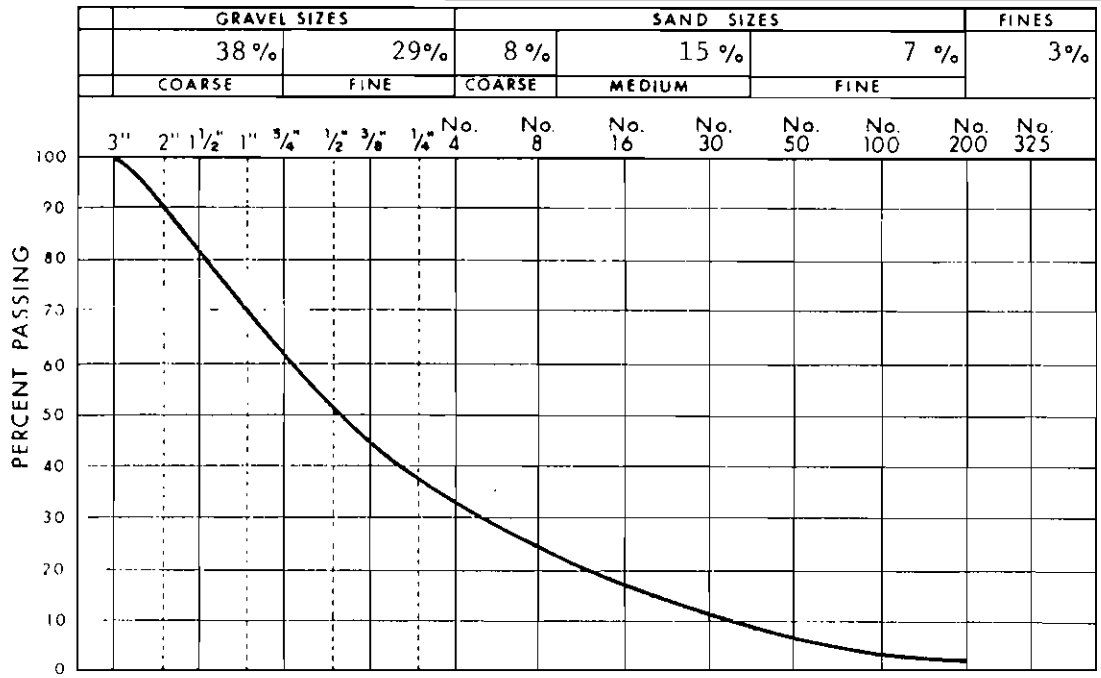
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-96C-B6-1 DEPTH 1.0-6.0

DATE SAMPLED September 8, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 199



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.2
1½"	80.4
1"	71.1
¾"	61.9
½"	51.1
⅜"	44.2
¼"	
No. 4	32.8
No. 8	24.8
No. 16	18.0
No. 30	12.0
No. 50	6.9
No 100	3.7
No. 200	2.7

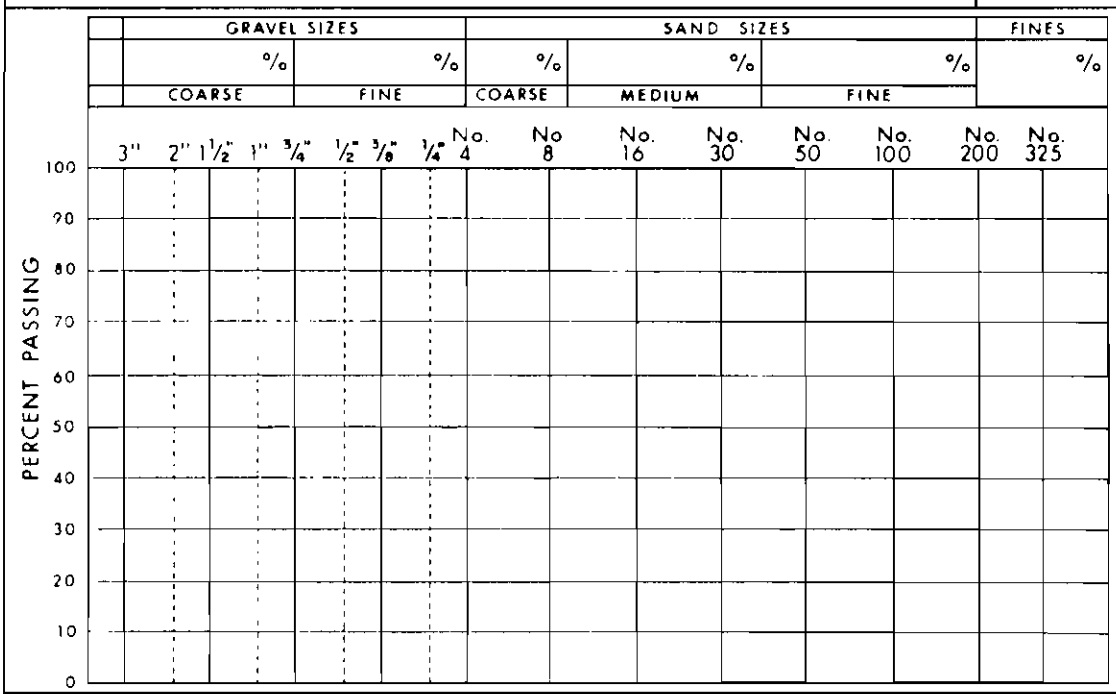
COMMENTS Moisture contents range from 1.6 to 4.8%

OVERSIZE (>3") = 4.3 %

SAMPLE _____ DEPTH _____

DATE SAMPLED _____ SAMPLED BY _____

R.M.HARDY REPORT NUMBER _____



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

DEPOSIT No. N75-96C-B6

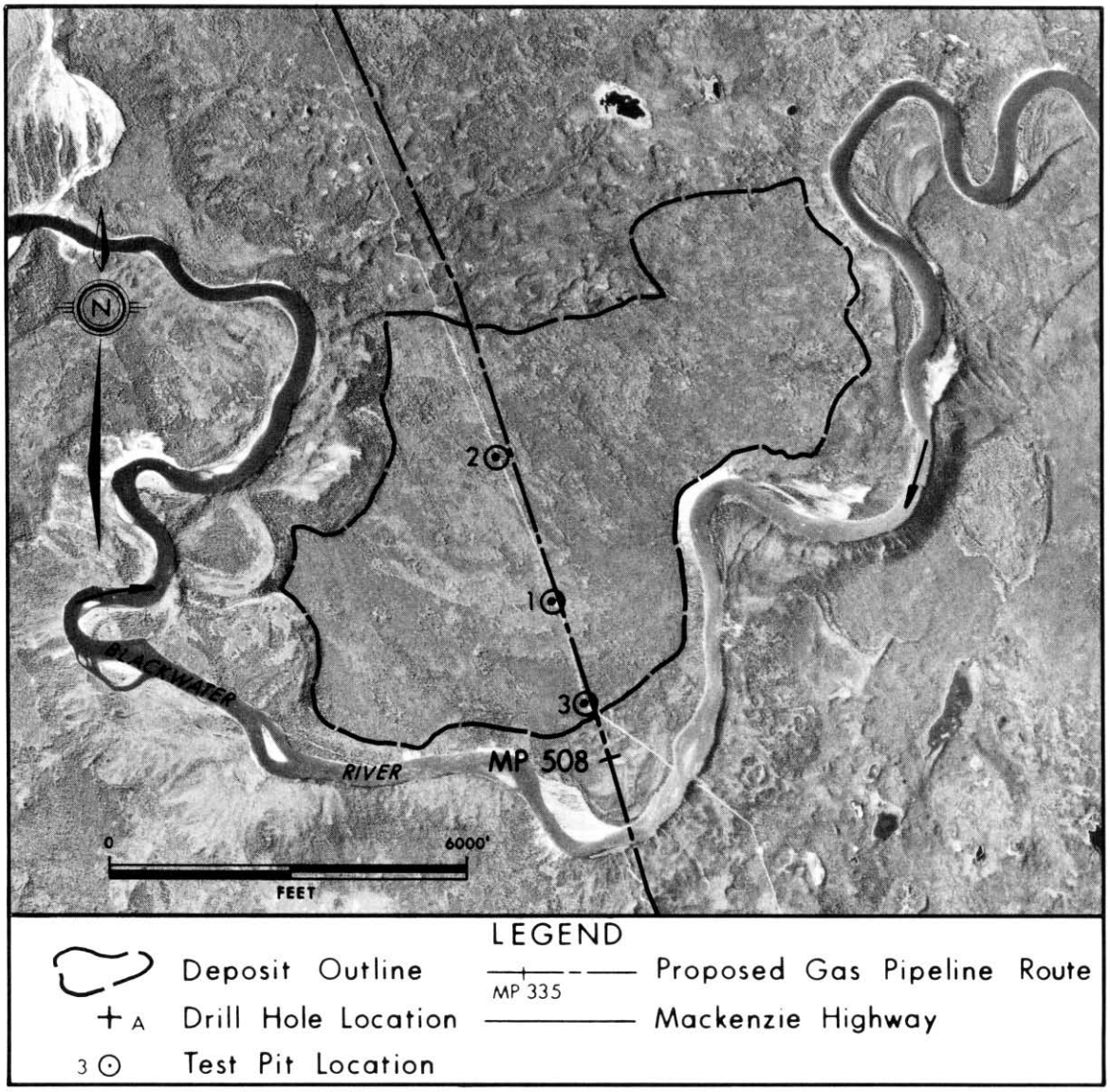
DEPOSIT 95N-B1

Physical Setting: Deposit 95N-B1 is a large outwash plain located immediately north of Blackwater River at the pipeline crossing.

Material: GRAVEL and SAND - well graded gravel, fine to coarse, cobbly, matrix of sand; poorly graded sand, fine to medium.

Volume: 29,000,000 cubic yards.

Assessment: Deposit 95N-B1 is a source of good to excellent quality granular material suitable for embankment fill, building pads, and concrete aggregate.



Airphoto No. A22859-35
Approximate Scale: 1" = 3100'

Latitude: 63° 56' N.
Longitude: 124° 03' W.

DEPOSIT 95N-B1

PHYSICAL SETTING

Deposit 95N-B1 is a large outwash plain deposit located immediately north of Blackwater River and 3 miles east of the Mackenzie River. The proposed gas pipeline and an existing cut line cross the deposit. This outwash plain corresponds to source number 191 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The outwash plain is relatively flat and slopes gently to the southwest. It is 2 miles long and 1 mile wide. The east, south, and west sides are bounded by steep banks of the Blackwater River valley and the northern edge by fine grained glaciolacustrine plain deposits.

The river bank sections are rugged with 100 to 150 foot cliffs. One of these sections shows 20 feet of gravel over till.

The deposit is well drained and has 1 foot or less of silt and organic silt over gravel. Test pits indicate that the top 7 feet of the deposit is unfrozen. The deeper gravels and sands are expected to have low to negligible ice contents.

BIOLOGICAL SETTING

The vegetation adjacent to the Blackwater River consists of pine, black spruce, balsam poplar, rose and bog birch, while on top of the hill pine, aspen, white spruce and white birch (60-70 feet in height) and alder occur. The Blackwater River valley provides poor moose winter habitat. The area provides good marten habitat. River cliffs provide suitable raptor habitat. The Blackwater River is a major spawning and rearing area for grayling and slimy sculpin and a summer feeding area for several species including lake chub, longnose sucker, and juvenile grayling. It may also be an overwintering area.

MATERIAL

Well graded gravels and slightly silty sands are abundant at 95N-B1. The sand is fine to medium grained and poorly graded. The gravel is fine to coarse, cobbly, with occasional boulders and a matrix of coarse sand. The gravel and cobbles are subrounded to subangular and may have rust stains or carbonate coatings.

Concrete suitability tests for test pit #2 show an excellent quality aggregate.

VOLUME

Assuming 15 feet of material over an area of 1200 acres, 29 million cubic yards of borrow material is estimated for this deposit.

DEVELOPMENT AND REHABILITATION

Deposit 95N-B1 is a source of good to excellent quality granular material suitable for embankment fill, building pads and concrete aggregate. Location of areas to be exploited will be dictated by haul distance, insitu material quality, material requirements and environmental concerns.

A buffer zone should be maintained between excavation areas and the Blackwater River, including its steep banks, to protect fish resources and maintain bank stability.

This deposit is crossed by the proposed pipeline right of way and access along the right of way would be easy. However, any hauling of material south along the pipeline route will involve crossing the Blackwater River and negotating fairly steep banks.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations

will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially vegetation would be disposed of in accordance with existing land use regulations. Overburden would then be stockpiled around the edge of the site. Excavation would take the form of a dugout pit and may be achieved with conventional earthmoving techniques and standard equipment. In winter, blasting and or ripping may be required to break the frost layer. Stockpiling may also be needed to thaw the material before use. Good to excellent concrete aggregate may be obtained by crushing, screening and washing.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
0	SP-SM	SAND - fine to medium grained, some coarse to fine gravel, trace silt, fibrous		UF
1.0				
1	GP	GRAVEL - fine, some coarse to medium sand, occasional cobbles, dry, white cementation on gravel		
3.0				
3	SP	SAND - medium to coarse, little fine to coarse gravel, clean, slightly layered 0^0-30^0 from horizontal, loose, intrusion of roots, pockets of dark brown silts, 2''-3''		
4.0				
4	SP-SM	SAND - little fine gravel, occasional layers of silty sand, trace organics		
7.0		Bottom of pit		
7				

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

MA, combined samples 1 - 6
G = 12%
S = 86%
F = 2%

SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)
B1				1
B2				2
B3				3
B4				4
B5				5
B6				6
				7

REMARKS

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: $63^0$56'04''N, $124^0$02'53''W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No. A 22859-35	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 5^0C	ENGINEERS FOR
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 09 M 09 Y 75 TIME: 12:00	FINISH: D 09 M 09 Y 75 TIME: 12:45		

TEST HOLE No. N75-95N-B1-1

SHEET 1 OF 1

PC-9,SK373

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TEST HOLE No. N75-95N-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
0	OL		SILT- (organic) trace fine sand, trace fine gravel, fibrous, light brown, dry.		UF							0	
			0.75										
1	GW		GRAVEL - coarse to fine, some medium, fine, coarse sand, cobbles, boulders, subrounded, 12"x8"x8", roots, cementation on gravel.				MA, combined samples 1-5 Oversize = 16.9%	B1				1	
2							-3" material; G = 68% S = 29% F = 3% (GW)	B2				2	
3								B3				3	
4								B4				4	
5								B5				5	
6			6.0 Bottom of pit.									6	

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 63°56'33"N. 124°03'15" W	ELEVATION:			
DRWN. BY: D.J.M.	AIRPHOTO No.: A 22859-35	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95N-B1-2	
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 5°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 09 M 09 Y 75 TIME: 12:00	FINISH: D 09 M 09 Y 75 TIME: 13:00				

TEST HOLE No. N75-95N-B1-2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION
0	SM	0.25 SAND - little silt, light reddish brown, fine-grained, fibrous
1	SP-SM	SAND - fine, trace silt, light brown, moist
2	* ML	2.0 SILT - and fine sand, grey-black inclusions
3	**	3.0 GRAVEL - coarse to fine, some sand, dark brown, damp, cobbles, boulders, (12'' x 8'' x 12'') subrounded, subangular, slight oxidation, possible pyrite
4		
5		5.0 Bottom of pit

** NOTE;
Total material:
Gravel = 69%
Sand = 20%
Fines = 11%
-3'' material, ''sand, fine to coarse, and coarse to fine gravel, some fines (silt)'' (SM)

ICE GRAPHIC LOG | NRC ICE TYPE VISUAL ICE %: UF

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:
MA, sample B1
G = 0%
S = 43%
F = 57%

MA, samples 2 & 3
oversize = 50.9%
-3'' material:
G = 37%
S = 41%
F = 22%
(SM)

SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
B1				2	* borderline silt/sand (SM-ML)
B2				3	
B3				4	
				5	

LOGGED BY: R.S.I.-J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 63°56'45''N, 124°03'22''W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 22859-35	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 5°C	
	METHOD: TEST PIT		
START: D 09 M 09 Y 75 TIME: 17:00	FINISH: D 09 M 09 Y 75 TIME: 19:00		

TEST HOLE No. N75-95N-B1-3

SHEET 1 OF 1

PC-9,SK373

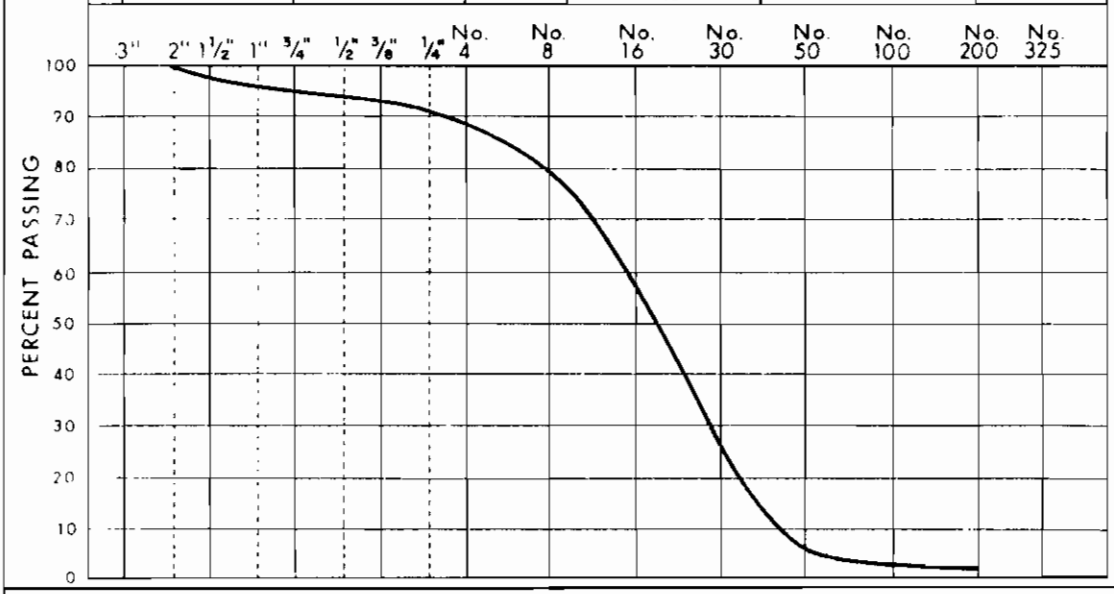
SIEVE ANALYSIS REPORT

SAMPLE N75-95N-B1-1 DEPTH 1.0-7.0

DATE SAMPLED September 9, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 230

GRAVEL SIZES		SAND SIZES			FINES
5 %	7 %	16 %	56 %	14 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	98.1
1"	96.2
¾"	95.2
½"	94.1
⅜"	92.9
¼"	
No. 4	88.0
No. 8	78.9
No. 16	58.0
No. 30	26.2
No 50	6.3
No. 100	2.7
No. 200	2.1

COMMENTS

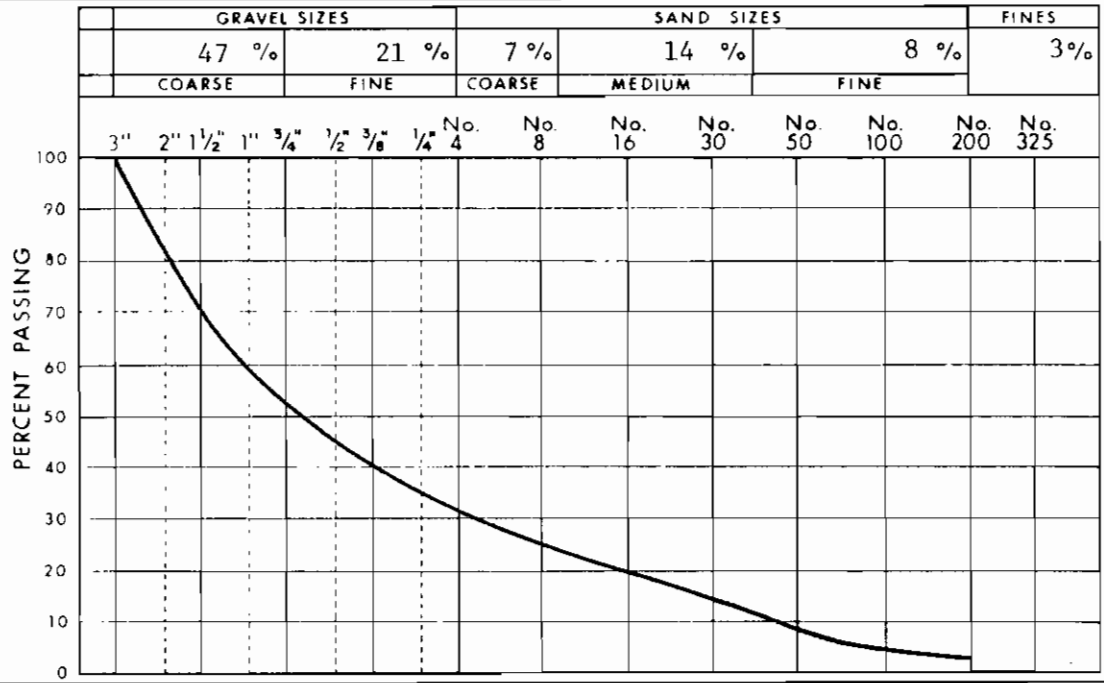
OVERSIZE (>3") = 0.0%

SAMPLE N75-95N-B1-2 DEPTH 1.0-6.0

DATE SAMPLED September 9, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 190

GRAVEL SIZES		SAND SIZES			FINES
47 %	21 %	7 %	14 %	8 %	3%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	83.1
1½"	71.1
1"	59.4
¾"	53.1
½"	46.6
⅜"	41.3
¼"	
No. 4	32.0
No. 8	26.0
No. 16	20.3
No. 30	14.9
No. 50	7.6
No. 100	4.6
No. 200	3.0

COMMENTS

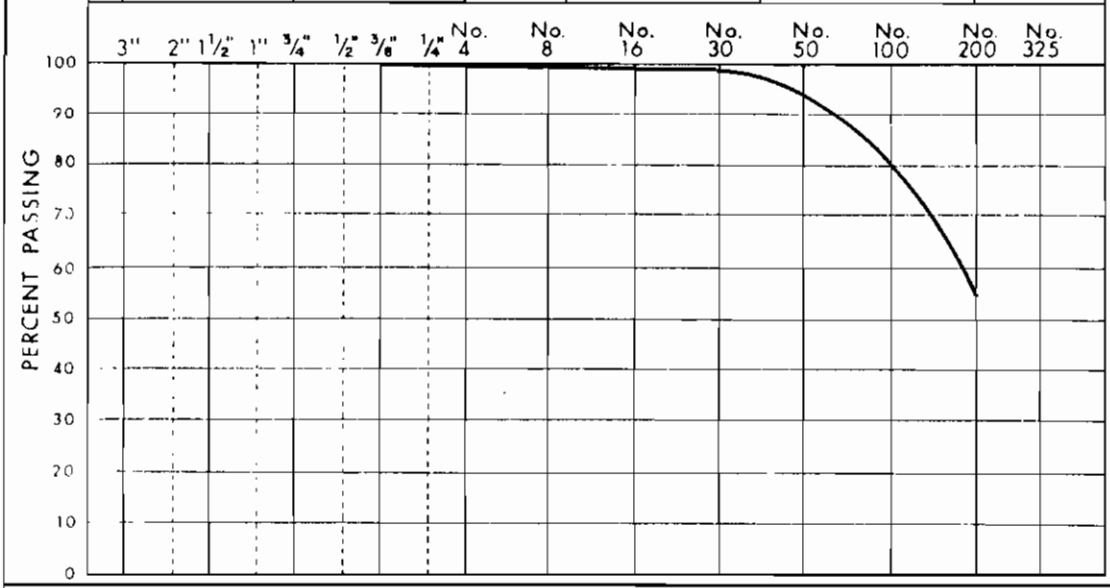
OVERSIZE (>3") = 16.9%

SIEVE ANALYSIS REPORT

SAMPLE N75-95N-B1-3 DEPTH 2.0-3.0
DATE SAMPLED September 9, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 176

GRAVEL SIZES		SAND SIZES			FINES
0 %	0%	0 %	3 %	40 %	57 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	99.9
No. 8	99.9
No. 16	99.8
No. 30	99.0
No. 50	94.3
No. 100	79.9
No. 200	56.5

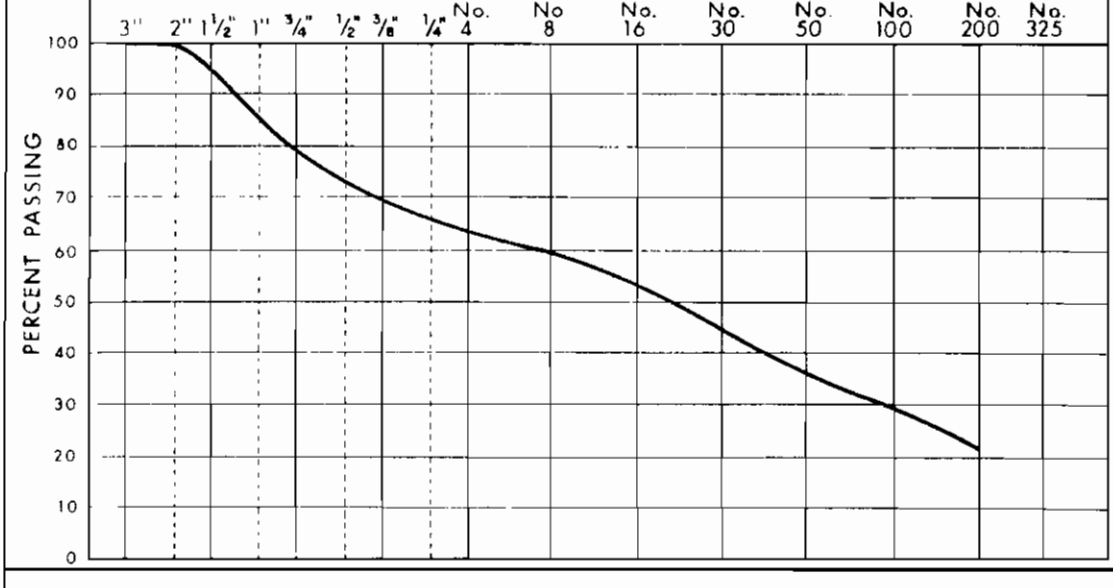
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95N-B1-3 DEPTH 3.0-5.0
DATE SAMPLED September 9, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 177

GRAVEL SIZES		SAND SIZES			FINES
21 %	16%	5 %	16 %	20%	22%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	94.3
1"	84.1
¾"	78.8
½"	72.9
⅜"	68.9
¼"	
No. 4	63.4
No. 8	59.5
No. 16	52.4
No. 30	44.8
No. 50	37.7
No. 100	29.7
No. 200	22.0

COMMENTS

OVERSIZE (>3") = 50.9 %

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-95N-B1-2 DATE SAMPLED : September 9, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-6 DATE TESTED : February, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.82 %
FINE AGGREGATE : LOSS = 10.87 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 18.8 %

ORGANIC IMPURITIES TEST

NUMBER : 3+
COAL REMOVED : 3
COAL & ROOTLETS REMOVED : 2+
COAL CONTENT : Nil
SIGNIFICANCE :

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	7.05
Granite		19.15
Sandstone	Medium strong, Good	7.4
Siltstone		1.3
Limestone	Slightly weathered, Medium strong, Good	6.4
Silicious Volcanics		14.6
Flint	Potentially reactive, Fair	0.15
Calcareous coatings	Weak, Poor	0.01
Clay	Soft, Weak, Deleterious	0.24
Ironstone		0.2
PN = 109	INTERPRETATION : Excellent	56.5

COMMENTS : Organic impurities test is satisfactory.

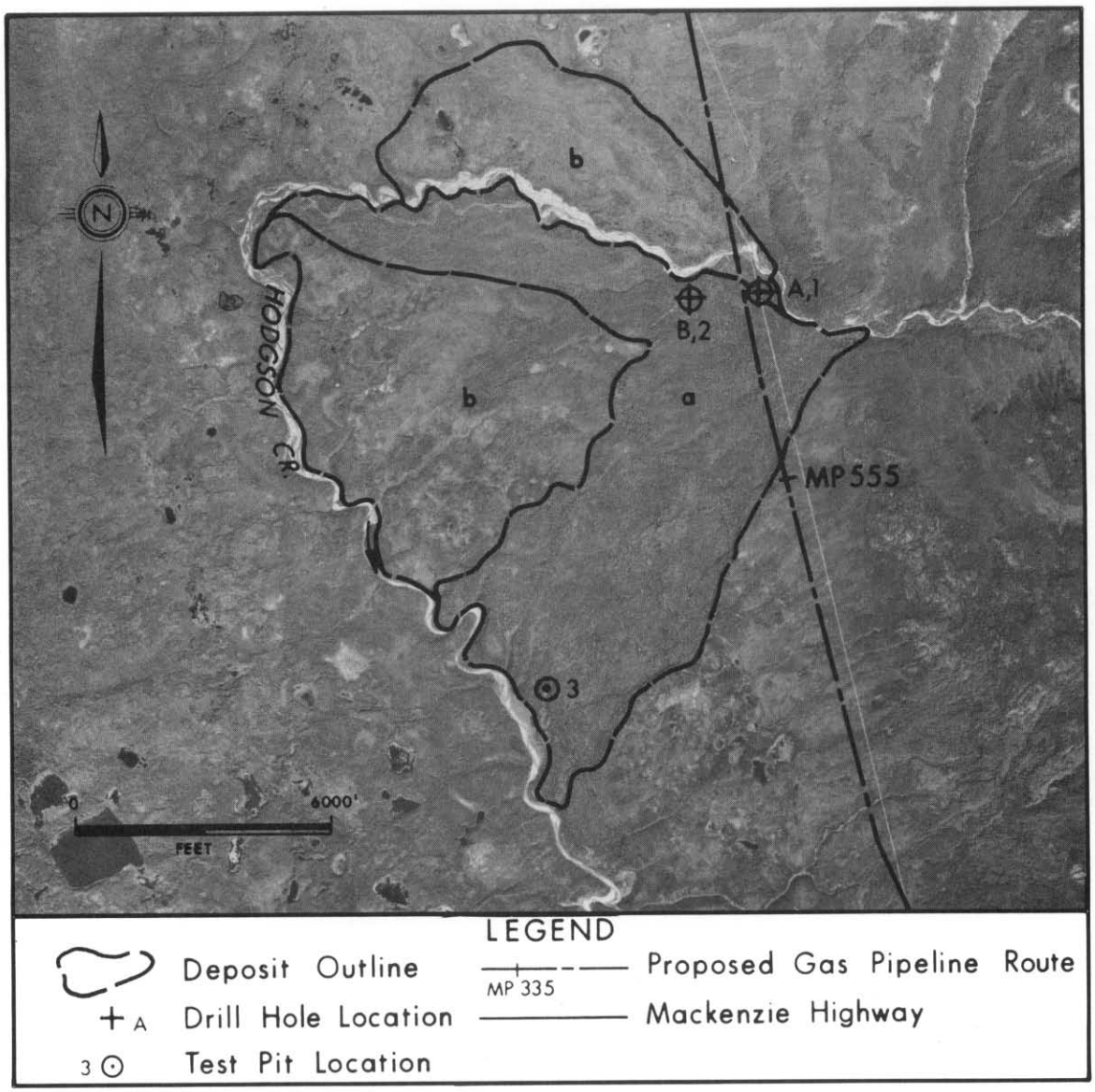
DEPOSIT 950-B1

Physical Setting: Deposit 950-B1 is an alluvial fan located on the west flank of McConnell Range near Hodgson Creek. It is crossed by the pipeline route.

Material: GRAVEL - well graded, occasional boulders, sand and silt lenses.

Volume: 14,700,000 cubic yards in area "a". Area "b" not considered.

Assessment: Deposit 950-B1 is a source of fair to good quality granular material suitable for general fill, embankment fill, and building pads. Area "a" is considered to have the best development potential. Further work is required.



Airphoto No. A22424-44
Approximate Scale: 1" = 4250'

Latitude: 63° 20' N.
Longitude: 123° 28' W.

DEPOSIT 950-B1

PHYSICAL SETTING

Deposit 950-B1 is an alluvial fan located on the west flank of the McConnell Range near Hodgson Creek. Wrigley is 7 miles south of the deposit and the gas pipeline crosses its eastern edge. This deposit corresponds to source number W-9 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The fan covers a 6 square mile area and has 2 distinct zones which are shown on the site airphoto as areas "a" and "b". Area "a" is fairly well drained, probably has thicker alluvial sediments, and contains coarser granular material. Area "b" is more poorly drained and probably represents only a thin veneer of alluvial sands and gravels. The fan materials of both "a" and "b" have been deposited over ice-rich glacio-lacustrine sediments.

The stratigraphy of the fan is subject to lateral variation. The coarser sediments including sand and gravel are more common and thickest near the apex of the fan. Drill holes and test pits from field investigations confirm this.

The surface of the fan is flat and sloping. Hodgson Creek emerges from a bedrock gorge near the fan's apex and flows down the north and west sides of the fan.

Small channels are also present on the surface of the fan. Silt overburden in gravelly sections of the fan varies from 1 to 5 feet. Drill holes indicate that the fan materials are unfrozen or have low ice content.

BIOLOGICAL SETTING

Black and white spruce (30 to 50 feet in height), larch, alder and juniper occur on the gentle to moderate slopes of this extensive site. The area provides poor moose winter range. No waterfowl habitat occurs on the site and potential raptor nesting habitat is limited. Adjacent Hodgson Creek is a spawning, rearing, and overwintering area for grayling, slimy sculpin, lake chub, and round whitefish. The site lies within the Wrigley hunting and trapping area.

MATERIAL

Good granular material is present in the apex of the fan. Gravel is angular to subangular, well graded with occasional boulders and is composed of igneous rock, limestone, dolomite, quartzite, and traces of sandstone, chert and siltstone. The gravel layers are probably discontinuous and interspersed with sand and silt lenses especially near the toe of the fan.

VOLUME

Area "a" of the fan contains 14.7 million cubic yards of material, assuming a deposit thickness of 6 feet over an area of 1514 acres.

Area "b" is not considered to have good quality borrow material and was not included in the total volume calculation. It covers an area of 1667 acres.

DEVELOPMENT AND REHABILITATION

Deposit 950-B1 is a source of fair to good quality granular material suitable for general fill, embankment fill, and building pads. The gravel zones might also be suitable for base or surface course and possibly concrete aggregate. Segment "a" is considered to have the best development potential. Further drilling is needed to outline gravel layers and to access the amount of coarse granular material present in this deposit.

Access is possible via the Mackenzie Highway centerline from Wrigley then overland via snow roads to the deposit or alternatively via the pipeline right of way which crosses the deposit. A seismic line also crosses the apex of the deposit roughly parallel to the pipeline route.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between areas of development and Hodgson Creek.

Initially the vegetative cover would be cleared and the overburden stripped and stockpiled around the edge of the site. A dugout pit would probably be excavated in the fan with conventional earthmoving techniques and equipment. Ripping may also be required to break up the material. Excessive boulder content may necessitate crushing and screening. Stockpiles may also be needed to thaw and drain the excavated material.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	Pt	0.3 PEAT – light brown, woody fibrous, dry.		UF							
2	SP	SAND – fine, trace medium, trace organics, dry, loose									
4		(4.0)								4	Drill chattering and vibrating
6	GP	GRAVEL – little sand sizes									
8											
10		Rock flour from large cobble or boulder								10	Drilling from 10.0' – 11.5' through large boulder, 40 minutes
12		12.5 End of hole								12.5	

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ⊢——⊣ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ⊙

LOGGED BY: K.J.H	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 65°20'04"N, 123°27'36"W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.: A 22424-44	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	N75-950-B1-A
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 18°C	ENGINEERS FOR	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 10 M 09 Y 75 TIME: 13:20	FINISH: D 10 M 09 Y 75 TIME: 14:40			

TEST HOLE No. N75-950-B1-A

184

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.7 PEAT – dark brown, woody, fibrous, moist, odourous.		UF								
2	ML		SILT – and fine sand, low-non plastic, damp, light brown.										
4			4.0		Nb								
6			6.5										
8	SW		SAND – coarse, med. fine, trace fine gravel, light brown, damp.										
10			Progressively greater percentage of gravel with depth										
12	GW ?		(11.0) GRAVEL – little fine sand, wet.										
14													

LABORATORY TEST DATA scale: 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

LOGGED BY: K.J.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 63°18'34''N, 123°28'37''W		ELEVATION:		N75-950-B1-B
DRWN. BY: A.M.	AIRPHOTO No.: A 22424-44		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 18°C		
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2
START: D 10 M 09 Y 75 TIME: 15:25		FINISH: D 10 M 09 Y 75 TIME: 15:45			

185

TEST HOLE No. N75-950-B1-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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		(GRAVEL)		Nb	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
			17.0										
	CL		CLAY - silty, trace medium sand, low plastic, damp, light grey.										
18													
			20.0 End of hole									20	
20													

LOGGED BY: K.J.H	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	63°18'34''N, 123°29'37''W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.:	A22424-44	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-950-B1-B
CHKD:	RIG:	HELI-DRILL	AIR TEMP.: Approx. 18°C	ENGINEERS FOR	
	METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2
START: D 10 M 09 Y 75 TIME: 15:25	FINISH: D 10 M 09 Y 75 TIME: 15:45				

TEST HOLE No. N75-950-B1-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
0	ML		SILT - and fine sand (SM-ML), light brown, rootlets to a depth of 3.5'		UF							0	
1			1.3 / 1.5 1.3' to 1.5' coarse sand				MA G = 0% S = 35% F = 65%	B1	X			1	
			1.5' to 2.0' layered fine sand										
2			2.0									2	
3			3.2										
	GP?		3.5 (GRAVEL) cobbles to boulders 3" to 12", sandy									3.5	
			Bottom of pit										

LOGGED BY:	D.A.O.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	63°20'04"N, 124°03'22"W	ELEVATION:	
DRWN. BY:	J.J.B.	AIRPHOTO No.:	A 22424-44	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 16°C
		METHOD:	TEST PIT		

START: D 10 M 09 Y 75 TIME: 13:00 FINISH: D 10 M 09 Y 75 TIME: 13:15

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-950-B1-1

SHEET 1 OF 1

TEST HOLE No. N75-950-B1-1

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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - silty, trace fine sand, dark brown		UF	▲ Dry density (pcf) ⊙ Water content %	w%						
			0.4			Plastic limit ⊢——⊣ Liquid limit							
	ML		SILT - some fine to medium sand, medium brown, evidence of interbedding			40 60 80 100 120 140 ▲							
1			1.25			0 20 40 60 80 100 ⊙							
	CL		CLAY - little fine sand, medium brown, evidence of interbedding										
2			2.2 — 2" to 3" layers of 1) medium sand, clean; 2) clay, silty, little fine sand; 3) organics, dark brown.				MA G = 0% S = 11% F = 89% 28.8	B1	X			2	
			2.8 — pieces of black wood										
3			3.0 Pit abandoned									3	

LOGGED BY:	J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	63°20'10"N, 123°28'16"W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 22424-44	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	J.K.W.	RIG:		AIR TEMP.:	ENGINEERS FOR
		METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START:	D 10 M 09 Y 75 TIME: 16:45	FINISH:	D 10 M 09 Y 75 TIME: 18:00		TEST HOLE No. N75-950-B1-2
					SHEET 1 OF 1

TEST HOLE No. N75-950-B1-2

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
	Pt		0.2 PEAT - mossy, rootlets		UF								
1	SM		SAND - fine, and silt, light brown, oxidized pockets, damp, sand and, silt appear to be in pockets. 1.5				MA G = 0% S = 45% F = 55%	B1	X			1	
	ML		2.0 SILT - and fine sand, medium brown, moist. Bottom of pit									2	Permafrost at 2.0'
2					Nb								

LOGGED BY: D.A.O.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 63°18'34"N, 123°29'37"W		ELEVATION:		
DRWN. BY: N.L.	AIRPHOTO No.: A 22424-44		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-950-B1-3
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 18°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 10 M 09 Y 75 TIME: 15:00		FINISH: D 10 M 09 Y 75 TIME: 15:15			

TEST HOLE No. N75-950-B1-3

PC-9,SK373

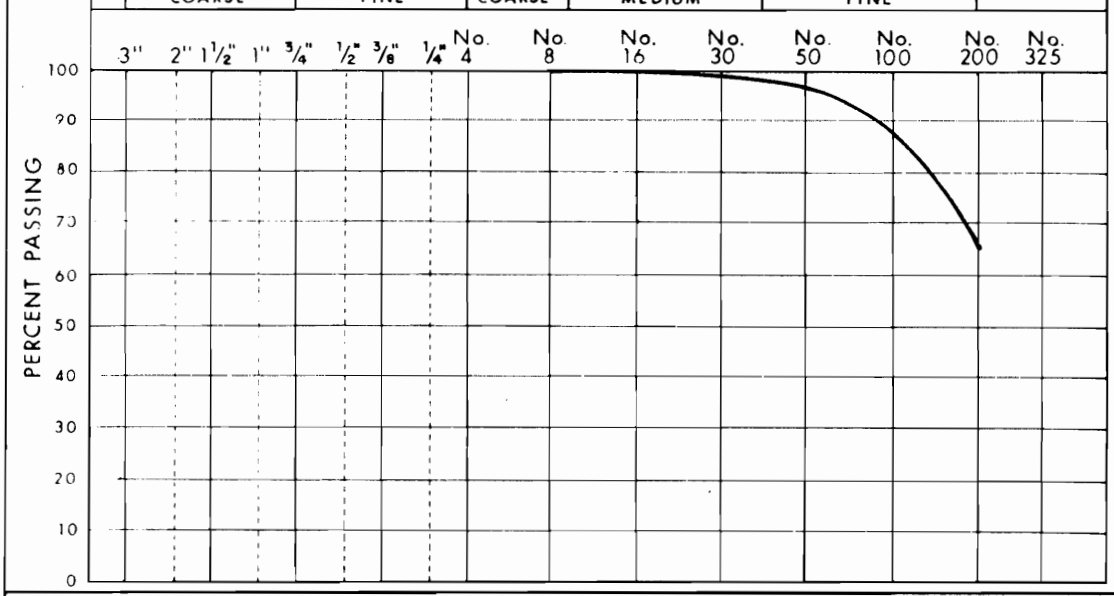
SIEVE ANALYSIS REPORT

SAMPLE N75-950-B1-1 DEPTH 1.0-2.0

DATE SAMPLED September 10, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 220

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0 %	2 %	33 %	65 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	100.0
No. 16	99.9
No. 30	99.5
No. 50	97.4
No. 100	87.2
No. 200	65.2

COMMENTS

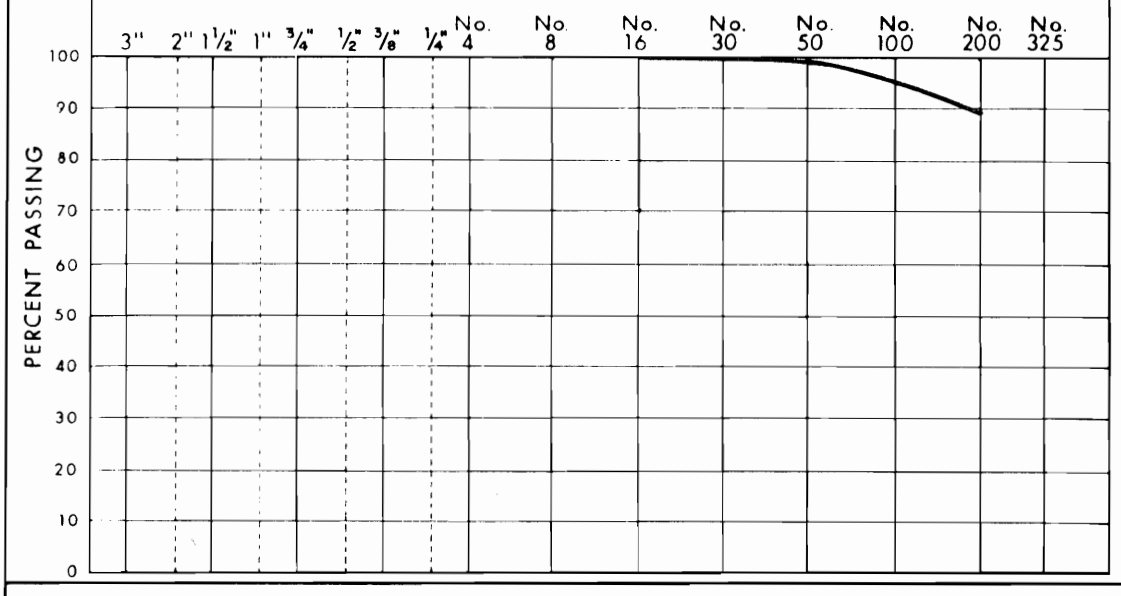
OVERSIZE (>3") = 0.0 %

SAMPLE N75-950-B1-2 DEPTH 2.0-3.0

DATE SAMPLED September 10, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 208

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0 %	1 %	10 %	89 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	100.0
No. 30	99.9
No. 50	98.9
No. 100	94.7
No. 200	89.1

COMMENTS Moisture content of 28.8%

OVERSIZE (>3") = 0.0 %

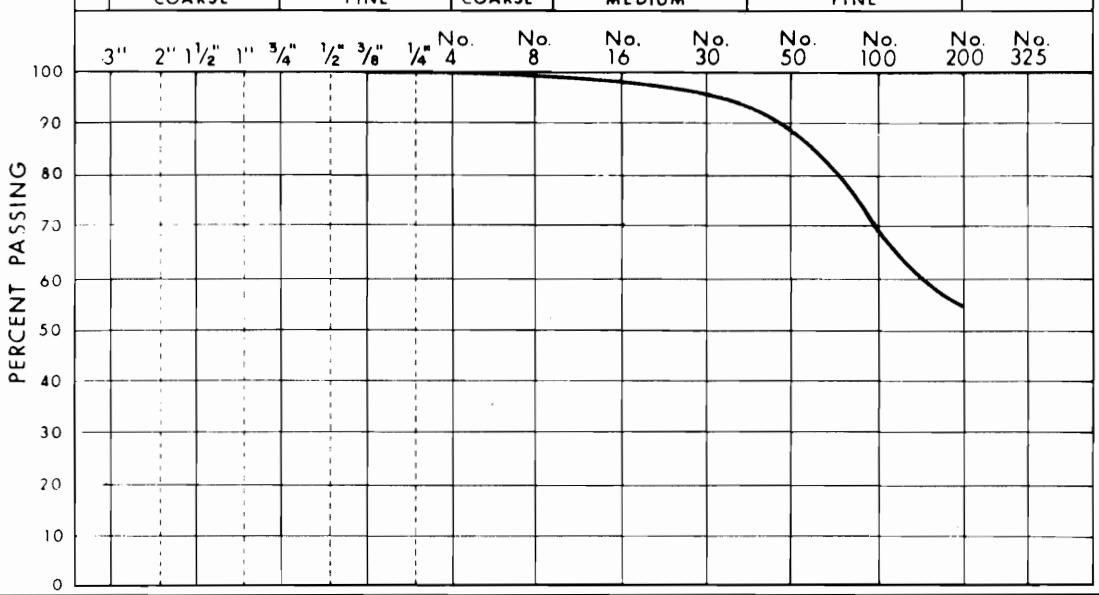
SIEVE ANALYSIS REPORT

SAMPLE N75-950-B1-3 DEPTH 1.0-2.0

DATE SAMPLED September 10, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 228

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	1 %	6%	38 %	55 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	99.9
No. 8	98.9
No. 16	98.0
No. 30	96.1
No. 50	89.3
No. 100	69.1
No. 200	54.8

COMMENTS

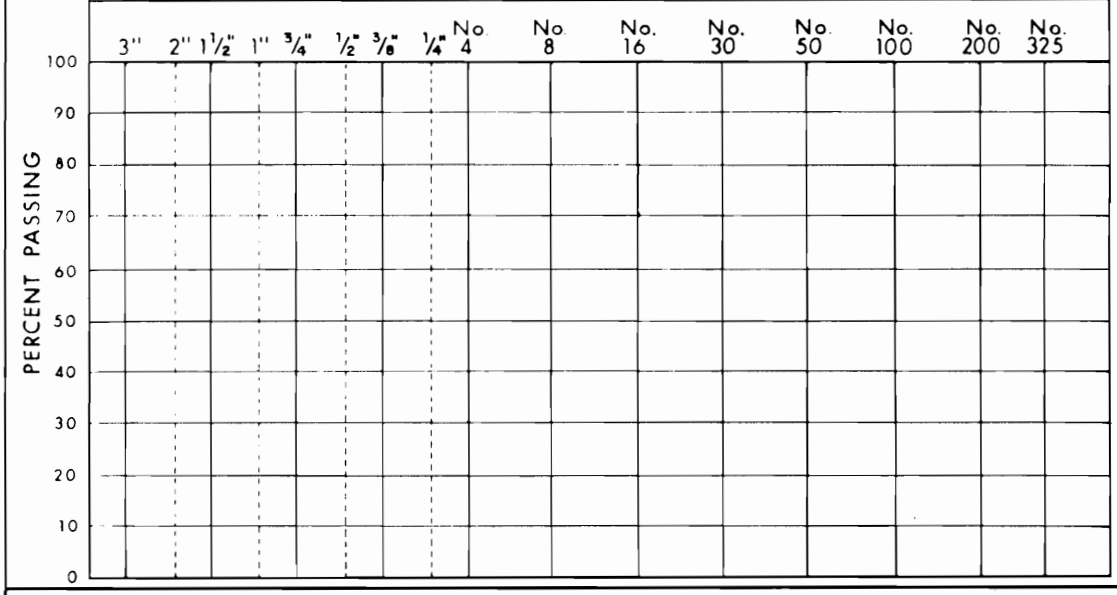
OVERSIZE (>3") = 0.0 %

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. N75-950-B1

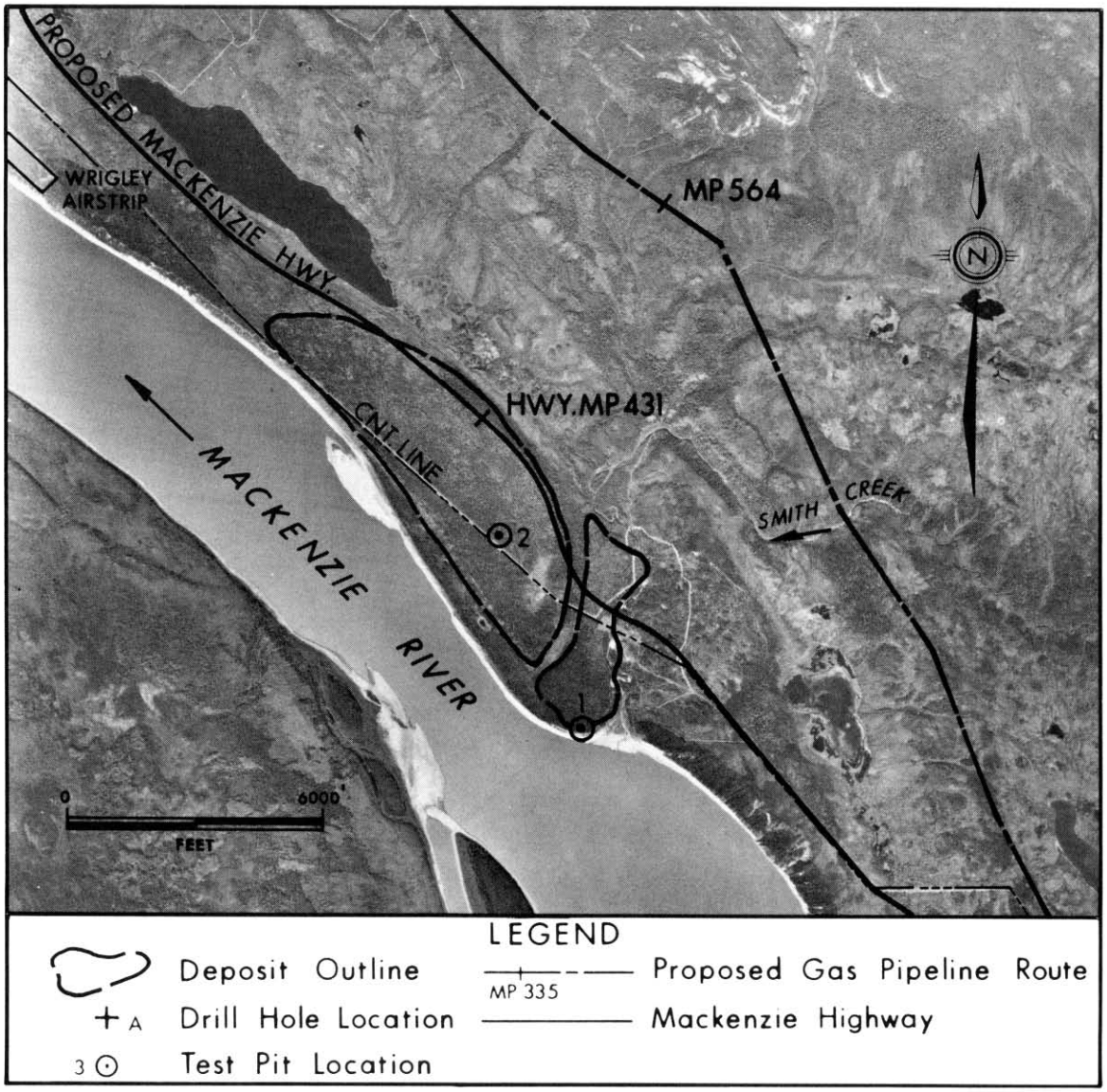
DEPOSIT 950-B2

Physical Setting: Deposit 950-B2 is a glaciofluvial terrace complex located north of the confluence of Smith Creek and the Mackenzie River. The pipeline route is 1½ miles away.

Material: GRAVEL - well to poorly graded, bouldery, with some sand and silt.

Volume: 32,200,000 cubic yards.

Assessment: Deposit 950-B2 is a source of good to excellent quality granular material suitable for general fill, embankment fill, building pads and concrete and asphalt aggregate.



Airphoto No. A22424-169
Approximate Scale: 1" = 4250'

Latitude: 64° 11' N.
Longitude: 123° 21' W.

DEPOSIT 950-B2

PHYSICAL SETTING

Deposit 950-B2 is a pair of glaciofluvial terraces located north of the confluence of Smith Creek and the Mackenzie River. The proposed Mackenzie Highway, the CNT line, and a winter road cross the deposit. The proposed gas pipeline is located 1½ miles to the northwest. Previous investigations of this deposit were done by DPW and Pemcan. The deposit corresponds to source numbers W-1 and W-2 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The terraces are flat lying. Sideslopes adjacent to Smith Creek and the Mackenzie River are fairly steep. The larger northern terrace rises 200 feet above the Mackenzie River while the smaller terrace is 150 feet above the river. The northeastern border of the deposit is the edge of a meltwater channel.

The glaciofluvial sands and gravels of the deposit are well drained and have ice contents that are low to negligible. Glaciolacustrine silt overburden of ½ to 4 feet is present over most of the deposit.

BIOLOGICAL SETTING

The site is located in white spruce forest. Moose numbers in the area have been reduced by hunting pressure from Wrigley. The site provides poor moose winter habitat. Raptors may utilize the tall trees at the site for nesting. Migrating waterfowl use the island-river complex during April-May. Smith Creek supports populations of long-nosed suckers and slimy sculpin and may be used as an overwintering area. The Mackenzie River provides year-round habitat for several resident and migratory fish species. The site occurs in the Wrigley hunting and trapping area.

MATERIAL

Deposit 950-B2 contains gravel with some sand and silt. The gravel is fine to coarse, well to poorly graded, subrounded and subangular to rounded, bouldery, gray, light brown to rust brown, and primarily composed of granite, limestone and quartzite. The sand is well graded, coarse to fine, brown, silty and gravelly.

VOLUME

Assuming an average depth of 30 feet over an area of 665 acres, the estimated total volume is 32.2 million cubic yards. It should be noted that till was found at fairly shallow depths in certain parts of the deposit and further drill hole data might reduce this total volume.

DEVELOPMENT AND REHABILITATION

Deposit 950-B2 is a source of good to excellent quality granular material suitable for general fill, embankment fill in berm construction, building pads and concrete and asphalt aggregate. This deposit is located within the proposed Wrigley Development control zone. Location of areas to be exploited will be dictated by haul distance, insitu material quality and material requirements for both the pipeline and the settlement.

Initial access may be achieved via the Mackenzie Highway and then by a snow road from the deposit east to the pipeline right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Excavations should be kept away from the river and creek bank to prevent slope failures and sedimentation of waterways. A buffer zone should also be maintained between the highway and development areas.

In the initial development stage, trees would be cleared and overburden stripped and stockpiled around the edge of the excavation area. Since the terraces are generally flat, dugout style pits would be used to extract the material. Conventional earthmoving techniques and equipment should be adequate because of low ice contents in the sand and gravel. Natural mixing during excavation would be adequate to obtain good gradations. Screening might be needed for concrete aggregate production.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

TEST HOLE LOG

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	GW	GRAVEL - coarse to fine, and sand, grey to light brown	UF						0	slope face
5		layered at 2" and 5" depths, 1" in thickness, grey							5	
10									10	
15		subrounded to rounded gravel		MA, combined, samples B1 - B3 G = 56% S = 41% F = 3% (GW)	B1	X			15	
20									20	approx. 50° slope
25					B2	X			25	
30									30	
35					B3	X			35	
40		Approximate base of slope							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 ⊙

LOGGED BY: D.A.D.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 63°10'08"N, 123°20'24"W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 22424-168	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 13°C	ENGINEERS FOR
	METHOD: EXPOSED SLOPE FACE		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 10 M 09 Y 75 TIME: 18:15	FINISH: D 10 M 09 Y 75 TIME: 18:45		TEST HOLE No. N75-950-B2-1
			SHEET 1 OF 1

TEST HOLE No. N75-950-B2-1

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.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SP-SM	SAND - fine, and coarse to fine gravel, dry, loose, light red brown, boulder, rounded, to 12''; numerous cobbles, subrounded, to 5''		UF	MA, combined samples 1 - 3 - 3'' material: G = 37% S = 53% F = 10% (SP-SM)	B1				0.5	2'' organic cover masses, grasses, seedlings
1										1	
2		(gap-graded material)				B2				2	
2.5											
3	SP	SAND - fine (trace organics), clean, dry, loose, light grey				B3				3	
3.5											
3.7	CL	TILL, CLAY - medium, coarse gravel, dry dense, cobbles to 5'' Bottom of pit								3.7	

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: K.J.H.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 63°11'02''N, 123°21'45''W	ELEVATION:		
DRWN. BY: R.J.S.	AIRPHOTO No.: A 22424-169	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-950-B2-2
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 15°C		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 10 M 09 Y 75 TIME: 18:18	FINISH: D 10 M 09 Y 75 TIME: 19:30			

199

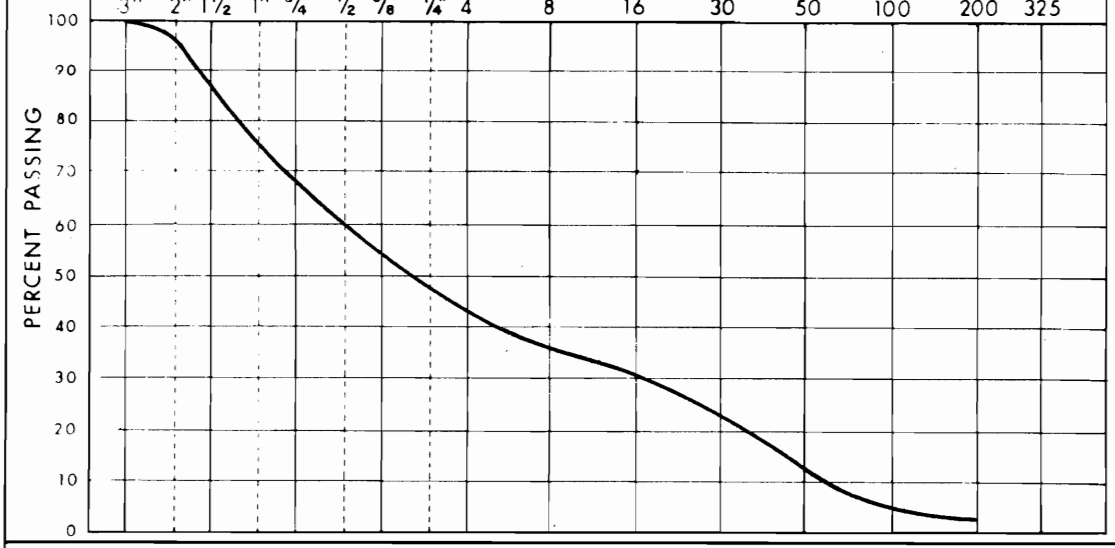
TEST HOLE No. N75-950-B2-2

PC-9,SK 373

SIEVE ANALYSIS REPORT

SAMPLE N75-950-B2-1 DEPTH Bank Samples
DATE SAMPLED September 10, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 182

GRAVEL SIZES		SAND SIZES			FINES
31 %	25%	9 %	17 %	15 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



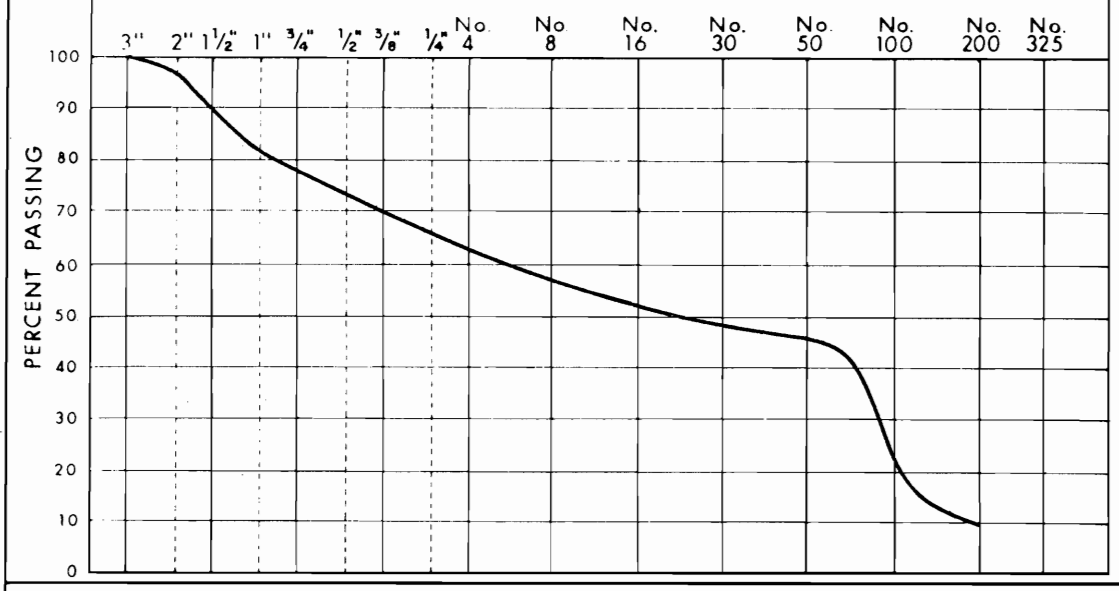
SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.4
1½"	86.9
1"	75.5
¾"	68.8
½"	60.4
⅜"	54.5
¼"	
No. 4	43.5
No. 8	36.1
No. 16	30.2
No. 30	22.7
No. 50	12.4
No. 100	5.0
No. 200	3.2

COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-950-B2-2 DEPTH 0.5-3.0
DATE SAMPLED September 10, 1975 SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 183

GRAVEL SIZES		SAND SIZES			FINES
23 %	14%	6 %	9 %	38 %	10 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.4
1½"	90.2
1"	81.7
¾"	77.4
½"	73.1
⅜"	70.2
¼"	
No. 4	62.8
No. 8	57.2
No. 16	52.5
No. 30	49.0
No. 50	45.9
No. 100	22.1
No. 200	9.6

COMMENTS

OVERSIZE (>3") = 0.0 %

SUMMARY OF LABORATORY TEST DATA FOR SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-950-B2-1 DATE SAMPLED September 10, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : down slope DATE TESTED February, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.08 %
FINE AGGREGATE : LOSS = 8.81 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 22.8 %

ORGANIC IMPURITIES TEST

NUMBER : 4+
COAL REMOVED : 4
COAL & ROOTLETS REMOVED : 3+
COAL CONTENT : 0.01%
SIGNIFICANCE :

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	18.2
Granite		10.25
Sandstone	Strong, Good	4.4
Siltstone		3.65
Limestone		19.25
Chert	Potentially reactive, Fair	0.05
Flint		0.05
Soft Sandstone	Weak, Friable, Poor	0.55
Ironstone	Soft, Deleterious	0.1
PN = 107	INTERPRETATION : Excellent	56.5

COMMENTS : Borderline on organic contamination, otherwise satisfactory.

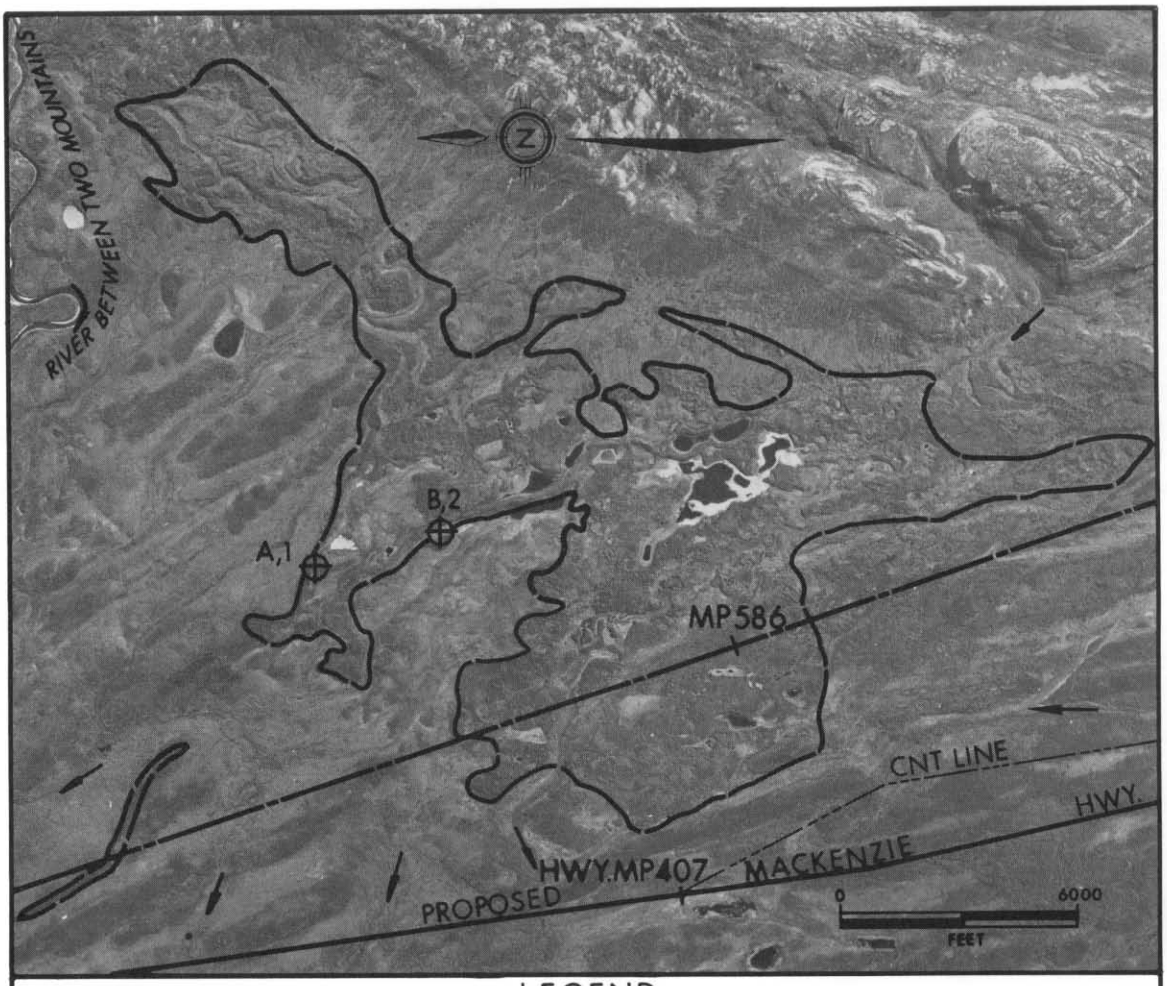
DEPOSIT 95J-B1

Physical Setting: Deposit 95J-B1 is an outwash deposit located 2 miles south of River Between Two Mountains and is crossed by the pipeline route.

Material: SAND and GRAVEL - layered, well to poorly graded, with silt.

Volume: 35,600,000 cubic yards.

Assessment: Deposit 95J-B1 is a source of fair to good quality granular material suitable for marginal and utility fill purposes. Gravel areas might provide concrete and asphalt aggregate.



LEGEND

- Deposit Outline
- MP 335 — Proposed Gas Pipeline Route
- + A Drill Hole Location
- Mackenzie Highway
- 3 ⊙ Test Pit Location

Airphoto No. A17429-147
Approximate Scale: 1" = 4850'

Latitude: 62° 53' N.
Longitude: 123° 06' W.

DEPOSIT 95J-B1

PHYSICAL SETTING

Deposit 95J-B1 is an extensive outwash deposit located 2 miles south of River Between Two Mountains and 3 miles east of the Mackenzie River. The proposed pipeline crosses the western edge of the deposit while the proposed Mackenzie Highway is located immediately to the west. This deposit corresponds to source number 142 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The deposit is an esker-kame complex covering approximately 12 square miles. Glaciofluvial gravel and sand overlie slopewash and till along the west side of Bell Ridge. The surface of the deposit is very irregular and hummocky because of esker ridges and small meltwater channels. Local relief is variable but can range up to 60 feet especially along its northern edge.

Overburden varies from negligible to 4 feet thick. Drainage on ridges and knobs is good but depressions between ridges are wet and marshy. Gravel and sand in ridged areas is generally unfrozen. Some ice was noted in test holes drilled in low areas on the southwestern corner of the deposit. Drumlined till plain lies between portions of the deposit and the pipeline right of way.

BIOLOGICAL SETTING

White spruce and aspen (40-45 feet) are abundant on upper slopes and ridge tops of the esker complex with black spruce in low-lying areas. Groundcover is largely mosses and cranberry with some scrub alder. Moose winter habitat and waterfowl habitat is limited in the immediate vicinity of the deposit. Extensive beaver activity was reported in the area in 1976. No suitable fish habitat was identified at the site. The site occurs in the Wrigley hunting and trapping area.

MATERIAL

This deposit is composed of layered sand and gravel. The gravel is medium to coarse grained, cobbly, subangular to subrounded and consists of limestone, dolomite and granitic rock. This gravel is coated with secondary carbonate layers or iron stain and is present as thin layers within the sand and as the primary component in esker ridges of the northern part of the deposit. Most of the deposit consists of sand that is brown, fine to coarse grained, well to poorly graded with silt and gravel in variable proportions.

VOLUME

A total volume of 35.6 million cubic yards was obtained by assuming a deposit depth of 12 feet over a total area of 3675 acres and subtracting 50% for swamps and lakes.

DEVELOPMENT AND REHABILITATION

Deposit 95J-B1 is a source of fair to good quality granular material suitable for marginal and utility fill purposes. Gravel areas might provide material for building pads and concrete and asphalt aggregate. The gravel will require further testing prior to use in concrete. Areas to be exploited will be dictated by access, insitu material quality and material requirements. Further work is needed to accurately define areas of good quality granular material. Best material will probably be located in esker ridges at the north end of the deposit.

The deposit is crossed by the pipeline right of way and access should present few problems. Snow road access would be used to reach areas of the deposit that are away from the pipeline right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations

will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between any development areas and the numerous lakes located within the deposit.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas. The irregular occurrence of gravel within the deposit might mean that several pits will be excavated to obtain sufficient quantities of good material. If care is taken during excavation, layers of higher quality gravel may be separated easily from the sand. Conventional earthmoving techniques including ripping should be adequate to develop this deposit.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	GW		GRAVEL - fine to coarse, some fine to coarse sand, possible trace silt, frequent cobbles.		UF							0.7	
								WT				1.2	
2													
4													
6													
			8.0 End of hole										
8													

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°54'12''N, 123°06'26''W		ELEVATION:		N75-95J-B1-A
DRWN. BY: A.M.	AIRPHOTO No.: A 17429-147		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL		AIR TEMP: Approx. 10°C		
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 12:30		FINISH: D 11 M 09 Y 75 TIME: 12:45			

TEST HOLE No. N75-95J-B1-A

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	SP		SAND – fine to medium, brown, dry		UF							2	
2								W 1	X			3	
4			5.0 sand becoming coarser									5	losing circulation
6													
8													
10												10	hole sloughing in.
12			13.0 Hole abandoned									13	

LOGGED BY: J.L.M	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION		TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°53'43''N, 123°06'05''W	ELEVATION:			N75.95J-B1-B
DRWN. BY: A.M.	AIRPHOTO No.: A 17429-147	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR		
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 7°C			
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED		SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 11:25	FINISH: D 11 M 09 Y 75 TIME: 11:50				

PC-9,SK373

TEST HOLE No. N75-95J-B1-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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.2 PEAT - organic cover		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
	SM		0.5 SAND - fine to medium, silty, light brown, rootlets										
1	SW		SAND - fine to coarse, well graded, some gravel, subrounded, occasional cobbles to 6", rounded, partial carbonate coating on gravel and cobbles, (trace silt)				MA, combined samples 1 - 5 Oversize = 4.9% -3" material: G = 59% S = 36% F = 5%	B1				1	
2								B2				2	
3								B3				3	
4			4.3					B4				4	
5	GW		GRAVEL - subrounded, some fine to medium sand, occasional cobbles to 5", partial carbonate coating on gravel and cobbles					B5				5	
6			6.0 Bottom of pit									6	

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°54'12"N, 123°06'26"W		ELEVATION:		N75-95J-B1 -1
DRWN. BY: F.B.B.	AIRPHOTO No.: A 17429-147		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 10:40		FINISH: D 11 M 09 Y 75 TIME: 12:05			

PC-9,SK373

TEST HOLE No. N75-95J-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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	GP		GRAVEL - fine, some sand, coarse to fine, roots, organics, brown		UF	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	w%					0	
1	SP		SAND - fine to medium, poorly graded, dry, brown				8.2	B1				1	
2			- occasional silt inclusions, roots, from 2' to 6'				4.2	B2				2	pit walls caving in from 2.5'
3			- slight oxidation bands				9.0	B3				3	
4			- wet				8.9	B4				4	
5							2.7	B5				5	
6			6.0 Bottom of pit									6	
6													Sand; medium = 40% fine = 57%

MA, combined samples 1 - 5
G = 0%
S = 97%
F = 3%

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°53'43"N, 123°06'05"W		ELEVATION:		
DRWN. BY: R.J.S.	AIRPHOTO No.: A 17429-147		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95J-B1-2
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 7°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 11:00		FINISH: D 11 M 09 Y 75 TIME: 12:00			

TEST HOLE No. N75-95J-B1-2

PC-9,SK373

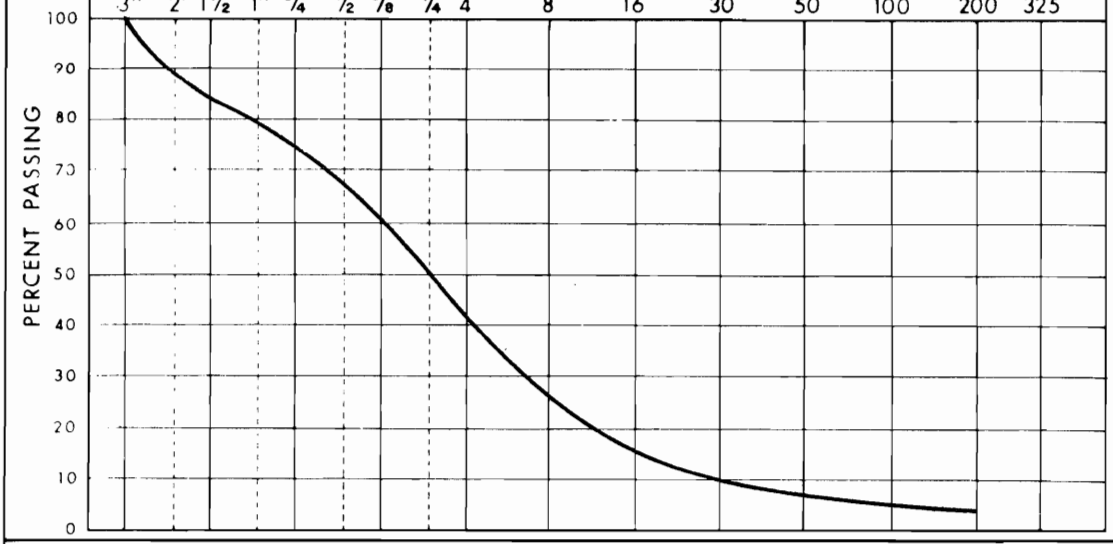
SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B1-1 DEPTH 1.0-6.0

DATE SAMPLED September 11, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 162

GRAVEL SIZES		SAND SIZES			FINES
26 %	33 %	15 %	18 %	3%	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	89.3
1½"	84.1
1"	79.4
¾"	73.7
½"	67.0
⅜"	60.1
¼"	
No. 4	41.4
No. 8	28.0
No. 16	16.6
No. 30	10.1
No. 50	6.9
No. 100	5.6
No. 200	4.6

COMMENTS

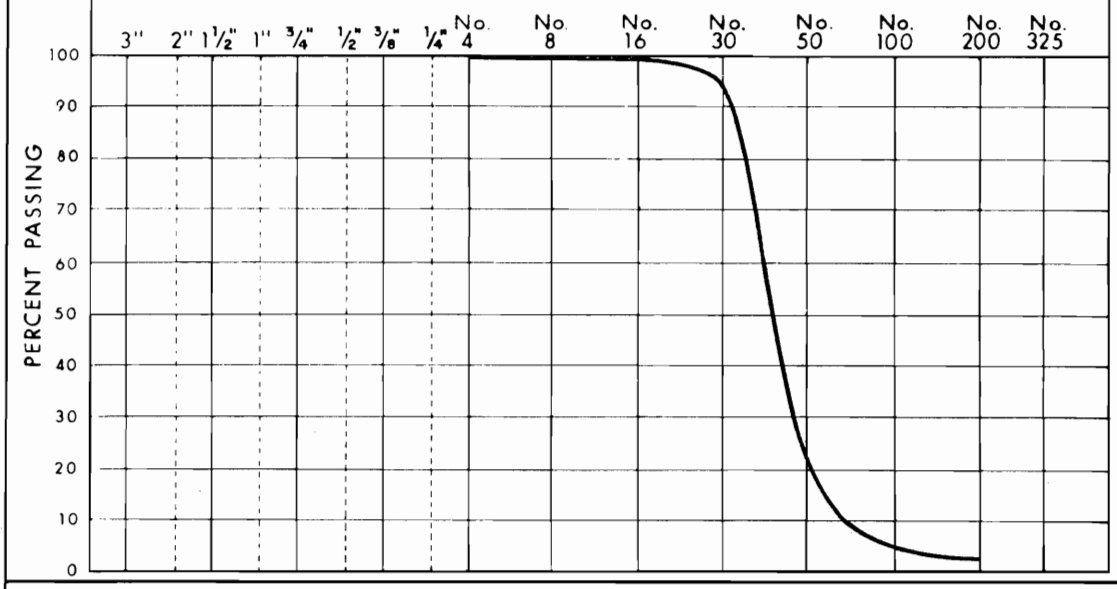
OVERSIZE (>3") = 4.9%

SAMPLE N75-95J-B1-2 DEPTH 1.0-6.0

DATE SAMPLED September 11, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 180

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0%	40 %	57 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	100.0
No. 8	99.9
No. 16	99.8
No. 30	95.1
No. 50	28.3
No. 100	4.8
No. 200	2.7

COMMENTS Moisture contents range from 2.7 to 9.0%

OVERSIZE (>3") = 0.0 %

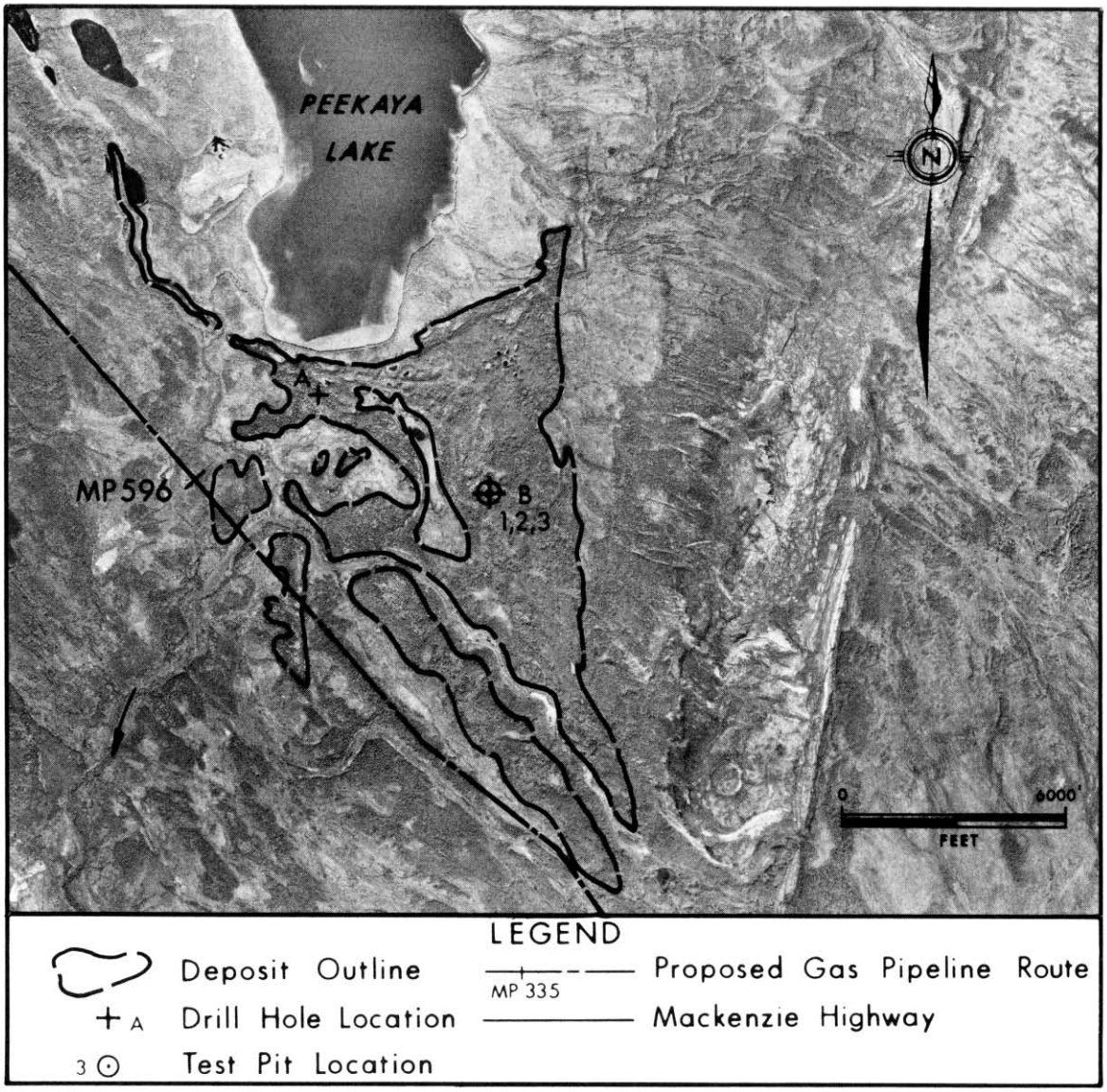
DEPOSIT 95J-B2

Physical Setting: Deposit 95J-B2 is a glaciofluvial complex near Peekaya Lake. The proposed pipeline route follows the southwest edge of the deposit.

Material: SAND and GRAVEL - variable gradations, cobbles and boulders.

Volume: 64,700,000 cubic yards.

Assessment: Deposit 95J-B2 is a source of fair to good quality granular material suitable for general fill. Further work is required to ascertain quality and quantity.



Airphoto No. A17429-171
Approximate Scale: 1" = 4800'

Latitude: 64° 47' N.
Longitude: 122° 55' W.

DEPOSIT 95J-B2

PHYSICAL SETTING

Deposit 95J-B2 is a glaciofluvial complex located near Peekaya Lake just west of the easternmost ridge of the McConnell Range and north of Willowlake River. The proposed gas pipeline follows the southwestern edge of the deposit.

The glaciofluvial complex consists of an esker and a dissected outwash plain. The deposit covers 6 square miles and is related geologically to outwash deposits 95J-B3 and 95J-B4 which occupy a meltwater channel east of this part of the McConnell Range.

The esker portion of the glaciofluvial complex stands 50 to 100 feet above the surrounding till plain and is well drained. The kames are generally well drained with low wet areas located between them. Organic cover is very thin to nonexistent over the deposit and permafrost was not encountered in either the test pits or the drill holes.

BIOLOGICAL SETTING

Dominant vegetation consists of aspen, white spruce (up to 80 feet), alder and rose. The site provides poor moose winter range. Extensive beaver activity was reported in the area in 1976. No waterfowl habitat is found on the site, however, raptor nests may be found in the area. The fisheries potential of Peekaya Lake and tributaries is not known. The site occurs in the Wrigley hunting and trapping area.

MATERIAL

This deposit contains large quantities of good quality sand and gravel. The gravel grades from fine to coarse with cobbles and the occasional boulder. The gravel is generally carbonate coated with a matrix of medium to coarse sand. Sand layers are individually poorly graded but

range in size from fine to coarse. Some silt is present in the upper layer of the deposit. Cobble and boulder areas are present because this deposit is near the McConnell Range.

VOLUME

Assuming a deposit thickness of 25 feet over an area of 1605 acres, a total volume of 64.7 million cubic yards may be calculated.

DEVELOPMENT AND REHABILITATION

Deposit 95J-B2 is a source of fair to good quality granular material suitable for general fill. Further work is required to ascertain the quality and quantity of material in this deposit. Location of areas to be exploited will be dictated by material quality, access, requirements and environmental concerns.

Stream channels in the area will have to be crossed to achieve access to the eastern sector of the deposit and care should be taken so as not to adversely affect them.

General fill may be found immediately adjacent to the pipeline right of way where it crosses the deposit. Better grade material is present in the eastern sector of the deposit the furthest edge of which is only 2½ miles from the right of way. Snow roads, possibly over existing cut lines, could be built to provide access.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially vegetative cover would be cleared in accordance with existing land use regulations. Peat cover and overburden would then be stripped

and stockpiled around the edge of the area to be developed. Development could take one of many forms. Esker ridges and kame hummocks may be horizontally levelled to their apparent base without leaving a depression. Kame terraces may be worked in benches if a slope was present. Adjacent to the pipeline, where the deposit is level, dugout style pits might be used.

Any of the above excavation methods could be accomplished with conventional techniques and earth-moving equipment. Rippers might be needed to break the winter frost layer.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SP		SAND – fine to medium, brown, poorly graded, dry, loose.		UF							1.0	No tests performed on samples
2								W1					
4												5.0	
6			6.0 fine, grey-brown, poorly graded loose.					W2				5.5 6.5	
8								W3				7.5 8.5	
10			10.0 coarse, some medium, brown, loose.					W4				9.5 10.5	
12								W5				11.0 13.0	
14												15.0	
16								W6					

LOGGED BY: D.V	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION		TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°47'25"N, 122°56'49"W	ELEVATION:			N75-95J-B2-A
DRWN. BY: A.M.	AIRPHOTO No.: A 17429-171	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA		
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 12°C	ENGINEERS FOR		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED		SHEET 1 OF 2
START: D 11 M 09 Y 75 TIME: 14:40	FINISH: D 11 M 09 Y 75 TIME: 15:15				

TEST HOLE No. N75-95J-B2-A

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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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	SP		(SAND) cont'd		UF	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙		W6				17.0	
												18.0	
18								W7					
												20.0	
20												21.0	
								W8					
22												23.0	
								W9					
24												25.0	
												26.0	
26								W10					
			28.0 End of hole									28.0	
28													

LOGGED BY: D.V	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°47'25"N, 122°56'49"W		ELEVATION:		N75-95J-B2-A
DRWN. BY: A.M.	AIRPHOTO No.: A 17429-121		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG: HELI-DRILL		AIR TEMP: Approx. 12°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2
START: D 11 M 09 Y 75 TIME: 14:40		FINISH: D 11 M 09 Y 75 TIME: 15:15			

219

TEST HOLE No. N75-95J-B2-A

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
2	GW		GRAVEL – little fine to coarse sand, brown, frequent cobbles		UF								Difficulty in drilling, lost circulation frequently.
4			(5.5)										
6	SW		SAND – fine to coarse, well graded.										
			7.0 End of hole										

LOGGED BY: D V	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°47'03''N, 122°55'15''W		ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.: A 17429-171		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	N75-95J-B2-B
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 10°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 15:40		FINISH: D 11 M 09 Y 75 TIME: 16:45			

TEST HOLE No. N75-95J-B2-B

220

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
	SM		0.25 SAND - fine to medium, silty, reddish brown, dense.		UF								
1	SP		SAND - medium to coarse, and fine to coarse gravel, cobbles and boulders (12'' x 6'' x 6''), subrounded.				MA, combined samples 1 - 5 G = 47% S = 50% F = 3% Cu = 18 Cc = 0.5	B1				1	
2			* (GP-SP) - calcite deposits on gravel - at 1', sand becoming coarser					B2				2	
3			- at 2', mostly fine gravel, medium sand					B3				3	
4			- layers of dense fine gravel at 3' and 4.75'					B4				4	
5			5.0 medium, trace fine gravel, poorly graded					B5				5	
6			6.0 Bottom of pit									6	
			* Note: borderline, sand/gravel										

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°47'03''N, 122°55'15''W		ELEVATION:		N75-95J-B2-1
DRWN. BY: N.L.	AIRPHOTO No.: A 17429-171		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 13:30		FINISH: D 11 M 09 Y 75 TIME: 14:30			

TEST HOLE No. N75-95J-B2-1

221

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	ML		0.25 SILT - and fine sand, reddish brown		UF								
1	GP		GRAVEL - fine to coarse, some fine to coarse sand, cobbles, boulders (12'' x 6'' x 6'')					B1				1	
2	SP		2.0 SAND - medium to coarse, and coarse to fine gravel, (borderline, sand/gravel)				MA, sample B2 G = 43% S = 54% F = 3% Oversize 4.3%	B2				2	Cu = 16 Cc = 0.44
3			3.0 Bottom of pit									3	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°47'03''N, 122°55'15''W		ELEVATION:		N75-95J-B2-2
DRWN. BY: A.J.B.	AIRPHOTO No.: A 17429-171		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 11 M 09 Y 75 TIME: 13:30		FINISH: D 11 M 09 Y 75 TIME: 14:30			

TEST HOLE No. N75-95J-B2-2

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
	SM		SAND - medium, silty, little coarse to fine gravel, roots, light brown		UF								No samples taken
0.75			boulders at 0.5' (18" x 12" x 12")										
1			Pit abandoned; boulders										

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	62°47'03"N, 122°55'15"W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 17429-171	PIPE MILEAGE:	
CHKD:	D.O.	RIG:		AIR TEMP.:	Approx. 13°C
		METHOD:	TEST PIT		

START: D 11 M 09 Y 75 TIME: 14:00 FINISH: D 11 M 09 Y 75 TIME: 14:30

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-95J-B2-3

SHEET 1 OF 1

TEST HOLE No. N75-95J-B2-3

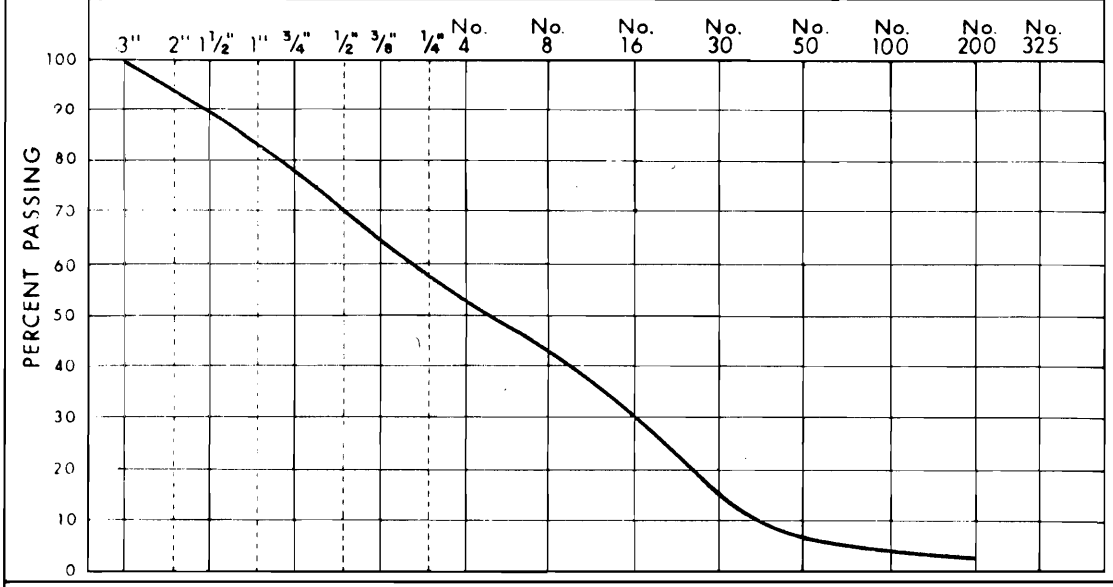
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B2-1 DEPTH 1.0-6.0
DATE SAMPLED September 11, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 225

GRAVEL SIZES		SAND SIZES			FINES
23 %	24 %	13 %	29 %	8 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.2
1½"	88.1
1"	82.3
¾"	77.4
½"	70.4
⅜"	65.2
¼"	
No. 4	53.1
No. 8	42.8
No. 16	30.8
No. 30	15.8
No. 50	7.2
No. 100	4.4
No. 200	3.3

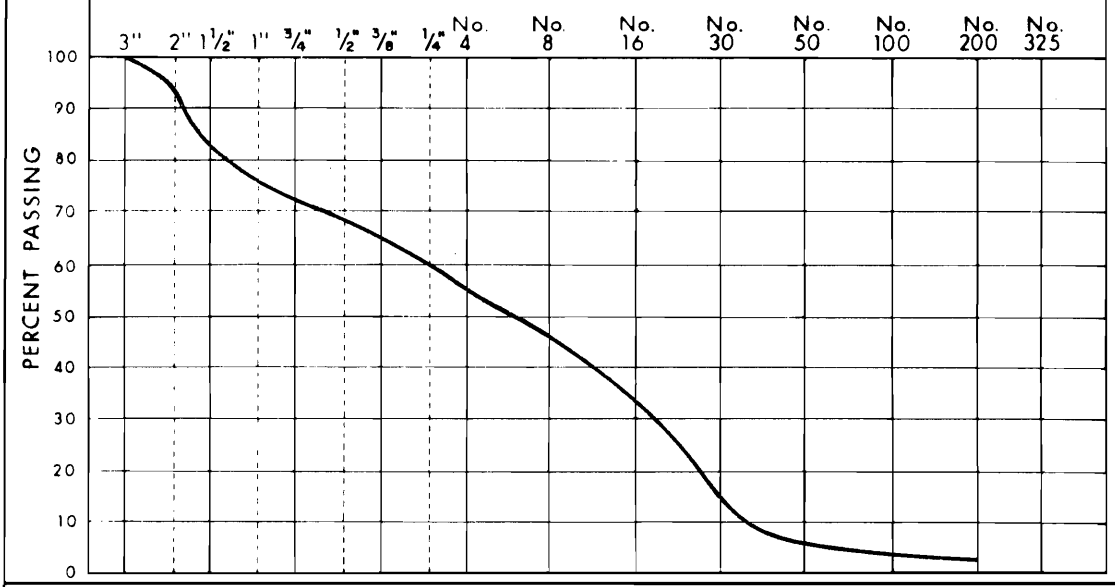
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95J-B2-2 DEPTH 2.0-3.0
DATE SAMPLED September 11, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 213

GRAVEL SIZES		SAND SIZES			FINES
26 %	17 %	11 %	36 %	7 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.4
1½"	83.8
1"	76.6
¾"	74.0
½"	68.9
⅜"	65.2
¼"	
No. 4	56.7
No. 8	47.5
No. 16	33.5
No. 30	15.0
No. 50	6.5
No. 100	4.3
No. 200	3.3

COMMENTS

OVERSIZE (>3") = 4.3%

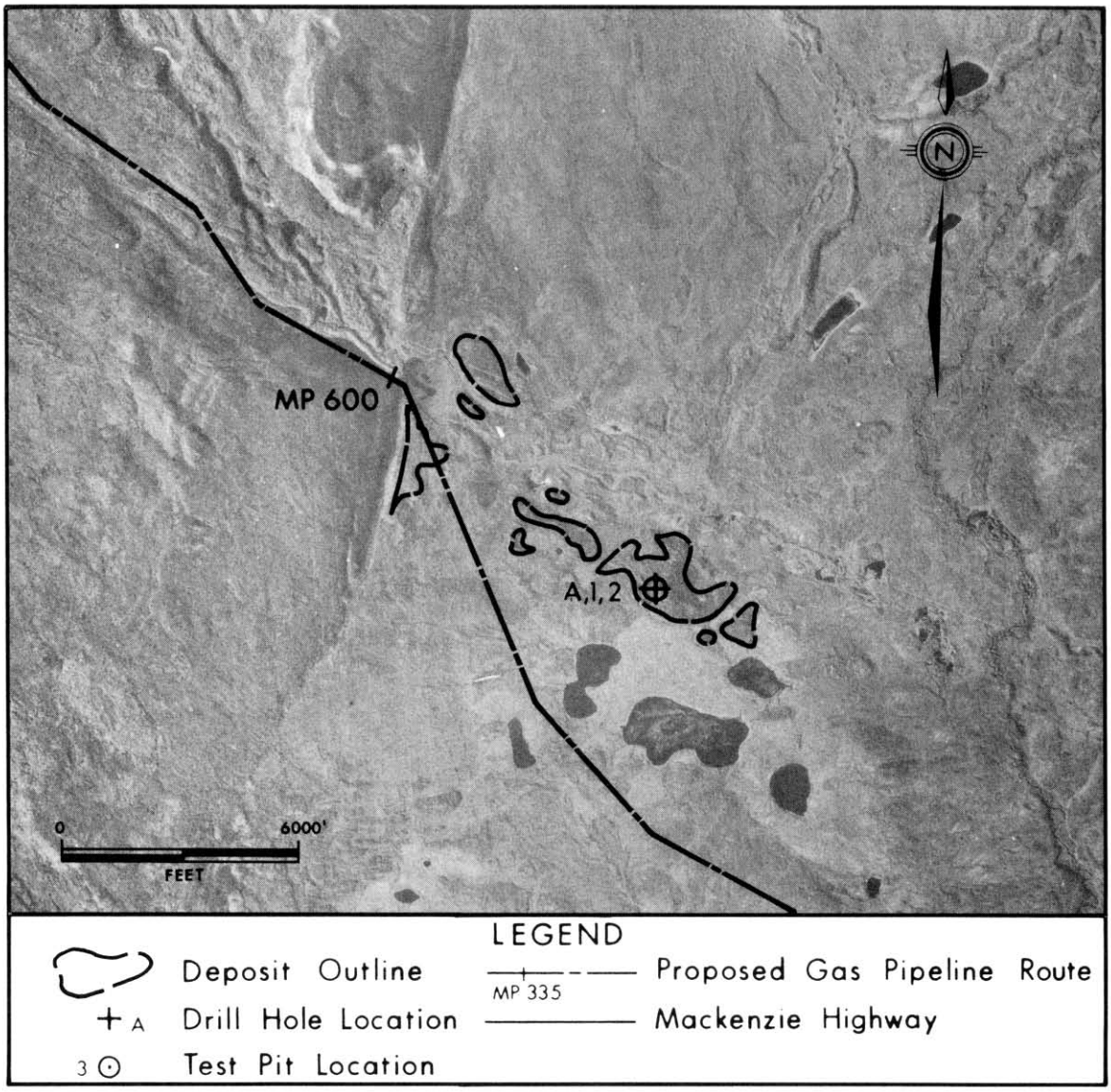
DEPOSIT 95J-B3

Physical Setting: Deposit 95J-B3 is part of a E-W trending esker-kame complex. The proposed pipeline route crosses part of the deposit near M.P. 600.

Material: SAND - well to poorly graded, trace gravel, and considerable fines.

Volume: 3,000,000 cubic yards.

Assessment: Deposit 95J-B3 is a source of poor quality granular material suitable for backfill and marginal fill applications. Further work is required.



Airphoto No. A18044-151
Approximate Scale: 1" = 4700'

Latitude: 62° 44' N.
Longitude: 122° 50' W.

DEPOSIT 95J-B3

PHYSICAL SETTING

Deposit 95J-B3 is the western portion of an east-west trending esker-kame complex located east of the McConnell Range and 4 miles north of Willowlake River. The proposed gas pipeline crosses part of the deposit near mile 600.

This discontinuous ice contact deposit is situated in a meltwater channel which extends through a gap in the easternmost ridge of the McConnell Range. Deposit 95J-B4 also occupies the meltwater channel and forms the eastern portion of this esker-kame complex. Immediately west of the McConnell Range is another large glaciofluvial complext (95J-B2) that is geologically related to 95J-B3 and 95J-B4.

Deposit 95J-B3 is a series of 25 to 50 foot high kames which cover a 2 square mile area. The surface of the kames is undulating. The kames are well drained, but wet areas are located between kames. Till plain sediments are found adjacent to the kames. A thin organic layer covers the kames. Ice contents of the kame sediments are low to negligible.

BIOLOGICAL SETTING

White spruce and aspen up to 100 feet high cover parts of the kames with a ground cover of cranberry and alder. Black spruce forest occurs in the low-lying areas. This area is low-quality moose habitat. Beaver lodges occur in the small lakes, but the poor quality habitat supports only low populations. The small lakes in the area provide marginal waterfowl habitat. The fisheries potential of the small streams is not known. The site occurs in the Wrigley hunting and trapping area.

MATERIAL

The borrow material is a well to poorly graded sand with a trace of gravel. The sand in the test pit excavated was well graded, fine to coarse, clayey and medium brown in colour. The test hole indicates that sands of this deposit have a considerable quantity of fines.

VOLUME

Assuming a 9 foot depth of material over an area of 204 acres, the total volume of material is 3.0 million cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 95J-B3 is a source of poor quality granular material suitable for backfill in pipeline construction and other marginal fill applications. Location of areas to be exploited will be dictated by haul distance, insitu material quality, material requirements and overburden thickness. Further work is required to accurately define the deposit extent, overburden thickness, and material properties.

Access distance from the right of way to the individual hummocks varies from direct access to about 1 mile. Snow roads would be constructed over the fairly flat terrain between the deposit and the right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped 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 drainage compatible with the surrounding areas could be maintained. This could be achieved with conventional earthmoving techniques and standard equipment.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	CI		CLAY - little medium to coarse sand, gravel fragments, med. plastic, reddish brown, occasional cobble, occasional boulder.		UF							2.0	
2								W1	X			3.0	
4													
12			12.0										
	SP-SC		SAND - fine, clayey, trace medium to coarse sand, occasional pebble, medium brown.									14.0	
14								W2	X			15.0	
16													
18													
			20.0 End of hole									20 0	
20													

LOGGED BY: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 82°43'51''N, 122°50'52''W	ELEVATION:			
DRWN. BY: K.M.	AIRPHOTO No.: A 18044-151	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95J-B3-A	
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 7°C	ENGINEERS FOR		
	METHOD: AIR				
START: D 12 M 09 Y 75 TIME: 18:05	FINISH: D 12 M 09 Y 75 TIME: 18:45		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	

PC-9,SK373

TEST HOLE No. N75-95J-B3-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		0.2 PEAT - woody, brown, roots		UF								
	SM		SAND - fine to medium, silty, trace coarse to fine gravel, light brown.										
			1.0										
1	ML		SILT - clayey, and fine to medium sand, trace fine gravel to ¾'', grey.				MA G = 7% S = 37% F = 56%	B1				1	
2													
3												3	
			3.5 Bottom of pit 3.5										
			Frozen ground at 3.5'		F								

LOGGED BY:	S.C.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	62°43'09''N, 122°45'56''W	ELEVATION:	
DRWN. BY:	N.L.	AIRPHOTO No.:	A 18044-153	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	J.K.W.	RIG:		AIR TEMP.: Approx. 12°C	ENGINEERS FOR
		METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START:	D 12 M 09 Y 75 TIME: 16:00	FINISH:	D 12 M 09 Y 75 TIME: 18:00		TEST HOLE No. N75-95J-B3-1
					SHEET 1 OF 1

TEST HOLE No. N75-95J-B3-1

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		0.25 PEAT - organics, roots, dark brown		UF		w%						
	SM		SAND - fine, little silt, trace fine to coarse gravel, light brown, dry, dense, occasional cobbles										
1			1.0									1	
	ML		SILT - some medium to fine sand, trace fine to coarse gravel, brown, dry, dense, occasional cobbles, slight oxidation				9.5 MA, combined samples 1 & 2 G = 17% S = 42% F = 41%	B1					Combined samples borderline SM-ML
2								B2				2	
			3.0 Pit abandoned				24.6						
3												3	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	62°43'51''N, 122°50'52''W	ELEVATION:		N75-95J-B3-2
DRWN. BY: F.B.B.	AIRPHOTO No.:	A 18044-151	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 12 M 09 Y 75 TIME: 14:30	FINISH: D 12 M 09 Y 75 TIME: 16:10				

TEST HOLE No. N75-95J-B3-2

PC-9,SK373

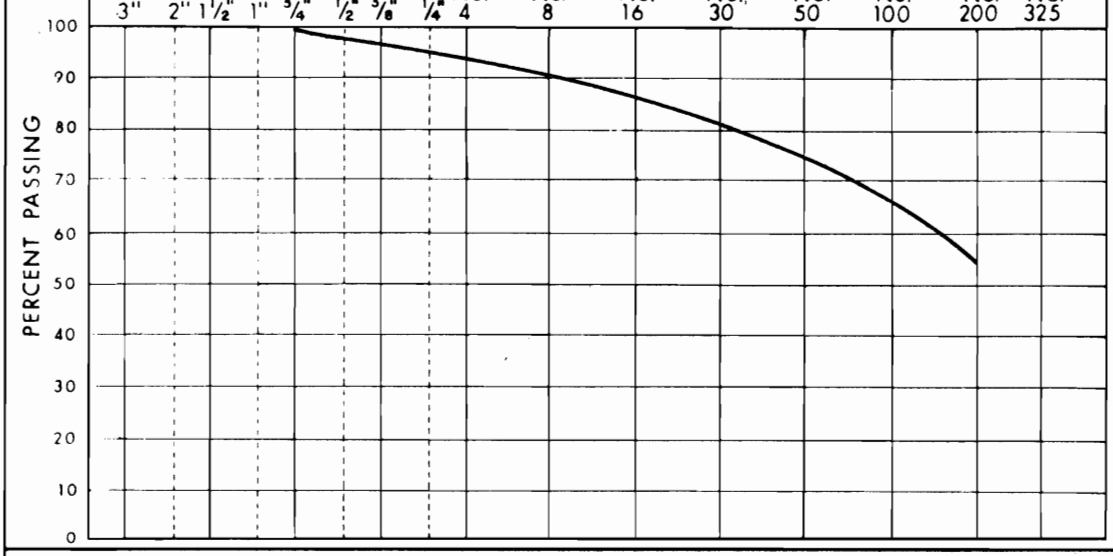
SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B3-1 DEPTH 1.0-3.0

DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 219

GRAVEL SIZES		SAND SIZES			FINES
0%	7 %	4%	11 %	22%	56%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	100.0
½"	98.6
⅜"	97.1
¼"	
No. 4	93.4
No. 8	90.0
No. 16	86.3
No. 30	81.4
No. 50	74.2
No. 100	64.8
No. 200	55.7

COMMENTS

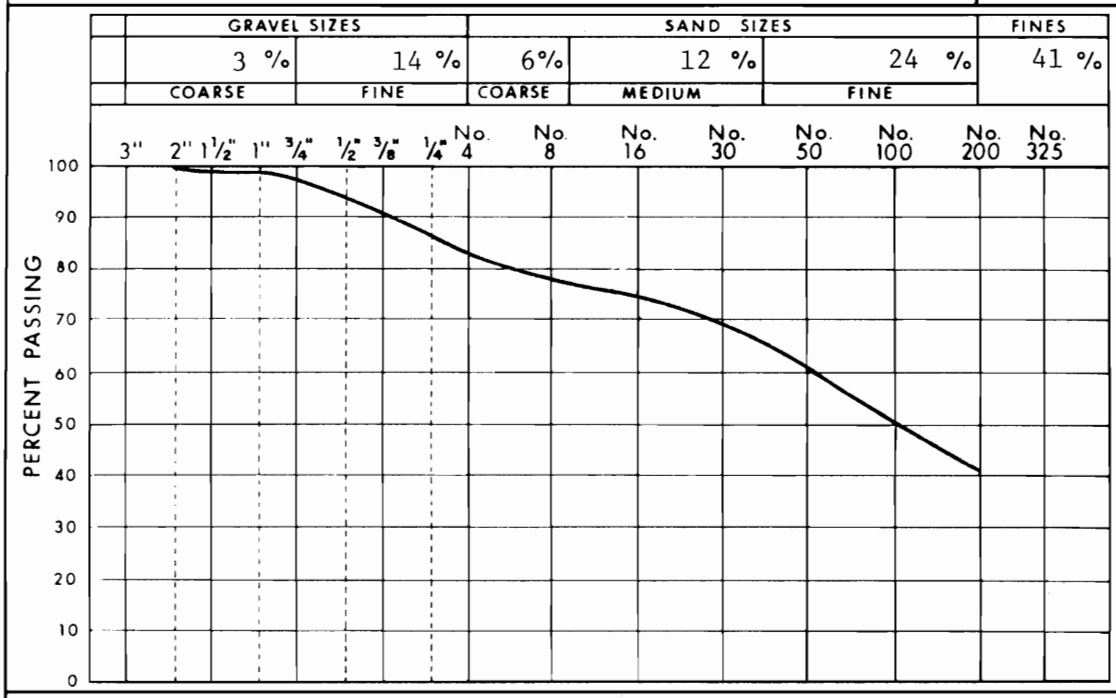
OVERSIZE (>3") = 0.0%

SAMPLE N75-95J-B3-2 DEPTH 1.0-3.0

DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 171

GRAVEL SIZES		SAND SIZES			FINES
3 %	14 %	6%	12 %	24 %	41 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	99.1
1"	99.1
¾"	97.1
½"	93.8
⅜"	91.3
¼"	
No. 4	82.8
No. 8	78.7
No. 16	74.4
No. 30	68.9
No. 50	60.8
No. 100	50.3
No. 200	41.2

COMMENTS Moisture contents range from 9.5 to 24.6%.

OVERSIZE (>3") = 0.0 %

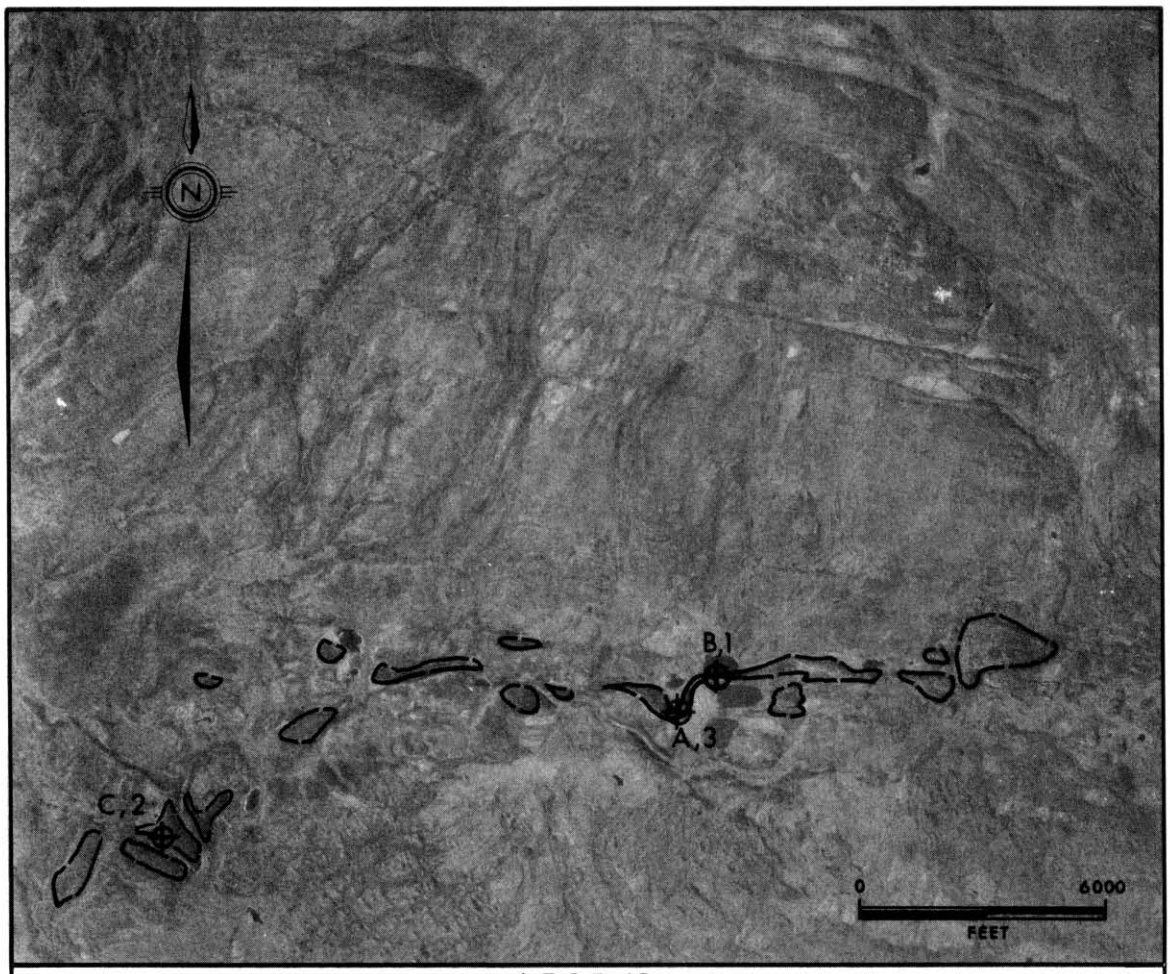
DEPOSIT 95J-B4

Physical Setting: Deposit 95J-B4 is part of a E.W trending esker-kame complex. The pipeline is 1½ miles southwest.

Material: GRAVEL and SAND - layered, well to poorly graded, silty.

Volume: 6,600,000 cubic yards.

Assessment: Deposit 95J-B4 is a source of good quality granular material suitable for general fill, embankment fill, and building pads.



LEGEND

Deposit Outline

MP 335 — Proposed Gas Pipeline Route

+A Drill Hole Location

Mackenzie Highway

3⊙ Test Pit Location

Airphoto No. A18044-153

Approximate Scale: 1" = 4700'

Latitude: 63° 44' N.

Longitude: 122° 41' W.

DEPOSIT 95J-B4

PHYSICAL SETTING

Deposit 95J-B4 is the eastern portion of an east-west trending esker-kame complex located east of the McConnell Range and 3 miles north of Willowlake River. The pipeline is 1½ miles southwest of the deposit.

This discontinuous ice contact deposit is situated in a meltwater channel which extends through a gap in the easternmost ridge of the McConnell Range. Deposit 95J-B3 also occupies the meltwater channel and forms the western portion of this esker-kame complex. Immediately north and almost at right angles to 95J-B4 and 95J-B3 is a series of moraine ridges and immediately south of 95J-B4 is a field of crevasse fillings.

The esker and kames of deposit 95J-B4 stand about 40-50 feet above the surrounding terrain. The surface of the esker and kames is undulating and the esker has steep sideslopes (35°). Both the esker and kames are well drained, but lakes exist in low areas adjacent to the deposit. Silty overburden is generally thin and ice contents are low to nonexistent.

BIOLOGICAL SETTING

A white spruce forest with alder, willow, buffalo-berry, rose, and cranberry dominates this site. The site provides poor moose winter range. Beaver lodges occur in two small adjacent lakes. The adjacent lakes provide only marginal waterfowl habitat. The fisheries potential of lakes and streams is not known. The site lies within the Wrigley hunting and trapping area.

MATERIAL

This deposit is a source of gravel and sand. The gravel is well to poorly graded, fine to coarse, subrounded to subangular, silty, cobbly

to bouldery, and grey with some white carbonate coatings. The sand which occurs as layers within the gravel is fine to coarse grained with some silt.

VOLUME

Assuming 12 feet of sand and gravel exists over an area of 339 acres, the total volume for this deposit is 6.6 million cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 95J-B4 is a source of good quality granular material suitable for general fill, embankment fill in berm construction and building pads. The gravel may also be suitable for base or surface course and possibly concrete aggregate. Location of areas to be exploited will be dictated by haul distance, insitu material quality and material requirements.

Access from the right of way would probably be overland 1½ miles via snow roads. Care would need to be taken in crossing the small tributary to Willowlake River at the west end of the deposit so as not to damage or permanently block the stream.

No biological factos were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially trees and vegetative cover would be cleared from the areas for development. Any overburden would then be stripped from the excavation area and stockpiled around the edge. This material and waste piles should be kept out of the area of future expansion and away from drainage channels and lakes.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage is maintained. Excavation should not be extended below the base of the deposit so that water does not pond in resulting depressions.

Standard excavation techniques and equipment should be adequate for the removal of material from this site.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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
2	CI		CLAY – little gravel (fragments) trace medium to coarse sand, root fibres, wood chips medium grey, hard.		UF								
4			4.7 End of hole					W-1				4.5 4.7	Abandoned: 4" penetration in 45 min.
			Refusal - cobble										

LOGGED BY: K.P.F	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	62°43'37" N, 122°40'58"W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.:	A 18044-153	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	N75-95J-B4-A
CHKD:	RIG:	HELI-DRILL	AIR TEMP:	ENGINEERS FOR	
	METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 12 M 09 Y 75 TIME: 13:40	FINISH: D 12 M 09 Y 75 TIME: 14:35				

TEST HOLE No. N75-95J-B4-A

240

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SP	SAND – coarse, trace fine gravel, med. brown, poorly graded.	UF					0.5	
1.0		cobbles encountered at 1.0'		W1				1.0	
2	GP ?	GRAVEL – air forces up well sorted, fine gravel cuttings, med. brown, dry.						2.5	hole sloughing
4									
6									
8.0		End of hole						8	
8									

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

LOGGED BY: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 62°43' 44'' N, 122°40' 37'' W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 18044-153	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 10°C	ENGINEERS FOR
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 12 M 09 Y 75 TIME: 12:10	FINISH: D 12 M 09 Y 75 TIME: 12:40		

TEST HOLE No. N75-95J-B4-B

SHEET 1 OF 1

TEST HOLE No. N75-95J-B4-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
0	Pt		0.5 PEAT - med. brown, fibrous, moss, wood chips roots		UF							0.5	
	ML		SILT - clayey, trace fine sand, med. brown, damp and soft.					W1	X			1.0	
2			3.0 sand becoming coarser									3.0	
4								W2	X			4.0	
			5.0		F								
6			7.0 little fine gravel (¼") some med–coarse sand.									7.0	
8								W3	X			8.0	
10			10.0										
	GM		GRAVEL - silty, small boulders 11.0										
12	ML		SILT - trace medium to fine sand (trace fine gravel cuttings) med. grey. 13.0										
14	GM		GRAVEL - fine, very silty, little coarse sand.										
16													

LOGGED BY: K.P.F	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°43' 09'' N, 122°45' 56'' W		ELEVATION:		
DRWN. BY: K.M.	AIRPHOTO No.: A 18044–153		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-95J-B4-C
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 10°C		
	METHOD: AIR				
START: D 12 M 09 Y 75 TIME: 15:30		FINISH: D 12 M 09 Y 75 TIME: 16:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2

PC-9,SK373

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TEST HOLE No. N75-95J-B4-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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GM				F	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
18			18.0 fine gravel										
20			20.0 increasing silt.										
22													
24													
26													
28			28.0 End of hole									28	Lost ciruclation difficulty in pulling out of hole.

LOGGED BY: K.P.F	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 62°43'09'' N, 122°45'56'' W		ELEVATION:		
DRWN. BY: K.M.	AIRPHOTO No.: A 18044-153		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-95J-B4-C
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 10°C		
	METHOD: AIR				
START: D 12 M 09 Y 75 TIME: 15:30		FINISH: D 12 M 09 Y 75 TIME: 16:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2

TEST HOLE No. N75-95J-B4-C

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.2 PEAT - woody, brown, roots, cobbles, boulders at surface		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
1	* GW-GM		GRAVEL - fine to coarse, some medium, coarse, fine sand, light brown, oxidized, roots, cobbles, boulders										
			1.5 at depth 1.5', brown, no organic matter				MA G = 55% S = 33% F = 12%	B1	X			2.0	Oversize material (>3'') not included in test sample
2												2.5	
3			3.5 Bottom of pit									3.5	
			* Note: Boulders to 36'' diameter from surface to bottom of pit. When pit was back-filled approximately 50% of volume was occupied by cobbles and boulders										

LOGGED BY:	S.C.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	62°43'37''N, 122°40'58''W	ELEVATION:	
DRWN. BY:	A.J.B.	AIRPHOTO No.:	A 18044-153	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 12°C
		METHOD:	TEST PIT		

START: D 12 M 09 Y 75 TIME: 10:30 FINISH: D 12 M 09 Y 75 TIME: 13:00

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-95J-B4-1

SHEET 1 OF 1

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TEST HOLE No. N75-95J-B4-1

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 fine to medium sand, roots, light brown		UF								
0.4													
1	GW		GRAVEL - coarse, subrounded to sub-angular, little fine to coarse sand, (trace silt inclusions), cobbles, occasional boulders (12" x 12" x 10"), grey, calcite deposits on gravel				MA, combined, samples 1 - 5 G = 41% S = 52% F = 7% (SW)	B1				1	
2								B2				2	
3								B3				3	
4								B4				4	
4.5													
5	SP		SAND - medium to coarse, trace fine gravel subrounded, damp, dark brown gravel becoming coarse at 5.5'					B5				5	
6.0			Bottom of pit										
6												6	

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 62°43'44''N, 122°40'37''W	ELEVATION:			
DRWN. BY: G.B.	AIRPHOTO No.: A 18044-153	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95J-B4-2	
CHKD:	RIG:	AIR TEMP.: Approx. 13°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 12 M 09 Y 75 TIME: 11:00	FINISH: D 12 M 09 Y 75 TIME: 13:50				

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TEST HOLE No. N75-95J-B4-2

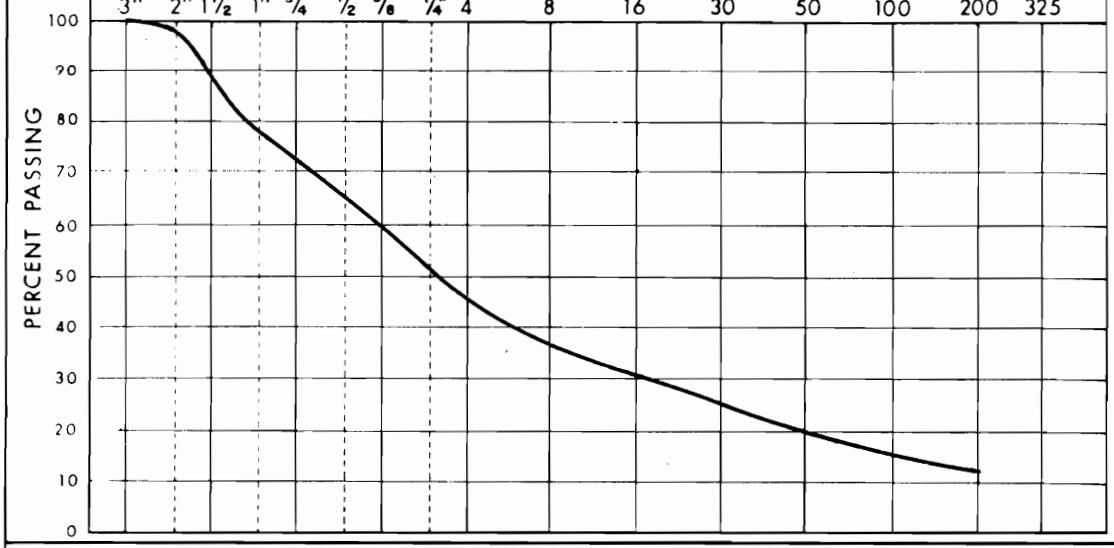
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B4-1 DEPTH 2.0-2.5
DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 207

GRAVEL SIZES		SAND SIZES			FINES
26 %	29 %	10 %	13 %	10 %	12 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	98.2
1½"	89.1
1"	77.6
¾"	73.8
½"	65.4
⅜"	59.2
¼"	
No. 4	45.4
No. 8	37.3
No. 16	31.0
No. 30	25.1
No. 50	20.1
No. 100	15.4
No. 200	12.3

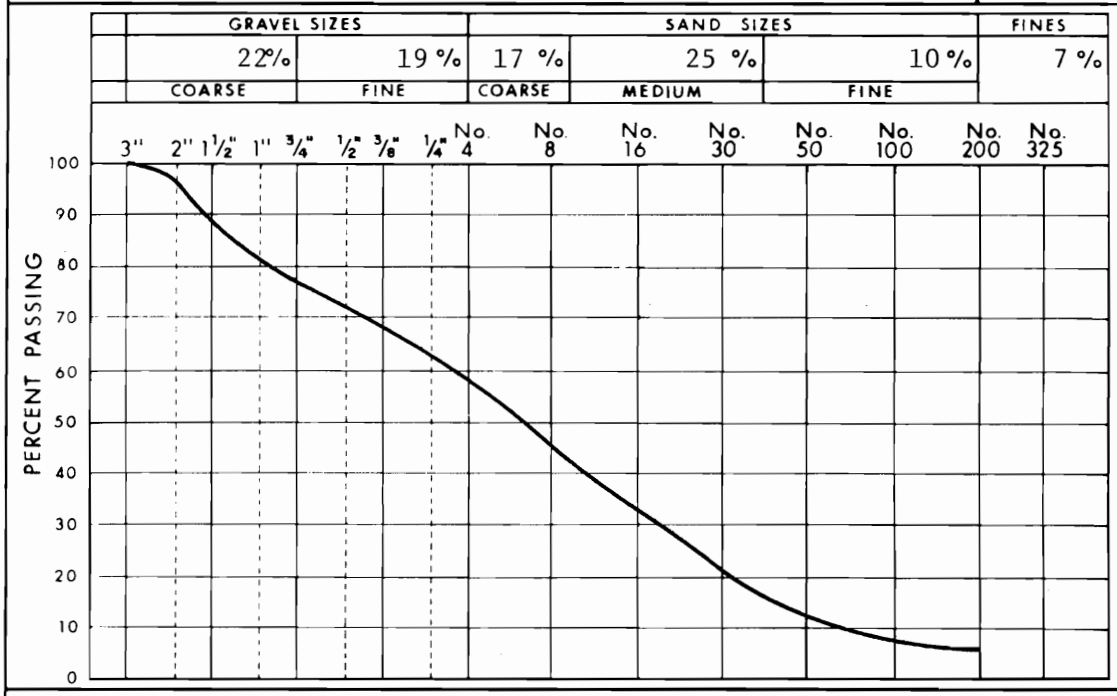
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-95J-B4-2 DEPTH 1.0-6.0
DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 11

GRAVEL SIZES		SAND SIZES			FINES
22%	19 %	17 %	25 %	10 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.9
1½"	88.7
1"	81.4
¾"	77.7
½"	72.4
⅜"	67.7
¼"	
No. 4	58.6
No. 8	45.0
No. 16	33.4
No. 30	20.9
No. 50	12.1
No. 100	8.7
No. 200	7.0

COMMENTS

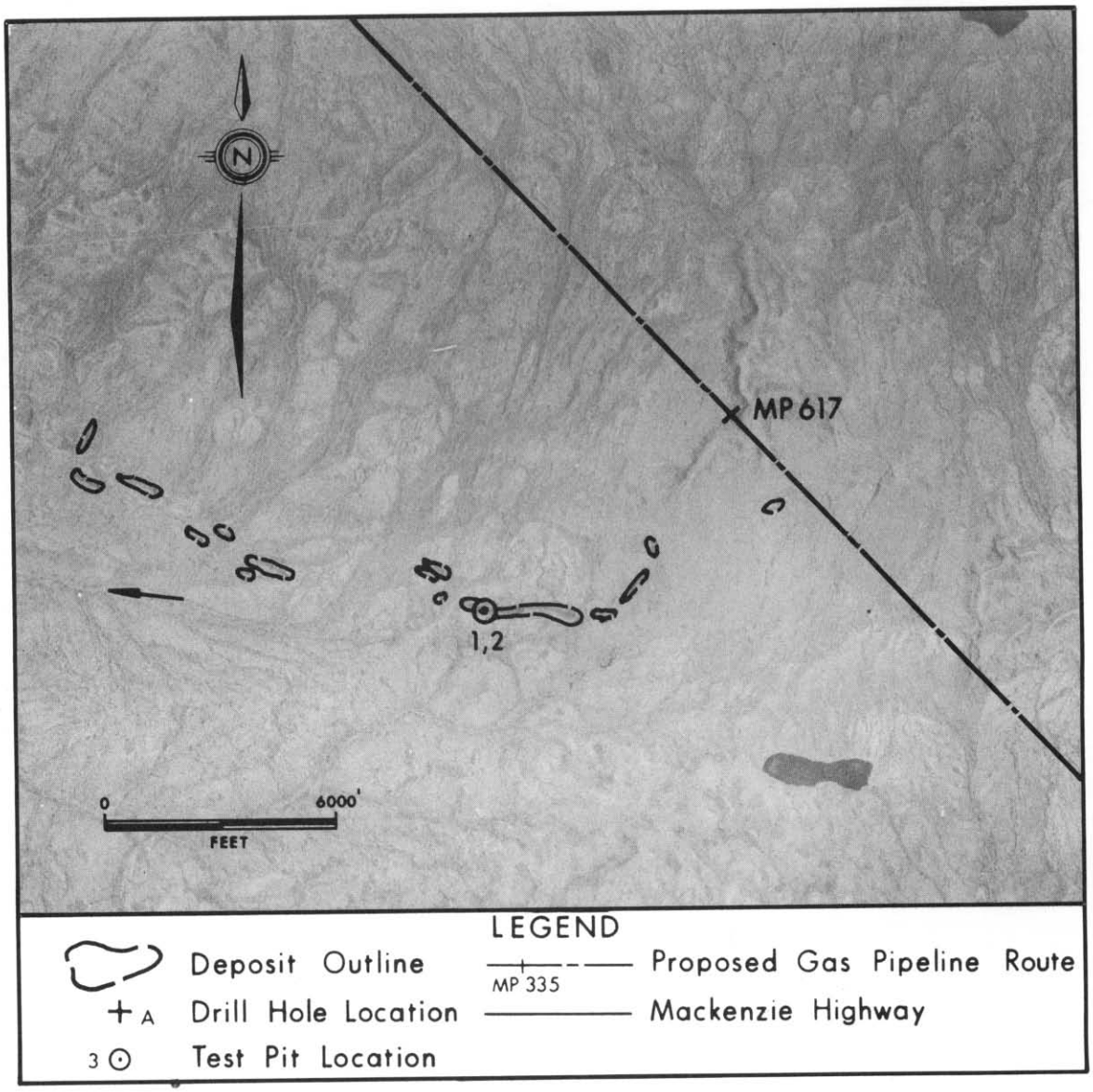
OVERSIZE (>3") = 0.0 %

Physical Setting: Deposit 95J-B5 is a discontinuous esker ridge located 6 miles south of Willowlake River and near M.P. 617 of the proposed pipeline route.

Material: SAND and GRAVEL - well graded gravel, poorly graded sand, layered.

Volume: 500,000 cubic yards.

Assessment: Deposit 95J-B5 is a source of good quality granular material suitable for embankment fill, building pads, base and surface course aggregate, and concrete aggregate.



Airphoto No. A18044-172
Approximate Scale: 1" = 4650'

Latitude: 62° 33' N.
Longitude: 122° 34' W.

PHYSICAL SETTING

Deposit 95J-B5 is a low, discontinuous esker ridge located 19 miles east of the Mackenzie River and 6 miles south of Willowlake River. Mile 617 of the proposed gas pipeline is near the eastern end of this ridge.

The esker is about 4½ miles long and 10 to 15 feet high. The ridge is 200 feet wide at this base. The deposit is located in a poorly drained channeled till plain, but the esker ridge itself is well drained. Test pits indicate the esker is unfrozen.

BIOLOGICAL SETTING

Vegetation on the site consists of pine, white spruce, white birch and black spruce with an understory of cranberry, buffalo-berry, rose and lichen. The site provides potential caribou habitat. A beaver dam occurs on a small adjacent creek. Waterfowl and raptor habitat is limited. No suitable fish habitat was identified in the area.

MATERIAL

The esker is stratified sand and well graded gravel. The gravel is fine to coarse grained, subrounded to subangular, with a few cobbles and a trace of silt. The main components are granite, limestone and altered siliceous rocks. Subordinate rock types are siltstone, sandstone and quartzite. The sand layers are dark brown and poorly graded with medium to coarse sizes. The estimated overall sand to gravel ratio is about 60:40. This material was found to be a good quality concrete aggregate based on petrographic, abrasion and sulphate tests.

VOLUME

Assuming an average thickness of 6 feet over an area of 52 acres, the expected total volume is 500,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 95J-B5 is a source of good quality granular material suitable for embankment fill, building pads, base and surface course aggregates, as well as concrete aggregate. The esker ridge is located in an area where granular deposits are scarce.

Access would be via a one mile snow road over flat terrain to the deposit. Development should occur from east to west for pipeline purposes.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Any overburden would then be stripped and stockpiled around the excavation area. Development would involve removal of layers from the side of the esker. This could be accomplished using conventional techniques and equipment. Natural mixing during excavation should provide adequate gradations.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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		0.25 PEAT - roots, dark brown, surface boulders		UF								
	SW		SAND - medium to coarse, trace gravel, occasional cobbles										
1			1.0									1	
	GW		GRAVEL - fine to coarse, subrounded to subangular, some medium to coarse sand, occasional cobbles, trace silty clay, dark brown				MA, combined samples 1 - 6 G = 31% S = 64% F = 5% (SW)	B1					
2			2.2									2	
	SP		SAND - medium to coarse, trace fine gravel, damp, dark brown					B2					
			2.7										
3	GW		GRAVEL - fine to coarse, subrounded to subangular, some medium to coarse sand, damp, dark brown					B3				3	
			3.4										
	SP		SAND - medium to coarse, trace fine gravel, damp, dark brown										
			3.9										
4	GW		GRAVEL - fine to coarse, subrounded to subangular, some medium to coarse sand, damp, dark brown					B4				4	
			5.0										
5	SP		SAND - medium to coarse, little fine gravel, damp, dark brown					B5				5	
			6.0										
6			no coarse sand after 6.0'					B6				6	
			7.0 Bottom of pit										
7												7	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°32'56''N, 122°34'26''W		ELEVATION:		
DRWN. BY: G.B.	AIRPHOTO No.: A 18044-172		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95J-B5-1
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 12 M 09 Y 75 TIME: 18:30		FINISH: D 12 M 09 Y 75 TIME: 19:30			

TEST HOLE No. N75-95J-B5-1

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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	SM		SAND - fine, some silt, light brown, roots 0.5		UF		w%					0	
1	SM		SAND - cmf, little silt, trace gravel and cobbles, reddish brown 1.0				MA, samples 1 & 2 +3" = 7.3% of total G = 48% S = 47% F = 5% (GW)	B1				1	
2	GW		GRAVEL - fine to coarse, subrounded - subangular, and coarse to fine sand, damp, well graded 3.0					B2				2	
3	SW		SAND - mfc, some fine to coarse gravel, subrounded, damp				MA, Combined 3 & 4 G = 34% S = 62% F = 4% (SW)	B3				3	
4								B4				4	
5			5.0 Bottom of pit									5	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 62°32'56"N, 122°34'26"W		ELEVATION:		N75-95J-B5-2
DRWN. BY: G.B.	AIRPHOTO No.: A 18044-172		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C		
	METHOD: TEST PIT				
START: D 12 M 09 Y 75 TIME: 18:30		FINISH: D 12 M 09 Y 75 TIME: 19:30		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

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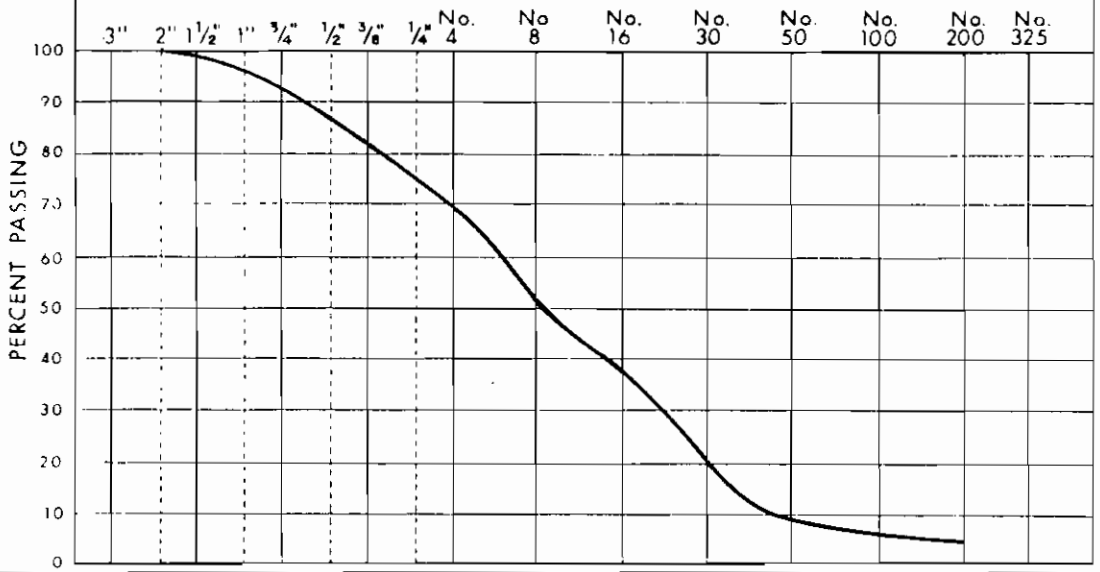
TEST HOLE No. N75-95J-B5-2

SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B5-1 DEPTH 1.0-7.0
DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 10

GRAVEL SIZES		SAND SIZES			FINES
8 %	23 %	21 %	33 %	10 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	99.6
1"	94.9
¾"	91.8
½"	86.7
⅜"	81.1
¼"	
No. 4	69.2
No. 8	51.5
No. 16	36.2
No. 30	20.0
No. 50	9.7
No 100	6.2
No. 200	4.8

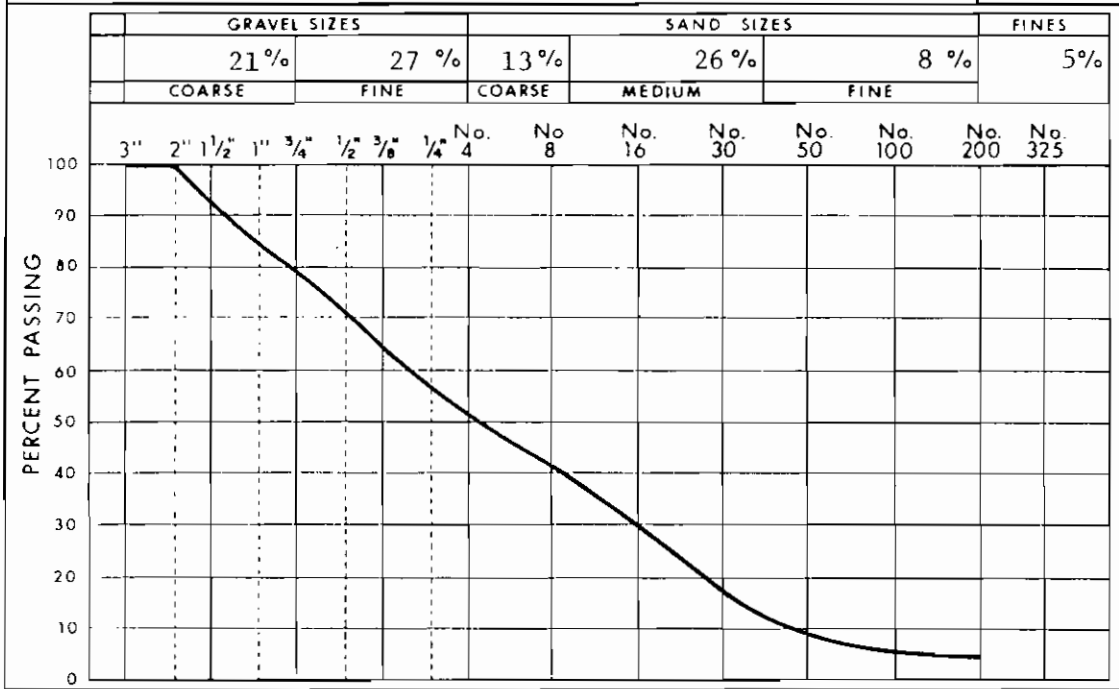
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-95J-B5-2 DEPTH 1.0-3.0
DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 56

GRAVEL SIZES		SAND SIZES			FINES
21 %	27 %	13 %	26 %	8 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	93.3
1"	85.9
¾"	79.4
½"	69.9
⅜"	64.1
¼"	
No. 4	52.3
No. 8	41.7
No. 16	29.8
No. 30	17.0
No. 50	9.5
No 100	6.6
No. 200	4.9

COMMENTS Moisture contents range from 3.2 to 5.6%

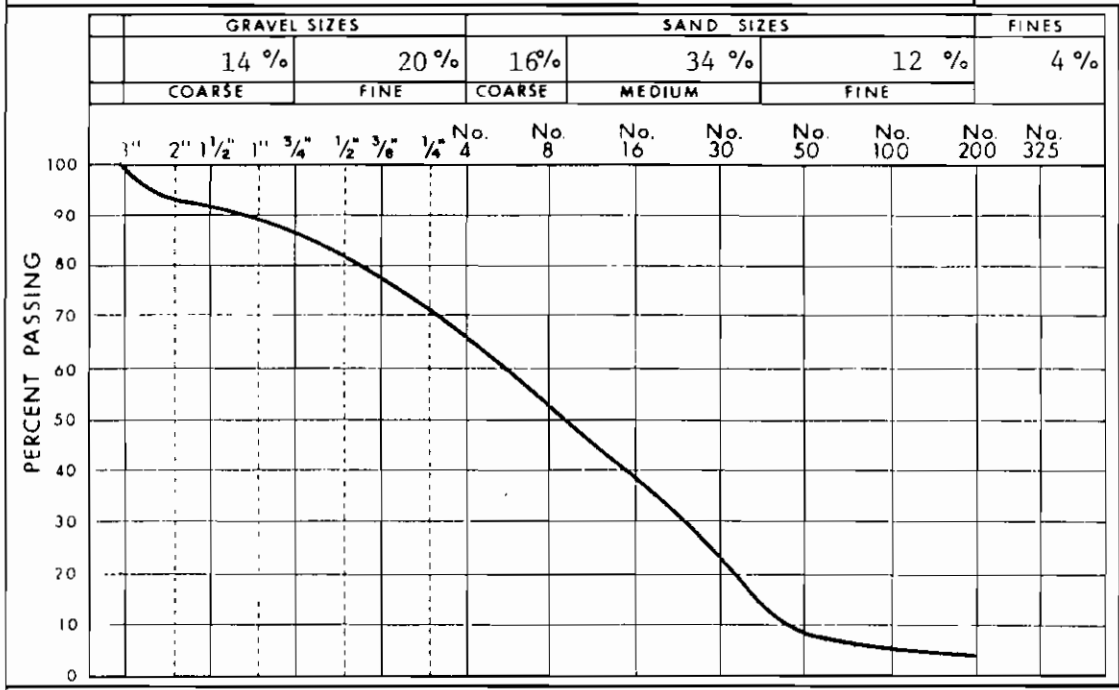
OVERSIZE (>3") = 7.3 %

SIEVE ANALYSIS REPORT

SAMPLE N75-95J-B5-2 DEPTH 3.0-5.0

DATE SAMPLED September 12, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 55



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.2
1½"	91.9
1"	89.4
¾"	86.3
½"	81.1
⅜"	77.3
¼"	
No. 4	66.0
No. 8	52.9
No. 16	38.8
No. 30	22.8
No 50	8.1
No 100	5.1
No. 200	4.1

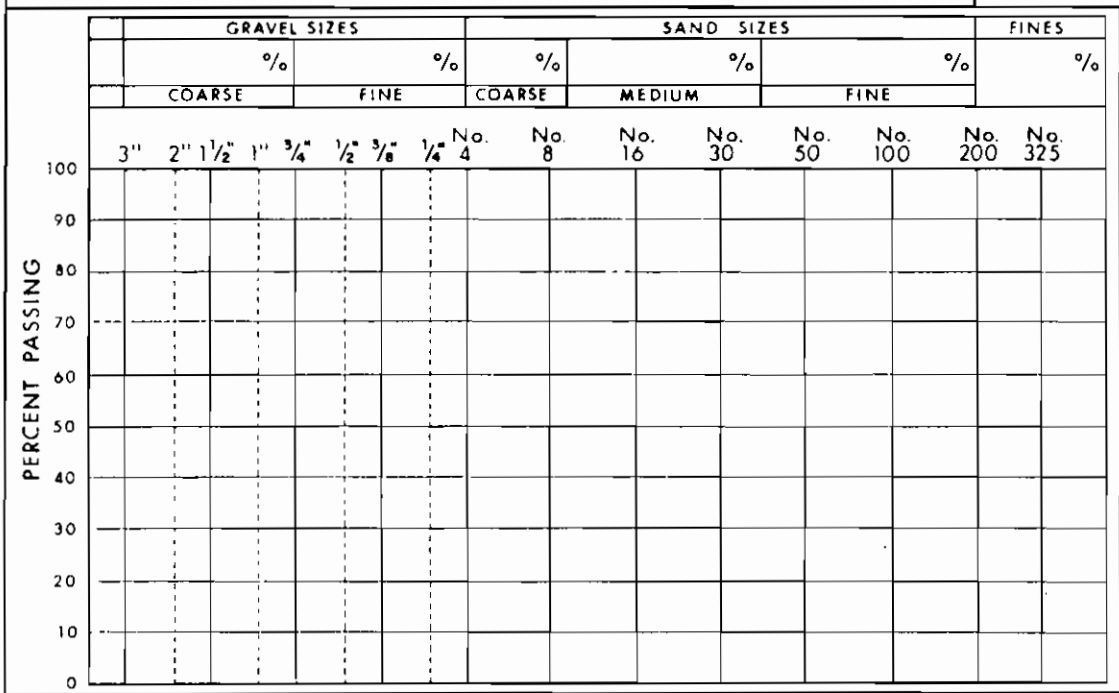
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE _____ DEPTH _____

DATE SAMPLED _____ SAMPLED BY _____

R.M.HARDY REPORT NUMBER _____



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") = %

SUMMARY OF LABORATORY TEST DATA FOR SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-95J-B5-1 DATE SAMPLED September 12, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-7 DATE TESTED March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 8.27 %
FINE AGGREGATE : LOSS = 14.64 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 21.2 %

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	2.95
Granite		7.18
Sandstone	Medium strong, Hard, Good	3.15
Siltstone		3.15
Limestone	Medium strong, Good	5.55
Altered Silicious Rocks		7.90
Soft Sandstone	Friable, Soft, Poor	0.10
Ironstone	Friable, Weak, Deleterious	0.42
PN = 114	INTERPRETATION : Good	30.40

COMMENTS : Organic impurities test satisfactory.

Northern Engineering Services Company Limited

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

DEPOSIT No. N75-95J-B5

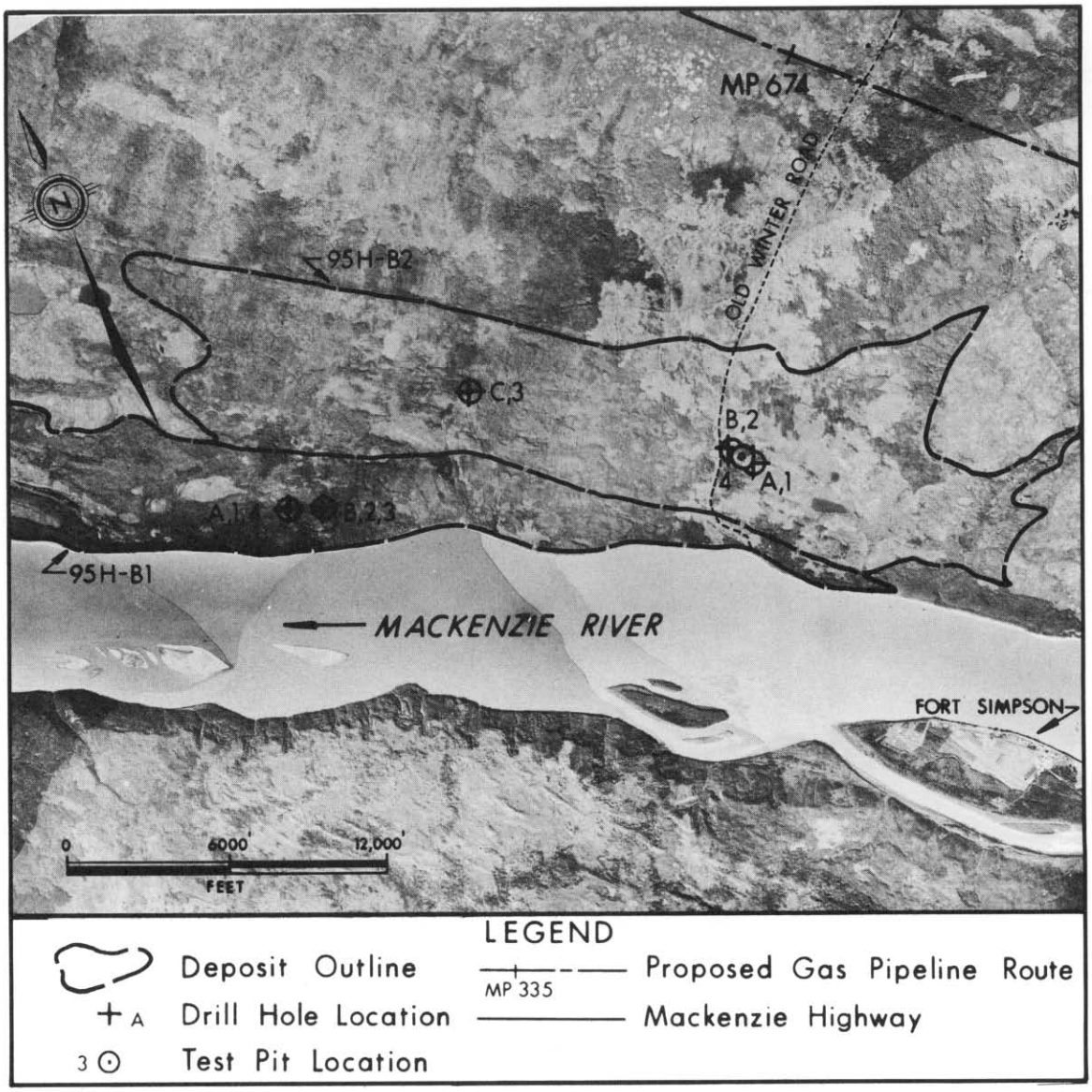
DEPOSIT 95H-B1

Physical Setting: Deposit 95H-B1 is a glaciofluvial terrace located on the north bank of the Mackenzie River 2 miles downstream of Fort Simpson.

Material: GRAVEL - fine to coarse, cobbly, sandy, shaley and limited to pockets and lenses.

Volume: 6,700,000 cubic yards.

Assessment: Deposit 95H-B1 is a source of fair to good quality granular material suitable for general fill, backfill, building pads and possibly concrete aggregate. Further investigation and testing is required.



Airphoto No. A11028-353 to 356; A11038-45, 46
Approximate Scale: 1" = 6700'

Latitude: 61° 55' N.
Longitude: 121° 28' W.

DEPOSIT 95H-B1

PHYSICAL SETTING

Deposit 95H-B1 is a glaciofluvial terrace located along the north bank of the Mackenzie River, 2 miles north of Fort Simpson. Mile 672 of the proposed pipeline is 4 miles north of the deposit. This deposit corresponds to source number FS-12 in Pemcan Services DIAND Granular Materials Inventory (1972) report.

The terrace is about 18 miles long and 1½ miles wide. It stands about 50 feet above the Mackenzie River and has a fairly flat surface. The entire area of the terrace does not appear on the airphoto which accompanies this writeup.

River erosion has exposed gravel pockets in the terrace which are at least 30 feet thick. Till underlies the gravel and shaley bedrock is exposed at the base of the terrace near river level.

Overburden of peat and silt are found over the gravel. Silt overburden ranges in thickness from 6 to 15 feet. Peat cover is from 0 to 2 feet thick.

Drainage on the terrace is fair to poor and peat filled depressions are common. Sand and gravel layers are generally unfrozen but silt layers at the surface have low to medium ice contents, especially away from the river exposure.

BIOLOGICAL SETTING

This extensive site has a mixed forest cover of black and white spruce, aspen and white birch (up to 60 feet high) with an understory of buffaloberry, rose, cranberry and bearberry. The site supports a wide range of

wildlife, but disturbances in the area including the CNT line, numerous other cut lines, a winter road, air traffic, marine traffic, hunting and trapping have reduced populations. Black bear tracks and red squirrels were seen during the 1975 survey. An eagle was flushed, but a nest was not located. The area provides fair moose winter habitat. The Mackenzie River supports several resident and migratory species of fish, including whitefish, grayling, cisco, sucker and pike.

MATERIAL

The granular material from this site is of fair to good quality, but good materials are limited to pockets and lenses within the terrace. The gravel ranges from fine to coarse with a large cobbly fraction and some boulders. The gravel is subrounded to subangular, sandy and primarily composed of shale and igneous rock.

VOLUME

The discontinuous nature of the terrace gravels makes it difficult to give accurate total volume estimate for granular material. In the 1380 acres studied, granular material is assumed to be present over 25% of the area. An estimate of 6.7 million cubic yards is based on an average thickness of 12 feet over 25% of the 1380 acres. More drilling is needed to establish how extensive gravel materials are.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B1 is a source of fair to good quality granular material that could be used for fill, backfill in pipeline construction, building pads, and possibly concrete aggregate. However, more data is required to delineate gravel layers in this deposit. Also overburden thickness will have to be studied in some detail because it might affect the choice of site for development.

Care will have to be exercised to protect the Mackenzie River bank from unacceptable disturbance.

Access is possible via a winter road which crosses both the deposit and the pipeline right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially vegetative cover would be removed according to existing land use regulations. Peat and overburden would then be stripped and stockpiled around the edges of the pit area. Development could take the form of a dugout pit excavation accomplished with conventional techniques and equipment.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		PEAT– med. brown, roots, spongy		UF							0	Free water on surface
2.0												2.0	
2	ML		SILT– and cmf. sand, trace fine gravel low plastic, light brown, occasional cobbles.					W1				3.0	
4.0			10" boulder									4.0	10 min. to cut through boulder
4								W2				5.0	
8.0			becoming grey										
8													
14.0													
14	SM		SAND– coarse to fine, silty, little coarse to fine gravel.									15.5	
16								W3				16.5	
24.0													
24	CL		CLAY– some cmf. sand, little fine gravel low plastic, grey, (till-like)										
26													
28.0			End of hole									28	Surface water flowing into hole throughout drilling of hole.

LOGGED BY: S.C.M	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°55'15"N, 121°28'47" W		ELEVATION:		N75-95H-B1-A
DRWN. BY: A.M.	AIRPHOTO No.: A 11026–Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 5°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 15 M 09 Y 75 TIME: 12:30		FINISH: D 15 M 09 Y 75 TIME: 13:15			

TEST HOLE No. N75-95H-B1-A

PC-9,SK373

TEST HOLE LOG

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	Pt	PEAT - med. brown, fibrous, spongy, moss, roots, wood chips	UF							
2		2.5								
4	Cl	CLAY - trace medium to fine sand, med. plastic, grey, occasional fine gravel fragments								
6		7.0 increasing cmf sand content							7.0	
8		9.0			W1	X			8.0	
10	CL	CLAY - little cmf. sand, trace fine gravel low plastic							11.0	
12		13.0 decreasing gravel.			W2	X			12.0	
14		14.0								
16	Cl	CLAY - little med. to fine sand, trace fine gravel, med. plastic, med. grey							17.0	
18		18.0 End of hole			W3	X			18.0	

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: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 61°55'07''N, 121°28'20''W	ELEVATION:	
DRWN. BY: K.M.	AIRPHOTO No.: A 11028- Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 5°C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: AIR		
START: D 15 M 09 Y 75 TIME: 13:50	FINISH: D 15 M 09 Y 75 TIME: 14:15		

TEST HOLE No. N75-95H-B1-B

SHEET 1 OF 1

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TEST HOLE No. N75-95H-B1-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		PEAT - organics, thick moss cover, dark brown to black		UF								No samples taken
			0.75										
1	ML		SILT - little fine sand, organics, light brown and grey, saturated, trace oxidation									1.5	
			1.5 Bottom of pit										

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°55'15"N, 121°26'47"W		ELEVATION:		N75-95H-B1-1
DRWN. BY: A.M.	AIRPHOTO No.: A 11028- Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: D.O.	RIG:		AIR TEMP: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 14 M 09 Y 75 TIME: 10:30		FINISH: D 14 M 09 Y 75 TIME: 11:30			

TEST HOLE No. N75-95H-B1-1

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	Pt		PEAT - organics, moss cover, dark brown to black		UF								No samples taken
			1.0										
	ML		SILT - little fine sand, grey and light brown, wet, occasional cobbles and boulders (24'' x 12'' x 12'')									1.7	
			1.7 Pit abandoned										

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°55'07''N, 121°28'20''W		ELEVATION:		N75-95H-B1-2
DRWN. BY: A.M.	AIRPHOTO No.: A 11028-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: D.O.	RIG:		AIR TEMP.: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 14 M 09 Y 75 TIME: 10:30	FINISH: D 14 M 09 Y 75 TIME: 11:30				

TEST HOLE No. N75-95H-B1-2

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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - organics, dark brown, moist		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
			0.8										
1	SM		SAND - medium, little silt, light brown, wet, occasional boulders (18" x 12" x 12")										
2			2.7										
3	SW-SM		SAND - medium to fine, and fine to coarse gravel, trace silt, pebbles sub-rounded to subangular, light brown, saturated				MA, sample B1 G = 40% S = 52% F = 8%	B1	X			3	
4			4.0 Bottom of pit									4	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	61°55'07"N, 121°28'20"W	ELEVATION:		N75-95H-B1-3
DRWN. BY: R.J.S.	AIRPHOTO No.:	A 11028-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP: Approx. 10°F	ENGINEERS FOR	
	METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 14 M 09 Y 75 TIME: 11:30	FINISH: D 14 M 09 Y 75 TIME: 12:30				

PC-9,SK373

TEST HOLE No. N75-95H-B1-3

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
	Pt		PEAT - organics, dark brown, boulders (12''+), angular to subrounded. 0.75		UF								
1	Cl		CLAY - trace fine sand, medium plastic, organics, brown, wet. 1.5										
	SM		SAND - fine to medium, silty, brown, wet. 2.5					B1	⊠			1.5	
2												2.5	
	ML		SILT - little medium to coarse sand, greenish-brown, saturated, slight oxidation, occasional cobbles. Bottom of pit 3.5									3.5	
3													

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.L.M.	LAT. & LONG: 61°55'15''N, 121°28'47''W	ELEVATION:		N75-95H-B1-4
DRWN. BY: A.J.B.	AIRPHOTO No.: A 11028 - Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 10°C		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 14 M 09 Y 75 TIME: 11:30	FINISH: D 14 M 09 Y 75 TIME: 13:00			

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TEST HOLE No. N75-95H-B1-4

PC-9,SK373

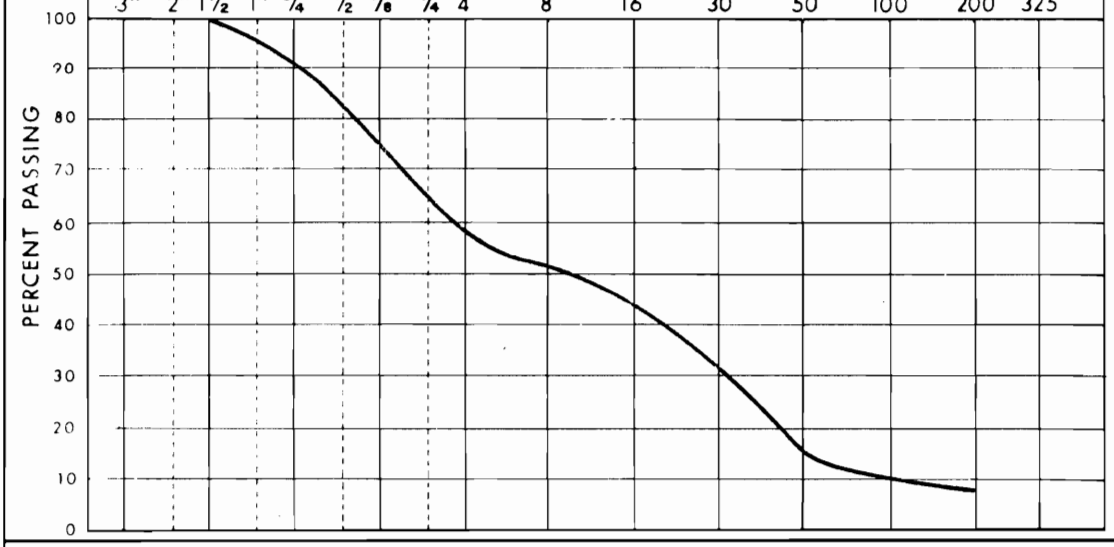
SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B1-3 DEPTH 3.0-4.0

DATE SAMPLED September 14,1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 200

GRAVEL SIZES		SAND SIZES			FINES
9 %	31%	10 %	25 %	17 %	8%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	96.7
¾"	90.8
½"	81.8
⅜"	74.3
¼"	
No. 4	59.7
No. 8	51.8
No. 16	44.9
No. 30	31.8
No. 50	15.8
No. 100	10.5
No. 200	8.2

COMMENTS

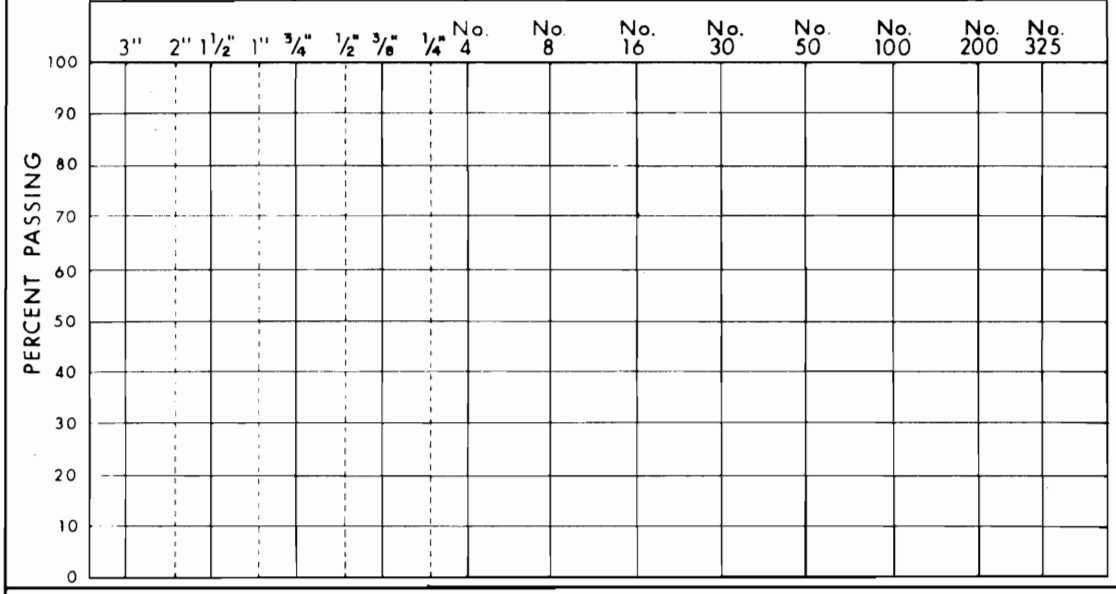
OVERSIZE (>3") = 0.0 %

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

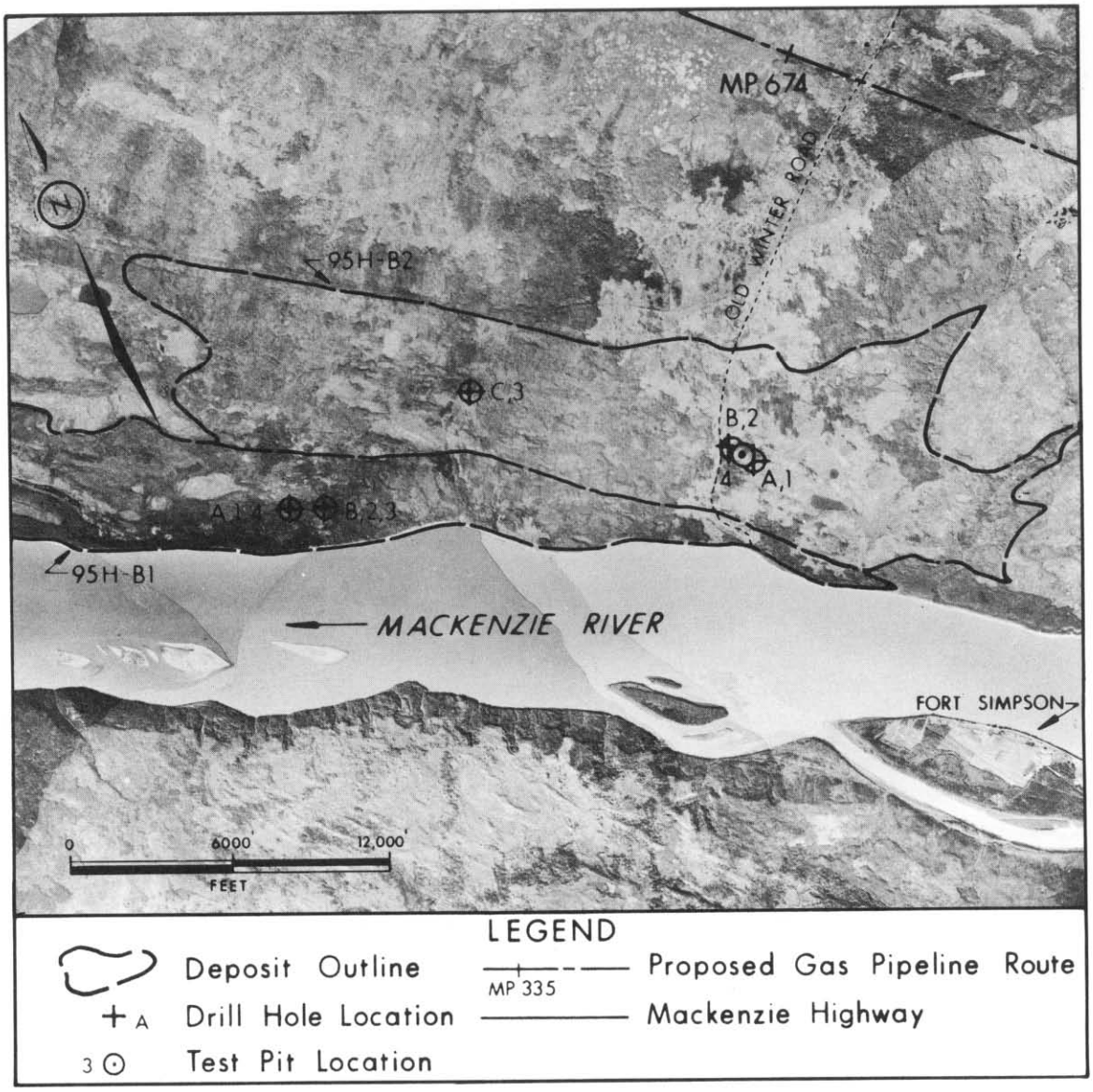
DEPOSIT No. N75-95H-B1

Physical Setting: Deposit 95H-B2 is a till plain terraced by the Mackenzie River. It is located on the west side of the Mackenzie, about 1 mile north of Fort Simpson.

Material: GRAVEL - poorly graded, fine to medium, silty. Sand also occurs in the deposit.

Volume: 1,300,000 cubic yards.

Assessment: Deposit 95H-B2 is a source of fair to good quality granular material suitable for most construction purposes.



Airphoto No. A11028-353 to 356; A11038-45, 46
Approximate Scale: 1" = 6700'

Latitude: 61° 54' N.
Longitude: 121° 23' W.

DEPOSIT 95H-B2

PHYSICAL SETTING

Deposit 95H-B2, located ½ mile north of the Mackenzie River, is a till plain deposit which has been terraced by the Mackenzie River. The till was deposited directly from glacier ice. After the glaciers receded the Mackenzie River covered the till plain deposits adjacent to the river one or more times forming terraces in the vicinity of deposits 95H-B2 and 95H-B1. Sand and gravel was deposited on these terraces and in some localities till and alluvial sands and gravels were also eroded.

The proposed gas pipeline is 2 miles northeast of 95H-B2. The deposit corresponds to source number FS-13 in Pemcan Services DIAND Granular Materials Inventory (1972) report. Subsequent to the field work done for this report a geophysics survey was conducted on this deposit. The results of this survey are discussed in Section 6.

The terrace of this deposit and the adjacent deposit 95H-B1 stand 50-100 feet above the Mackenzie River. A low scarp separates 95H-B2 from till plain deposits to the northeast. The gravel and sand layers which overlie the till are discontinuous and in some places are overlain by 4 to 10 feet of silt and peat overburden. The gravel zone in the vicinity of the old winter road and the airstrip is about ¼ of a square mile. Pemcan determined that over 10 feet of gravel is present in this zone. Also a high ground water table was identified in the gravels. Drill hole logs indicate that finer grained portions of this deposit are sometimes frozen with low ice content especially in areas with peat cover. Gravel zones for the most part appear to be unfrozen.

BIOLOGICAL SETTING

A black spruce (up to 50 feet tall) and larch forest with bog birch and willow is typical of the area. An old winter airstrip on the site is primarily revegetated with bog birch and willow. Black bear tracks

were seen on a winter road on the site during the 1975 survey. No important waterfowl or fisheries habitat was identified at the site. The site lies in the Fort Simpson hunting and trapping area.

MATERIAL

The gravel in this deposit is silty, poorly graded, fine to medium with some coarse and boulder sizes, subangular to subrounded, and predominately limestone and quartzite. The sand is fine to coarse with some gravel.

VOLUME

The gravel pocket contains 1.3 million cubic yards of material assuming a 9 foot depth of deposit over 93 acres area. More granular material may exist in unexplored sections of the deposit.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B2 is a source of fair to good quality granular material suitable for most construction purposes including backfill. Gravel within the deposit may be suitable, with processing, for concrete aggregate. Development of this deposit is environmentally preferrable to 95H-B1 because it is further from the river and portions of the site have been disturbed by an old winter airstrip. Conflict over use of this deposit may occur because it has been suggested as a granular source area for the community of Fort Simpson.

Direct access to the gravelly areas would probably be along the winter road. Seismic lines and other old cut lines could also be used for access to other portions of the dpeosit.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental land use

and socio-economic information prior to final selection and development of the deposit.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Peat and overburden would then be stripped and stockpiled near the site. Excavation could take the form of a dugout pit and could be done with conventional earth-moving techniques and equipment including rippers. A high ground water table might necessitate the need for draining pit areas if summer work is done. Better quality aggregate may be obtained by screening and washing.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		PEAT,- medium brown, fibrous, saturated, roots, moss, grasses.		UF								
5.0													
6	SC		SAND,- fine, trace coarse, clayey, medium grey, occasional fine gravel, saturated at depth 6.5'.										
7.0													
8	CH		CLAY,- little fine sand, high plastic, med. grey, soft.										
9.0													
10	SC		SAND,- medium to coarse, clayey, med. grey, occasional fine gravel.										
20.0			End of hole									20	Abandoned at 20' because of poor circulation and sloughing.

LOGGED BY: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 61°54'18" N, 121°23'03" W	ELEVATION:	
DRWN. BY: K.M.	AIRPHOTO No.: A 11028- Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 5°C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: AIR		
START: D 14 M 09 Y 75 TIME: 18:50	FINISH: D 14 M 09 Y 75 TIME: 20:10		TEST HOLE No. N75-95H-B2-A
			SHEET 1 OF 1

TEST HOLE No. N75-95H-B2-A

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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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
2	Pt		PEAT - dark brown, saturated. Grasses, willow roots.		UF								
			3.0										
4	GC		GRAVEL - silty, clayey; some medium to fine sand, medium grey, pebbles rounded										
			5.0 free flowing water from depth 5.0'										
6													
8													
10			fine, med, coarse sand.										
			12.0 fine gravel										
12			13.0										
14	SW		SAND, - cmf, little fine to coarse gravel, rounded, medium grey, saturated.										Hole sloughing. Reamed three times.
16													

LOGGED BY: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 61°54'22"N, 121°23'15"W	ELEVATION:		N75-95H-B2-B	
DRWN. BY: K.M.	AIRPHOTO No.: A 11028- Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA		
CHKD: J.K.W.	RIG: HELI-DRILL	AIR TEMP: APPROX. 7 °C			
	METHOD: AIR				
START: D 14 M 09 Y 75 TIME: 16:30	FINISH: D 14 M 09 Y 75 TIME: 18:30		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2	

TEST HOLE No. N75-95H-B2-B

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PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION
16	SW	(SAND) cont'd
		17.0
18	CH	CLAY - little fine gravel, little cmf. sand, medium grey, pebbles rounded.
		19.0
20	SW	SAND - fine to coarse, trace fine gravel, rounded medium grey.
22		
26		26.0 little fine gravel, occasional coarse.
28		
32		32.0 trace fine gravel in cmf. sand increasing clay and silt.
34	SW-SC	
40		40.0 End of hole

ICE GRAPHIC LOG | NRC ICE TYPE VISUAL ICE % : UF

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
20	Circulation problems.
22	
26	
28	
32	
34	
40	

LOGGED BY:	K.P.F	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	61°54'22" N, 121°23'15"	ELEVATION:	
DRWN. BY:	K.W.	AIRPHOTO No.:	A 11028-355	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	J.K.W.	RIG:	HELI-DRILL	AIR TEMP: Approx. 7°C	ENGINEERS FOR
		METHOD:	AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 14 M 09 Y 75 TIME: 16:30 FINISH: D 14 M 09 Y 75 TIME: 18:30

TEST HOLE No. N75-95H-B2-B

SHEET 2 OF 2

PC-9,SK373

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TEST HOLE No. N75-95H-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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
0	Pt		PEAT - med. brown, fibrous, roots, grasses, moss, wood chips.		UF							7.0	
2.0	CH		CLAY - med to high plastic, med. grey, firm.					W1				8.0	
9.0			med. brown									11.0	
12.0								W2				12.0	
	Cl		CLAY - some cmf. sand, little gravel, med.-high plastic (till-like)										
16.0				+ + + + + + + + +	Vx			W3				16.0	some ice inclusions in returned cuttings.
18.0					UF ?							17.0	

LOGGED BY: K.P.F	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°55'16'' N, 121°25'53''W		ELEVATION:		N75-95H-B2-C
DRWN. BY: K.M.	AIRPHOTO No.: A 11028- Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 5°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2
START: D 15 M 09 Y 75 TIME: 11:00		FINISH: D 15 M 09 Y 75 TIME: 11:35			

277

TEST HOLE No. N75-95H-B2-C

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
20	CI		CLAY, (cont'd)		UF ?								
22													
			23.0									23.0	
24	SC		SAND - med. to fine, clayey, med. grey, dry.					W4				24.0	
28													
												29.0	
30								W5				30.0	
			31.0 cobble										
32													
			34.0 cobble										
34													
36												36.0	
								W6				37.0	
38			38.0 End of hole										

LOGGED BY: K.P.F	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 61°55'16'' N, 121°25'53'' W	ELEVATION:	
DRWN. BY: K.M.	AIRPHOTO No.: A 11028- Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 5°C	
	METHOD: AIR		
START: D 15 M 09 Y 75 TIME: 11:00	FINISH: D 15 M 09 Y 75 TIME: 11:35		TEST HOLE No. N75-95H-B2-C; SHEET 2 OF 2

TEST HOLE No. N75-95H-B2-C

278

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 – organics, black to dark brown.		UF								
			0.5										
1	SM–ML		SAND – fine-grained, and silt, trace fine to coarse gravel, light brown, occasional cobble, boulder (+12") slight oxidation, occasional sand inclusions.				MA, combined samples 1–5	B1				1	
								B2					
2							G = 10% S = 45% F = 45%					2	
3								B3				3	
								B4					
4			4.5 wet, more sandy									4	
								B5					
5			5.0 Bottom of pit									5	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°54'18''N, 121°23'03'' W		ELEVATION:		N75-95H-B2-1
DRWN. BY: D.J.M.	AIRPHOTO No.: A 11028–Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 16°C	ENGINEERS FOR	
	METHOD: TEST PIT				
START: D 14 M 09 Y 75 TIME: 16:30		FINISH: D 14 M 09 Y 75 TIME: 18:00		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

279

TEST HOLE No. N75-95H-B2-1

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	Pt		PEAT - roots, wood chips, dark brown to black, damp, occasional boulders		UF								no samples taken
2			2.5 Pit abandoned									2.5	
			Frozen at 2.5'		F								

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	61°54'22''N, 121°23'15''W	ELEVATION:	
DRWN. BY:	N.L.	AIRPHOTO No.:	A 11028 - Mosaic	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 16°C
		METHOD:	TEST PIT		

START: D 14 M 09 Y 75 TIME: 14:00 FINISH: D 14 M 09 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. N75-95H-B2-2

SHEET 1 OF 1

280

TEST HOLE No. N75-95H-B2-2

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
0	Pt		PEAT - dark brown, spongy, medium fibrous		UF								No samples
1													
2			2.5 Bottom of pit										Test pit filled with water to a depth of 1.5' after 24 hours

LOGGED BY: S. C. M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R. H.	LAT. & LONG: 61°55'16''N, 121°25'53''W		ELEVATION:		N75-95H-B2-3
DRWN. BY: N. L.	AIRPHOTO No.: A 11028 - Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: J. K. W.	RIG:		AIR TEMP.: Approx. 5°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 14 M 09 Y 75 TIME: 12:00	FINISH: D 14 M 09 Y 75 TIME: 14:00				

281

TEST HOLE No. N75-95H-B2-3

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
1	Pt		PEAT - black to dark brown, damp, frequent boulders (24'' x 12'' x 8'')		UF								
2			2.0									2	
	*SC		SAND - medium to fine, and coarse to fine gravel, some clay, light brown, saturated, very stiff				MA, sample B1 G = 35% S = 37% F = 28% (SC)	B1	X				
3			3.0 Bottom of pit									3	
			* Note: borderline, clayey sand/clayey gravel (GC-SC)										

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	61°54'22''N, 121°23'08''W	ELEVATION:	
DRWN. BY:	R.J.S.	AIRPHOTO No.:	A 11028-Mosaic	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 13°C
		METHOD:	TEST PIT		

START: D 14 M 09 Y 75 TIME: 18:00 FINISH: D 14 M 09 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. N75-95H-B2-4

SHEET 1 OF 1

PC-9,SK273

282

TEST HOLE No. N75-95H-B2-4

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B2-1 DEPTH 0.0-5.0

DATE SAMPLED September 14, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 189

GRAVEL SIZES		SAND SIZES			FINES
4 %	6%	4 %	11 %	30 %	45%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	100.0
¾"	96.4
½"	95.7
⅜"	93.7
¼"	
No. 4	90.3
No. 8	86.7
No. 16	83.5
No. 30	79.0
No. 50	70.6
No. 100	55.5
No. 200	44.9

COMMENTS

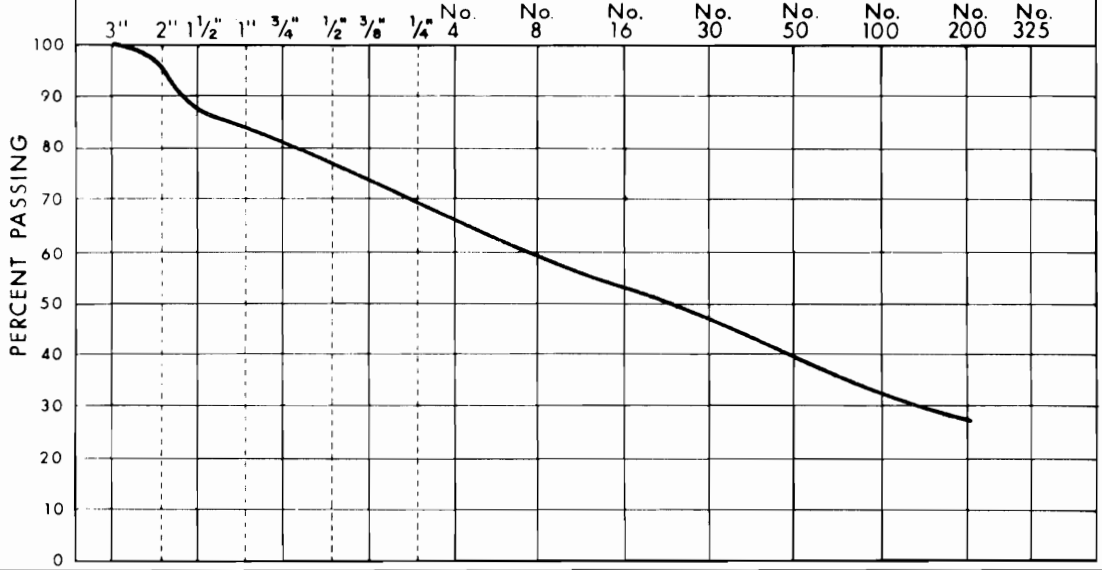
OVERSIZE (>3") = 0.0 %

SAMPLE N75-95H-B2-4 DEPTH 2.0-3.0

DATE SAMPLED September 14, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 186

GRAVEL SIZES		SAND SIZES			FINES
19 %	16%	7 %	16 %	14 %	28 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.6
1½"	87.3
1"	83.5
¾"	80.8
½"	77.0
⅜"	74.0
¼"	
No. 4	65.2
No. 8	59.3
No. 16	53.1
No. 30	47.1
No. 50	39.7
No. 100	32.8
No. 200	27.9

COMMENTS

OVERSIZE (>3") = 0.0%

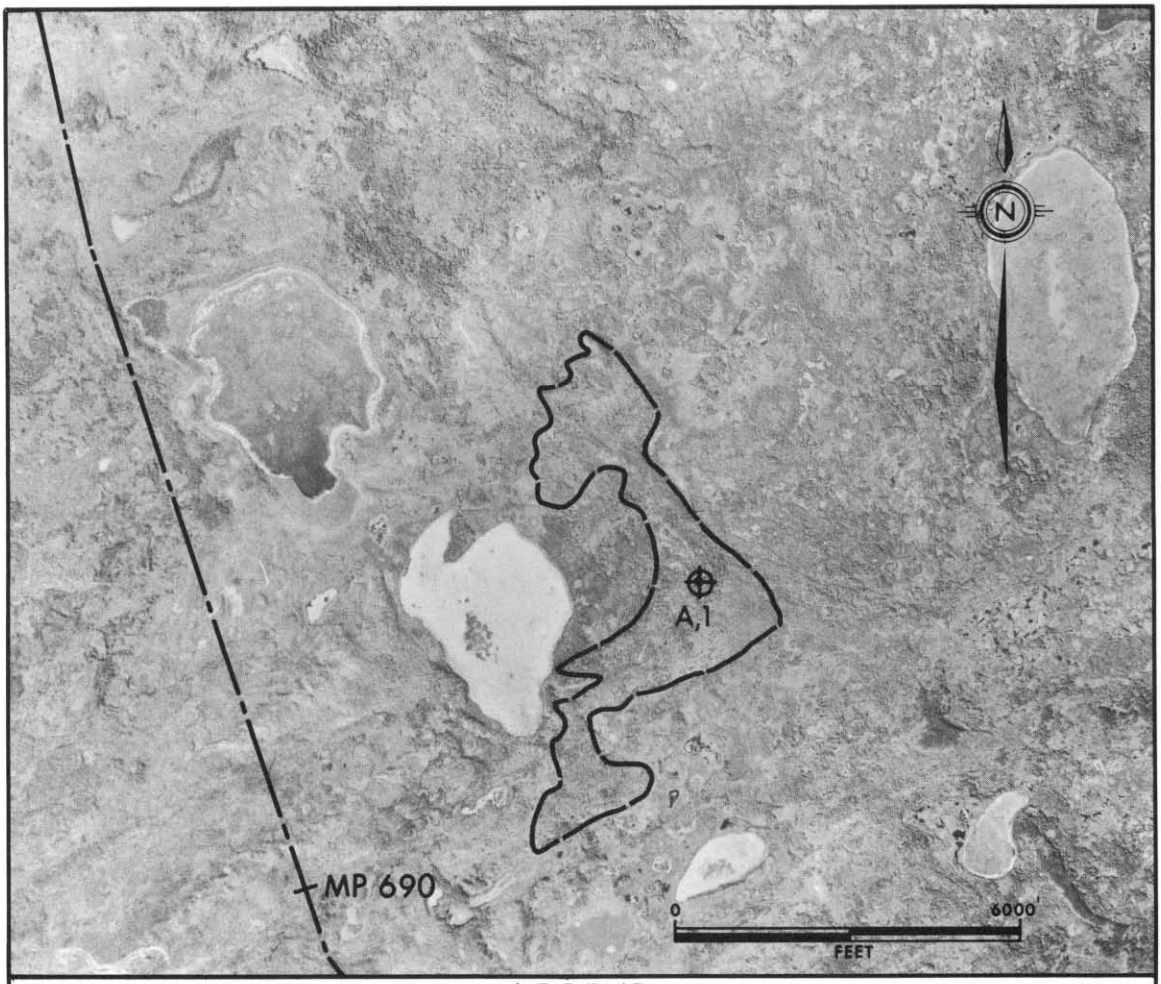
DEPOSIT 95H-B3

Physical Setting: Deposit 95H-B3 is a sand dune located 3 miles east of Fort Simpson and about 1 mile east of the pipeline.

Material: SAND - fine grained, trace fines.

Volume: 7,700,000 cubic yards.

Assessment: Deposit 95H-B3 is a source of poor quality granular material suitable for marginal fill applications.



Airphoto No. A11029-424
Approximate Scale: 1" = 3350'

Latitude: 61° 46' N.
Longitude: 121° 06' W.

DEPOSIT 95H-B3

PHYSICAL SETTING

Deposit 95H-B3 is a sand dune located 3 miles east of Fort Simpson. Mile 690 of the proposed gas pipeline is 1 mile west of the deposit.

The dune is part of a dune field that has developed on glaciolacustrine silts and sands of Glacial Lake McConnell. The dunes in the dune field are well drained and unfrozen, but terrain adjacent to the dunes is flat, poorly drained and in some localities has high ice content permafrost.

The dune of deposit 95H-B3 is about 40 feet high and has 15° sideslopes.

BIOLOGICAL SETTING

An aspen and pine forest with alder, rose, lichen and bunchberry occurs on the site. The area provides woodland caribou habitat. Red squirrels inhabit the area. Limited waterfowl habitat occurs near the site, but the general area is a waterfowl breeding area. A loon was sighted on the nearby lake. No suitable fish habitat was identified near the site. The site lies within the hunting and trapping areas of Fort Simpson and Jean Marie River.

MATERIAL

The sand is poorly graded, fine grained, brown, with a trace fines and some organic material in the upper few feet.

VOLUME

The sand dune contains about 7.7 million cubic yards of material, assuming a 30 foot average height and triangular cross section over an area of 317 acres.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B3 is a source of poor quality granular material suitable for marginal fill applications. The sand from this site is uniform and similar to numerous other dunes in the dune field. Haul distance and environmental concerns would be the deciding factors in choosing a specific site for borrow pit development.

This deposit falls within the Fort Simpson Block Land Transfer area.

Access to the deposit would be via snow roads over the flat glacio-lacustrine plain, a distance of about 1 mile.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially, vegetative cover would be cleared. Overburden, if any, would be stripped and stockpiled around the edges of the site. Development would be accomplished using conventional techniques and equipment. Rippers might be required in winter to break up the frost layer.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SP		SAND - fine, poorly graded, loose		UF								
2													
3.5			grey										
4								W1	X			4.0	
												5.0	
6													
												7.0	
8								W-2	X			8.0	
													Air return samples taken at intervals
36													(1) 4'-5' (2) 7'-8' (3) 12'-13' (4) 17'-18' (5) 23'-24' (6) 27'-28' (7) 32'-33' (8) 37'-38'
												37.0	
								W-8	X				
38			38.0 End of hole									38.0	

LOGGED BY: D.V	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°45'41''N, 121°06'19''W	ELEVATION:		N75-95H-B3-A
DRWN. BY: K.M.	AIRPHOTO No.: A 11029-424	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 6°C		
	METHOD: AIR			
START: D 16 M 09 Y 75 TIME: 12:20	FINISH: D 16 M 09 Y 75 TIME: 12:45		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

TEST HOLE No.N75-95H-B3-A

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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SP-SM		SAND - fine, fairly uniform, light brown, rootlets		UF	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	W%					0	
1							7.1	B1				1	
2			2.3 black, organic inclusions				9.4	B2				2	
3							MA, combined samples 1 - 3 G = 0% S = 95% F = 5% (SP-SM)					3	
4													
5													
6							4.3	B3				6	
7			7.0 Bottom of pit									7	

LOGGED BY: D.V.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION		TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°45'41"N, 121°06'19"W	ELEVATION:			N75-95H-B3-1
DRWN. BY: F.B.B.	AIRPHOTO No.: A 11029-424	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA		
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 8°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED		SHEET 1 OF 1
START: D 15 M 09 Y 75 TIME: 11:20	FINISH: D 15 M 09 Y 75 TIME: 11:50				

TEST HOLE No. N75-95H-B3-1

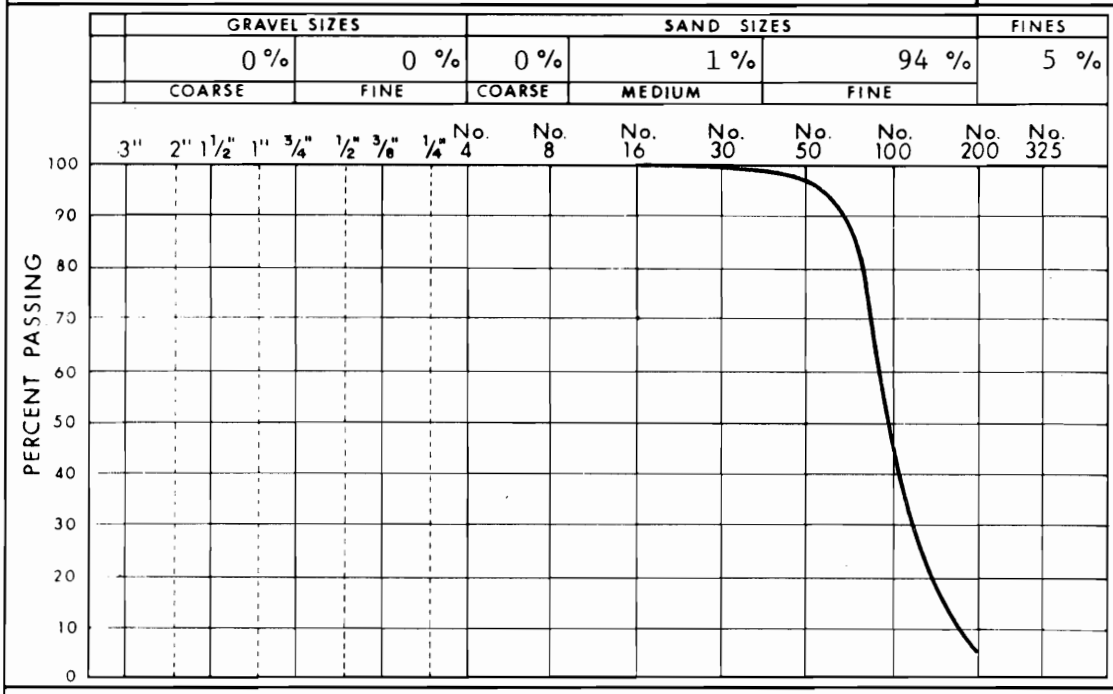
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B3-1 DEPTH 1.0-6.0

DATE SAMPLED September 15, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 159



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	100.0
No. 30	99.9
No. 50	98.4
No 100	45.9
No. 200	5.3

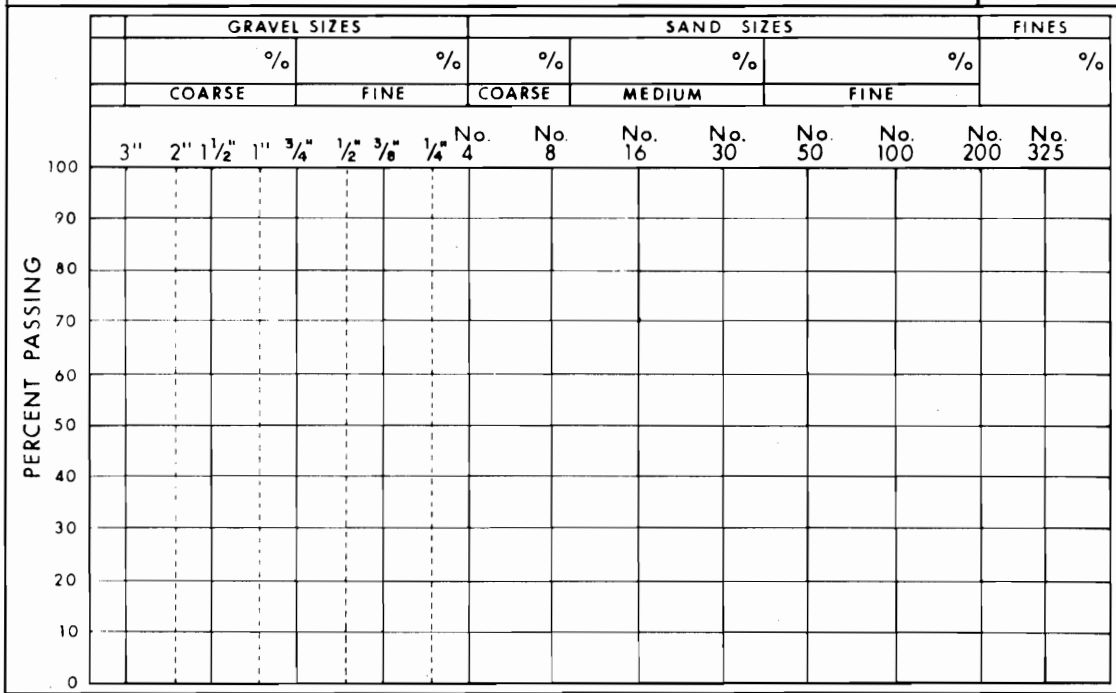
COMMENTS Moisture contents range from 4.3 to 9.4%

OVERSIZE (>3") = 0.0 %

SAMPLE _____ DEPTH _____

DATE SAMPLED _____ SAMPLED BY _____

R.M.HARDY REPORT NUMBER _____



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. N75-95H-B3

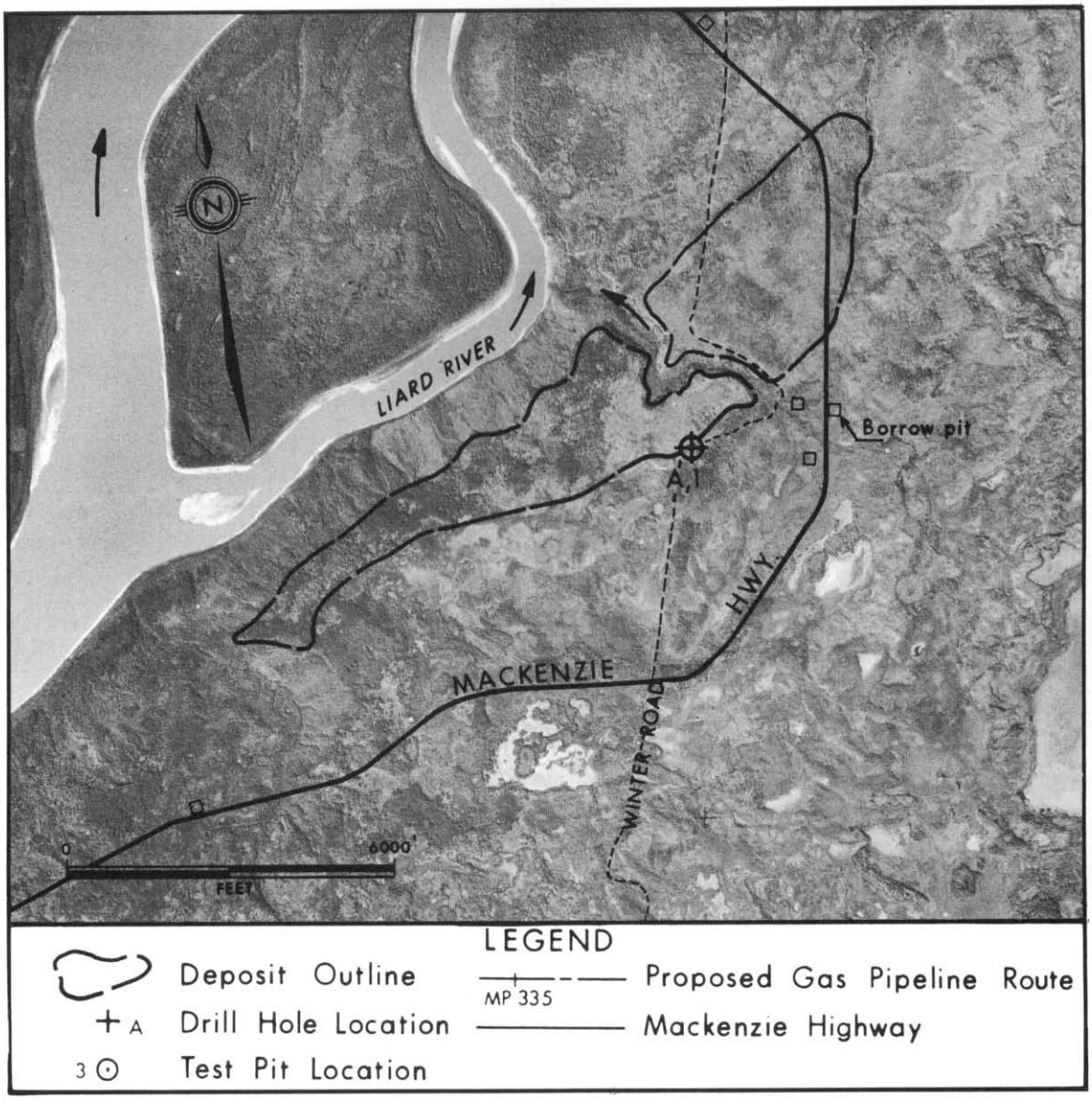
DEPOSIT 95H-B4

Physical Setting : Deposit 95H-B4 is an alluvial terrace along the east bank of the Liard River about 12 miles south of Fort Simpson.

Material : SAND - poorly graded, fine to medium, trace coarse sand to fine gravel.

Volume : 17,800,000 cubic yards.

Assessment : Deposit 95H-B4 is a source of poor quality granular material. Similar material is found closer to the pipeline, therefore it is not recommended for development.



Airphoto No. A11028-331
Approximate Scale: 1" = 3300'

Latitude: 61° 42' N.
Longitude: 121° 14' W.

DEPOSIT 95H-B4

PHYSICAL SETTING

Deposit 95H-B4 is an alluvial terrace along the east bank of the Liard River about 12 miles south of Fort Simpson. The proposed gas pipeline is about 5 miles east-northeast of the deposit and the Mackenzie highway crosses the north end of the deposit.

This terrace is the highest terrace along the Liard River and is 150 feet above the river. A tributary stream has incised a deep gully through the terrace into the underlying till sediments. The deposit may be distinguished from the adjoining glaciolacustrine sand plain because it is linear and has better drainage.

The terrace is flat lying and is fairly well drained. Drill holes indicate that the deposit is unfrozen.

BIOLOGICAL SETTING

The forest on the site consists of mature white spruce and aspen which have potential commercial and domestic value. Moose winter habitat along the Liard River is under-utilized due to hunting pressure from Fort Simpson. No waterfowl or fish habitat is present on the site, but the adjacent Liard River is utilized. The site lies in the Fort Simpson hunting and trapping area.

MATERIAL

Poorly graded, fine to medium, brown sand 20 feet thick is found in the terrace. Traces of coarse sand to fine gravel indicate possibilities of fine gravel lenses.

VOLUME

Assuming a 20 foot depth of sand over an area of 552 acres, a total volume of 17.8 million cubic yards was calculated.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B4 is a source of poor quality granular material which would be suitable for backfill or other marginal fill applications. It falls within the Fort Simpson Land Block Transfer Area. Similar sandy material is found in deposits closer to the pipeline, therefore this deposit is not recommended for development.

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 – organic cover, moss		UF			W 1	X				
			1.5									1.5	
2	SP		SAND – fine to medium, brown										
												3.0	
			4.0 — medium to coarse, brown-grey, loose.					W 2	X			4.0	
4								W 3	X			5.0	
6												7.0	
								W 4	X			8.0	
8													
			(10.0) — grey, wet										
10													
12													
14													
			15.5 — trace fine gravel, sub-rounded										
16													

LOGGED BY: D.V.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 61°41'39'' N, 121°14'17''W.	ELEVATION:			
DRWN. BY: A.M.	AIRPHOTO No.: A 11028-331	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B4-A	
CHKD:	RIG: HELI-DRILL	AIR TEMP.: Approx. 6°C	ENGINEERS FOR		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2	
START: D 16 M 09 Y 75 TIME: 15:10	FINISH: D 16 M 09 Y 75 TIME: 15:45				

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TEST HOLE No. N75-95H-B4-A

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
	SP		(SAND) cont'd		UF							17.0	
18								W5	X			18.0	
			20.0										
20												20.0	
	CH		CLAY – high plastic, grey 21.0 End of hole					W6	X			21.0	

LOGGED BY: D.V	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°41'39''N, 121°14'17'' W		ELEVATION:		N75-95H-B4-A
DRWN. BY: A.M.	AIRPHOTO No.: A 11028-331		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 6°C		
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2
START: D 16 M 09 Y 75 TIME: 15:10		FINISH: D 16 M 09 Y 75 TIME: 15:45			

TEST HOLE No. N75-95H-B4-A

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	SP-SM		SAND - fine, (trace fines), grey		UF		MA, combined, samples 1 - 3 G = 0% S = 92% F = 8%					0	
1								B1				1	
2								B2				2	sand: medium 16% fine 76%
3												3	
4			4.1 medium, brown 4.4 medium, light grey					B3				4	
5												5	
6			5.9 medium, brown					B4				6	
7			7.0 Bottom of pit									7	

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°41'39''N, 121°14'17''W		ELEVATION:		N75-95H-B4-1
DRWN. BY: R.J.S.	AIRPHOTO No.: A 11028-331		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C		
	METHOD: TEST PIT				
START: D 15 M 09 Y 75 TIME: 10:15		FINISH: D 15 M 09 Y 75 TIME: 10:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

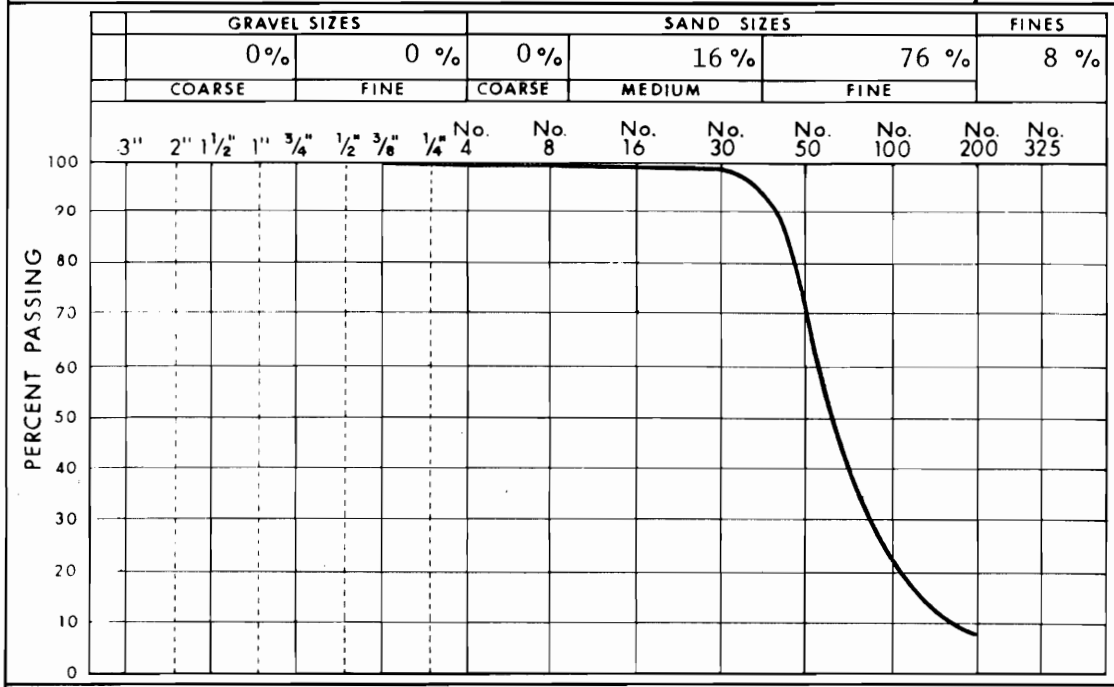
TEST HOLE No. N75-95H-B4-1

PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B4-1 DEPTH 1.0-3.0 & 4.0-5.0
DATE SAMPLED September 15, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 202



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	99.8
No. 8	99.8
No. 16	99.6
No. 30	99.0
No. 50	69.4
No. 100	22.4
No. 200	8.3

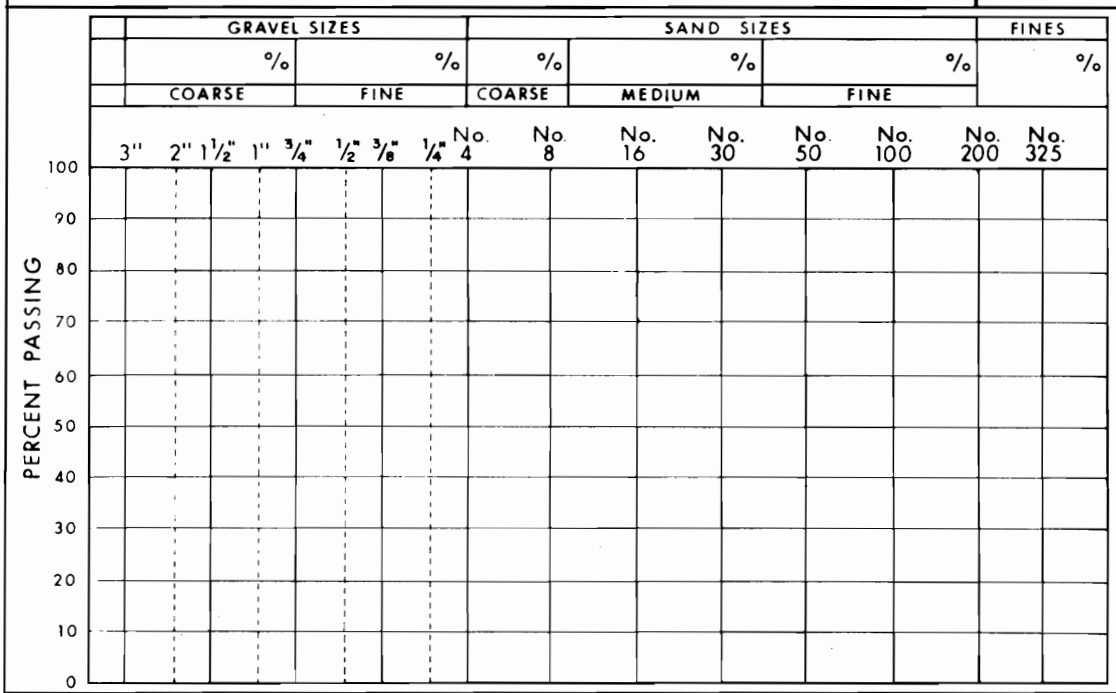
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER



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.
N75-95H-B4

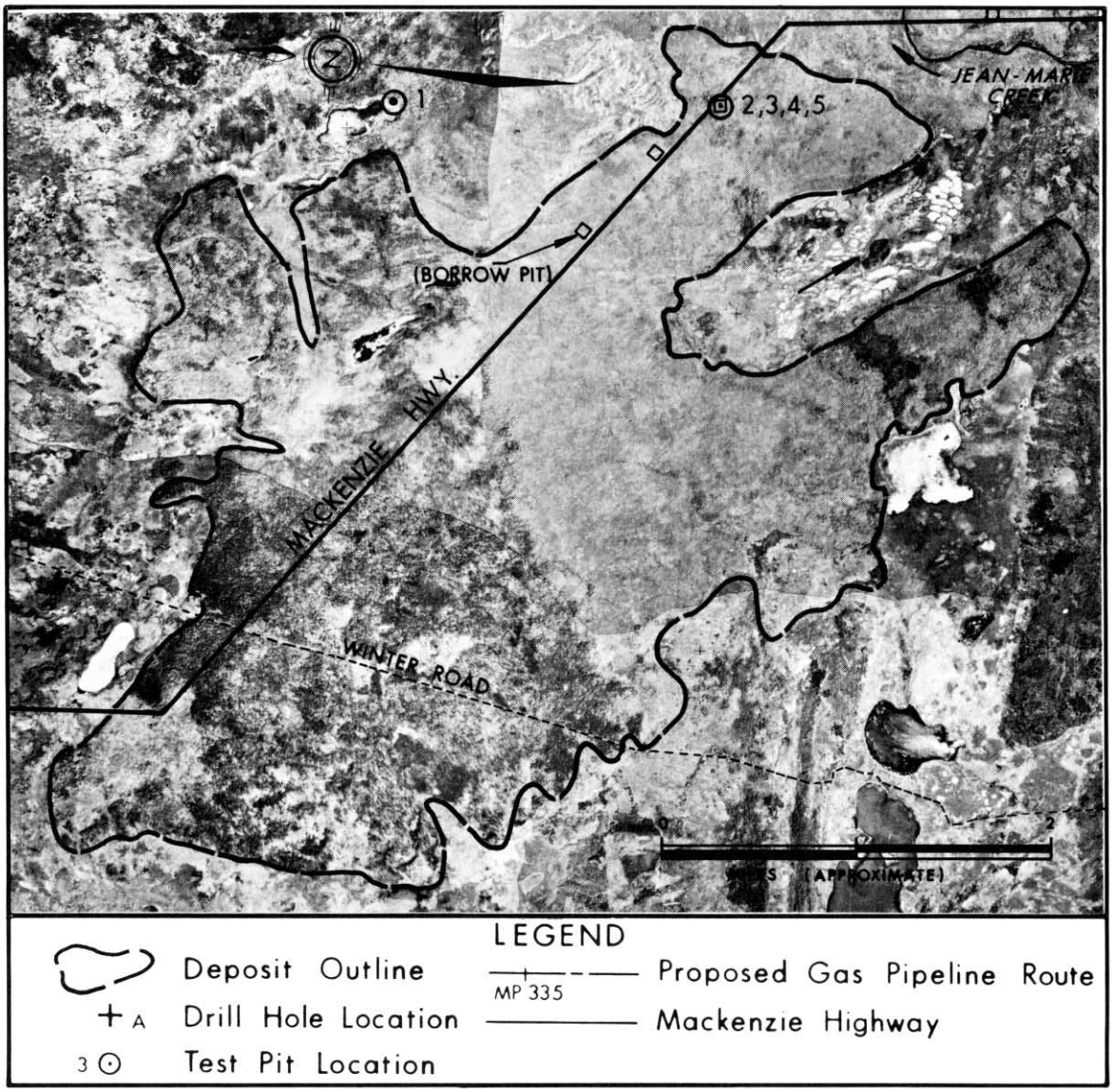
DEPOSIT 95H-B5

Physical Setting: Deposit 95H-B5 is a flat outwash plain located along the Mackenzie Highway about 26 miles south of Fort Simpson.

Material: GRAVEL - well graded, fine to coarse, sandy, trace fines; fine sand also found in deposit.

Volume: 137,800,000 cubic yards.

Assessment: Deposit 95H-B5 is a source of good quality granular material suitable for embankment fill, general fill, building pads, and possibly concrete and asphalt aggregate. Haul distance is in the order of 20 miles via the Highway.



Airphoto No. A11029-335, 336; A11334-302, 303
Approximate Scale: 1" = 4900'

Latitude: 61° 27' N.
Longitude: 121° 15' W.

DEPOSIT 95H-B5

PHYSICAL SETTING

Deposit 95H-B5 is a flat outwash plain located along the Mackenzie Highway a few miles northwest of Jean Marie Creek and approximately 26 miles south of Fort Simpson. The proposed gas pipeline is about 12 miles northeast of the deposit.

The outwash plain is an extensive sand and gravel deposit bounded by sand dunes to the east, a meltwater channel to the south, drumlins on the southwest and till plain to the west and north. The boundaries of the deposit are fairly indistinct on air photos except for two minor scarps along the northeast. Relief across the deposit is generally less than 25 feet. Three highway borrow pits located in the outwash plain have exposed over 10 feet of sand and gravel. Overburden of a foot of eolian silt and sand is found in some portions of the deposit.

The deposit is well drained internally. A few small lakes are present within the deposit.

Ice content is expected to be low to nonexistent in well drained areas as shown by drill hole, test pit, and borrow pit data.

BIOLOGICAL SETTING

A forest of white birch, aspen, white spruce and pine dominates this extensive deposit. The understory consists of alder, rose, cranberry, bunchberry and bearberry. Improved moose browse is available in a recently-burned portion of the site. Black bear sign was observed in the area. A brood of ducks was sighted in a nearby lake, and a red-tailed hawk and sandhill crane were also seen on the site. No suitable fish habitat was identified on the site. The site lies in the Fort Simpson hunting and trapping area.

MATERIAL

The gravels found in the highway pits are well graded, fine to coarse, subrounded to subangular, and sandy with a trace of fines. Cobbles were generally absent although a few boulders were seen on the pit floors. Lenses of coarse to medium sand were noted within the gravel. Sands in other areas of the deposit are medium to fine grained with a trace of silt and gravel.

VOLUME

Assuming a 10 foot depth of material over an area of 8544 acres, the deposit is calculated to contain 137.8 million cubic yards of sand and gravel. Twenty to thirty feet of gravel was noted in the southernmost highway pit.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B5 is a source of good quality granular material suitable for embankment fill, general fill, building pads, and possibly concrete and asphalt aggregate. Location of areas to be exploited would be dictated by material quality, pipeline requirements, haul distance and environmental concerns. Part of the deposit had previously been used for highway construction.

Access is excellent via the all weather Mackenzie Highway, but haul distance to the pipeline is in the order of 20 miles. Seismic lines from the highway may be used to intercept the pipeline at various points along the right of way. Terrain between the deposit and the right of way is glaciolacustrine sand plain with some peat cover.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially, vegetative cover would be cleared in accordance with existing land use regulations. Overburden would then be stripped and stockpiled around the edge of the site. A dugout pit could be excavated using conventional earthmoving techniques and standard equipment. In winter ripping may be required to break the frost layer.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SW		SAND – little fine gravel, light brown		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙		W1				2.0	
2			2.0 well graded, dark brown					W2				3.0	
8			8.0 possible trace silt									9.0	
10								W3				10.0	
12													
14												15.0	
16								W4				16.0	
18			trace silt 18.0 End of hole									18.0	Silt adhering to bit

LOGGED BY: D.V	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 61°24'04''N, 121°00'48''W	ELEVATION:		N75-95H-B5-A	
DRWN. BY: A.M.	AIRPHOTO No.: A11029-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA		
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 6°C	ENGINEERS FOR		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 16 M 09 Y 75 TIME: 18:00	FINISH: D 16 M 09 Y 75 TIME: 18:35				

TEST HOLE No. N75-95H-B5-A

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	SP-SM		SAND - medium to fine, trace silt, trace organics, reddish brown, dense		UF							0	
1			1.0 sand becoming coarser, brown									1	
2			occasional silt inclusions									2	
3			sand layered at about 30°				MA, combined samples 1 - 4 G = 1% S = 93% F = 6% Sand fractions: coarse = 2% medium = 63% fine = 28%	B1				3	
4								B2				4	
5			occasional gravel with calcite coatings					B3				5	
6								B4				6	
7			7.0 Bottom of pit									7	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	61°24'04"N, 121°00'48"W	ELEVATION:		
DRWN. BY: A.J.B.	AIRPHOTO No.:	A 11334-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	N75-95H-B5-1
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C	ENGINEERS FOR	
	METHOD:	TEST PIT			
START: D 16 M 09 Y 75 TIME: 11:30	FINISH: D 16 M 09 Y 75 TIME: 13:30			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-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
	SP		0.25 SAND - medium, reddish brown		UF		w%						
1	GW		GRAVEL - fine to coarse, subrounded, and coarse to medium sand, brown, damp, calcite deposition on gravel				MA, combined samples 1 & 2 5 G = 52% S = 46% F = 2% (GW)	B1				1	
2			2.7 Bottom of pit				3	B2				2 2.7	

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: R.H.	LAT. & LONG: 61°27'31''N, 121°15'22''W	ELEVATION:		N75-95H-B5-2	
DRWN. BY: D.M.	AIRPHOTO No.: A 11029-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA		
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 10°C			
	METHOD: TEST PIT		ENGINEERS FOR		
START: D 16 M 09 Y 75 TIME: 17:15	FINISH: D 16 M 09 Y 75 TIME: 17:45		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	

TEST HOLE No. N75-95H-B5-2

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
1	GW		GRAVEL - fine, some sand, medium to coarse, brown, damp		UF		w%					1	
			1.75				MA, combined samples 1 & 2						
2	SP		SAND - medium, trace fine, gravel, brown				4 G = 13% S = 83% F = 4%	B1				2	
			3.0 Bottom of pit				4	B2					
3			(Combined material 1' - 3' = SAND, medium, little fine to coarse gravel (to 1½''), trace silt, (SW)									3	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	61°27'31''N, 121°15'22''W	ELEVATION:		N75-95H-B5-3
DRWN. BY: G.B.	AIRPHOTO No.:	A 11029-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C		
	METHOD:	TEST PIT			
START: D 16 M 09 Y 75 TIME: 17:30	FINISH: D 16 M 09 Y 75 TIME: 18:00			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

309

TEST HOLE No. N75-95H-B5-3

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
	SP		SAND - medium to coarse, some fine gravel, subrounded		UF							0.5	
			0.75				MA, combined samples 1 & 2	B1					
1	GW-GM		GRAVEL - fine, little coarse to medium sand, trace silt, brown, damp				G = 55%					1.5	
			- trace coarse gravel at 2.0'				S = 37%	B2					
2			2.5 Bottom of pit				F = 8% (GW-GM)					2.5	

LOGGED BY:	J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	R.H.	LAT. & LONG:	61°27'31''N, 121°15'22''W	ELEVATION:	
DRWN. BY:	F.B.B.	AIRPHOTO No.:	A 11029-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED
CHKD:	J.K.W.	RIG:		AIR TEMP.: Approx. 10°C	
		METHOD:	TEST PIT		
START:	D 16 M 09 Y 75 TIME: 17:15	FINISH:	D 16 M 09 Y 75 TIME: 17:45		

TEST HOLE No. N75-95H-B5-4

SHEET 1 OF 1

PC-9,SK373

310

TEST HOLE No. N75-95H-B5-4

TEST HOLE LOG

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	SP-SM	SAND - fine to medium, trace fine gravel, trace silt, brown, damp, gravel with calcite depositions	UF	MA, samples B1 & B2 G = 36% S = 53% F = 11%					0.5	
0.75		little fine to coarse gravel, sub-rounded			B1					
1									1.5	
1.25		medium sand, trace fine gravel, grey brown			B2					
2									2.5	
2.5		Bottom of pit								

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.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 61°27'31''N, 121°16'22''W		ELEVATION:	
DRWN. BY: D.M.	AIRPHOTO No.: A 11029-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	RIG:		AIR TEMP.: Approx. 10°C	ENGINEERS FOR
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED
START: D 16 M 09 Y 75 TIME: 17:30		FINISH: D 16 M 09 Y 75 TIME: 18:00		

TEST HOLE No. N75-95H-B5-5

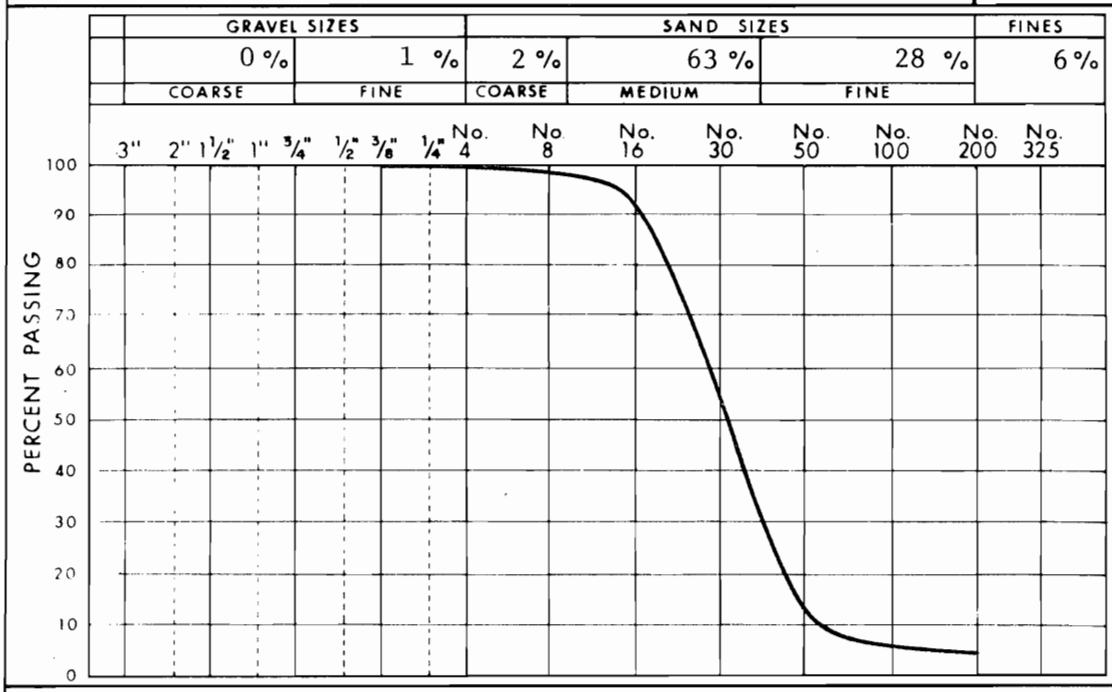
SHEET 1 OF 1

PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B5-1 DEPTH 3.0-7.0
DATE SAMPLED September 16, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 212



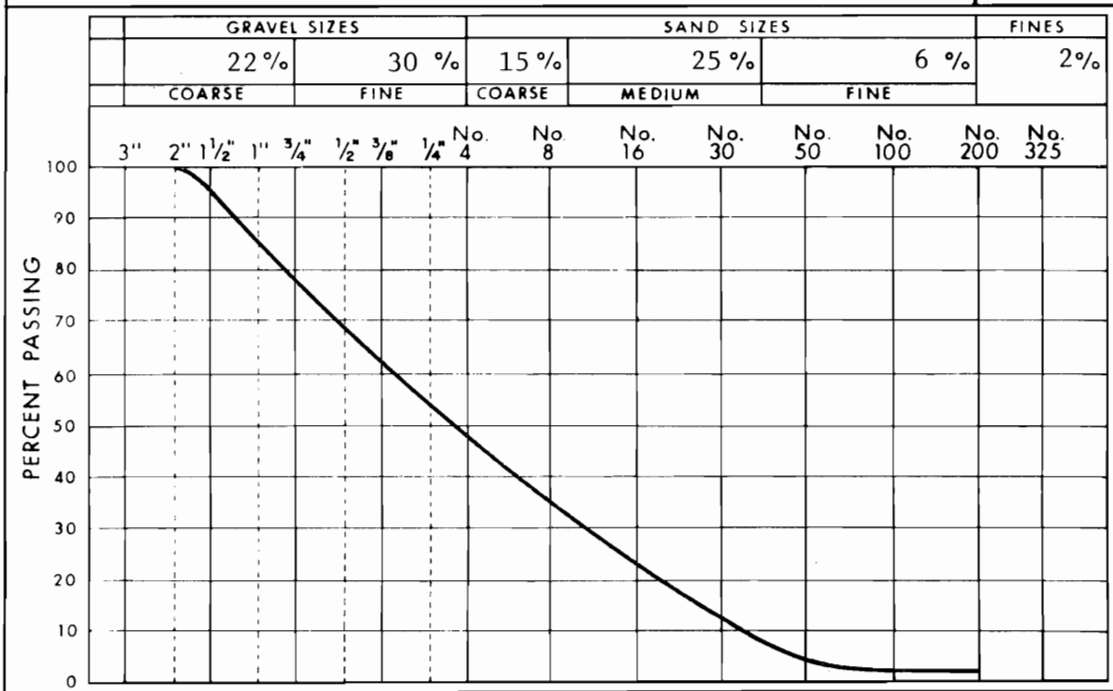
SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	99.5
No. 8	98.3
No. 16	91.7
No. 30	52.7
No. 50	13.7
No. 100	7.0
No. 200	5.5

COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95H-B5-2 DEPTH 1.0-2.7
DATE SAMPLED September 16, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 35



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	97.3
1"	86.0
¾"	78.1
½"	69.1
⅜"	62.3
¼"	
No. 4	48.3
No. 8	34.6
No. 16	24.6
No. 30	12.9
No. 50	4.1
No. 100	2.8
No. 200	2.2

COMMENTS Moisture contents range from 2.8 to 4.9%

OVERSIZE (>3") = 0.0%

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

NORTHERN Engineering Services Company Limited

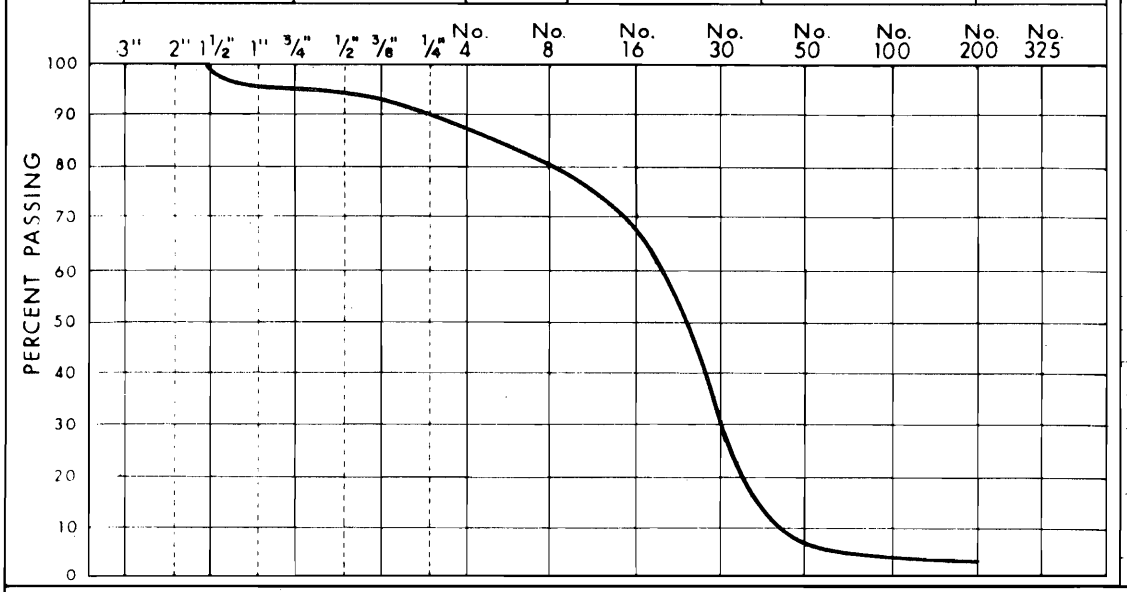
DEPOSIT No. N75-95H-B5

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B5-3 DEPTH 1.0-3.0
DATE SAMPLED September 16, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 24

GRAVEL SIZES		SAND SIZES			FINES
4 %	9 %	10%	58 %	15 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	95.9
¾"	95.9
½"	94.5
⅜"	92.3
¼"	
No. 4	87.3
No. 8	80.5
No. 16	67.2
No. 30	31.5
No. 50	7.2
No 100	5.2
No. 200	4.3

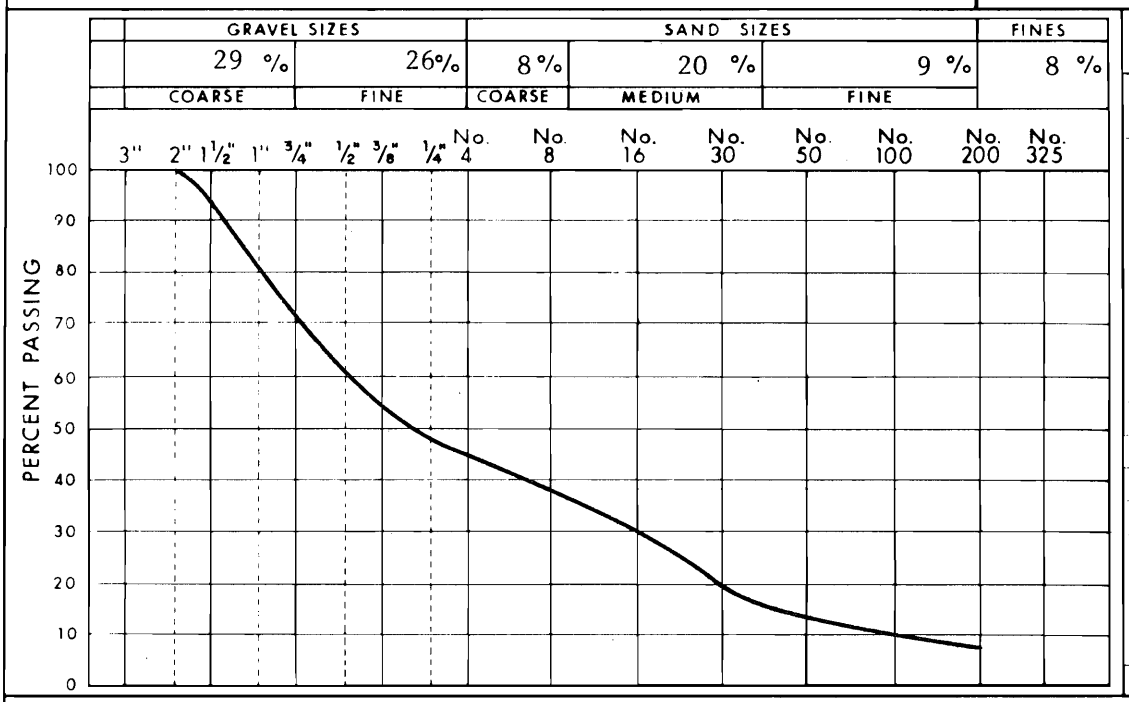
COMMENTS Moisture contents range from 4.2 to 4.4%

OVERSIZE (>3") = 0.0 %

SAMPLE N75-95H-B5-4 DEPTH 0.5-2.5
DATE SAMPLED September 16, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 150

GRAVEL SIZES		SAND SIZES			FINES
29 %	26%	8 %	20 %	9 %	8 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	94.6
1"	79.4
¾"	71.0
½"	61.9
⅜"	56.1
¼"	
No. 4	45.4
No. 8	37.8
No. 16	29.9
No. 30	19.7
No. 50	12.6
No.100	10.3
No. 200	7.7

COMMENTS

OVERSIZE (>3") = 0.0%

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

NORTHERN Engineering Services Company Limited

DEPOSIT No.
N75-95H-B5

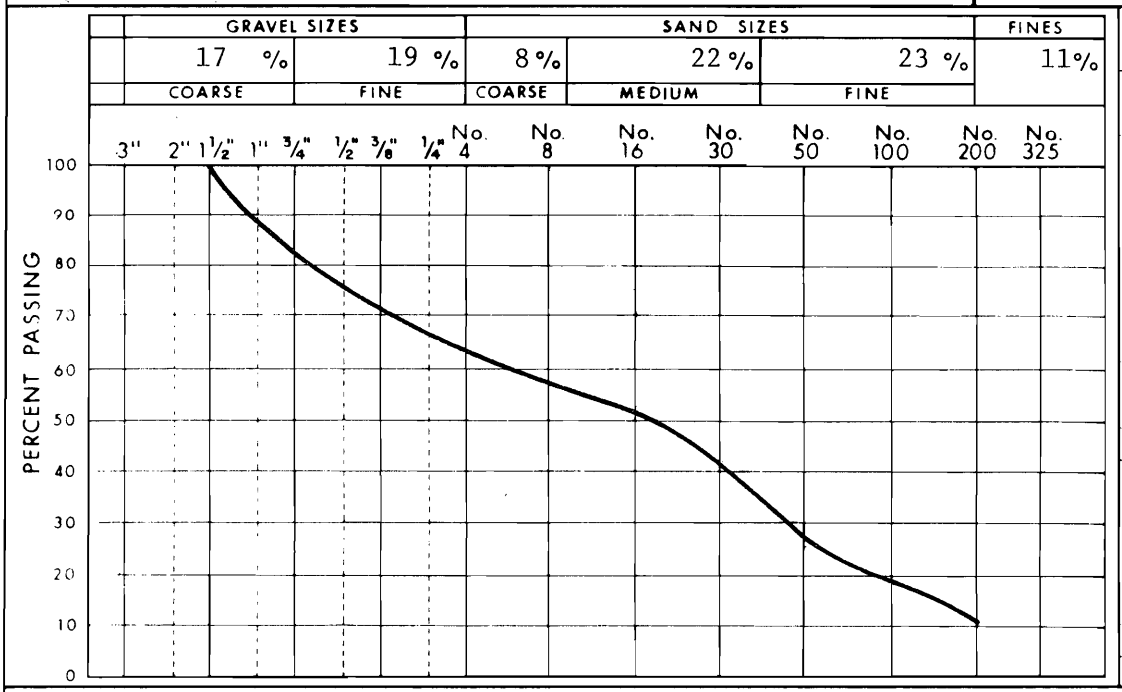
PAGE
313

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B5-5 DEPTH 0.5-2.5

DATE SAMPLED September 16, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 28



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	89.4
¾"	83.4
½"	76.3
⅜"	72.0
¼"	
No. 4	64.1
No. 8	57.7
No. 16	52.3
No. 30	42.1
No. 50	26.4
No. 100	19.3
No. 200	11.1

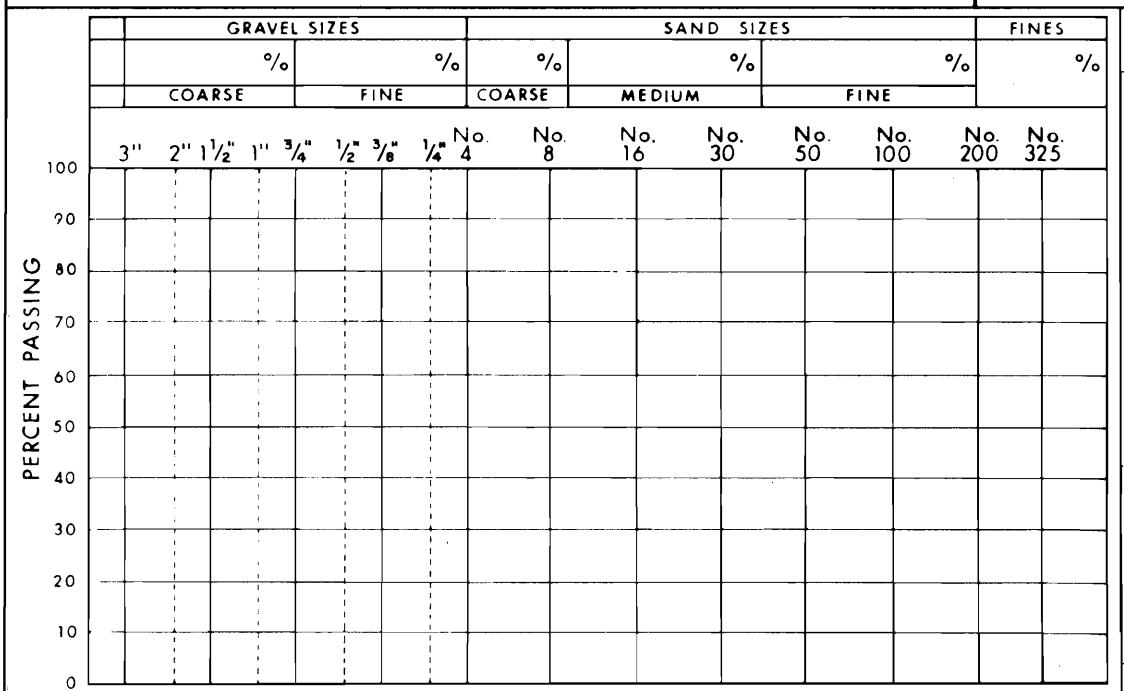
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER



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. N75-95H-B5

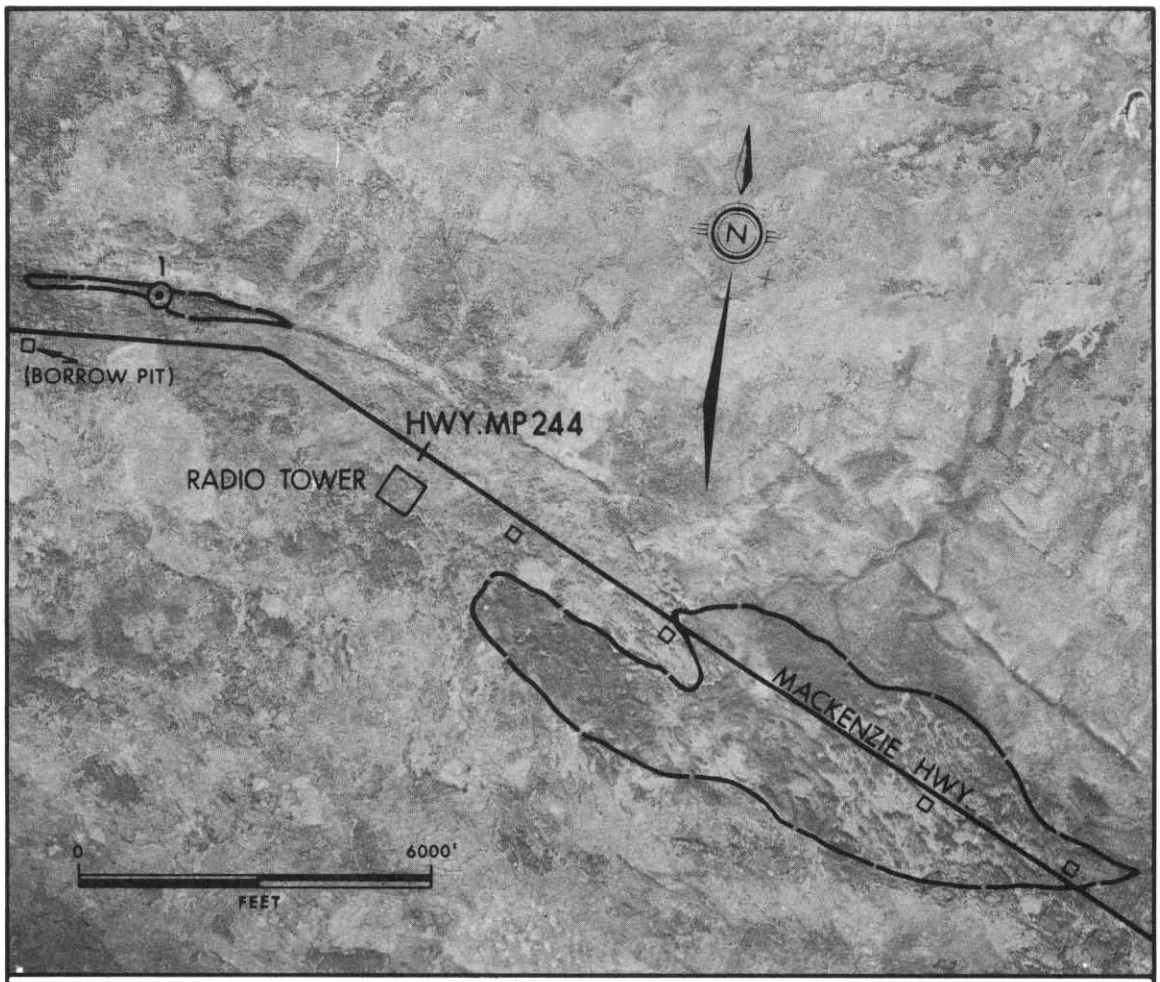
DEPOSIT 95H-B6

Physical Setting: Deposit 95H-B6 consists of a veneer of beach sands and gravels over thin till and bedrock. The proposed pipeline route is 3 miles northeast.

Material: SAND and GRAVEL - fine sand, limestone and shale gravel.

Volume: 8,600,000 cubic yards.

Assessment: Deposit 95H-B6 is a source of fair to good quality granular material suitable for general fill, backfill and building pads.



Airphoto No. A11029-242
Approximate Scale: 1" = 3250'

Latitude: 61° 22' N.
Longitude: 120° 52' W.

DEPOSIT 95H-B6

PHYSICAL SETTING

Deposit 95H-B6 consists of a veneer of beach sands and gravels over thin till and bedrock. The deposit is approximately 58 miles south of Fort Simpson on the Mackenzie Highway. A radio tower near highway mile 244 is located between two segments of the deposit. The proposed gas pipeline is 3 miles to the northeast and crosses the highway to the south near pipeline mile 722.

The beach material is thin, discontinuous and covers only certain portions of the east-west trending bedrock escarpment in this area. Till has been exposed in highway borrow pits and at the radio tower site between the beach areas outlined on the airphoto. A borrow pit and drainage channel in the western portion of the deposit has shown 15 feet of sand and gravel over fossiliferous limestone. Borrow pits in the eastern portion of the deposit have sand and gravel over till and bedrock. Numerous boulders are present in the till which appears in the highway borrow pits.

BIOLOGICAL SETTING

This site has a mixed forest cover of pine, aspen, white birch and white spruce with an understory of alder, rose and willow. The area is used by moose, but it is poor winter range. No suitable waterfowl or fish habitat is found near the site. The site lies in the Fort Simpson hunting and trapping area.

MATERIAL

Mostly unfrozen fine sand and coarse to fine gravel are present in the well drained beach areas outlined on the airphoto. The gravel consists largely of fossiliferous limestone and shale and is well graded with angular to subrounded particles.

VOLUME

Assuming a deposit depth of 9 feet over an area of 593 acres, 8.6 million cubic yards of borrow material is present.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B6 is a source of fair to good quality granular material which is suitable for general fill, backfill, and building pads. Areas to be exploited will be dictated by haul distances, insitu material quality, and material requirements.

Access to the deposit may be achieved via either the Mackenzie Highway or a 3 mile snow road northeast to the pipeline right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between the development areas and the highway for aesthetic reasons. Use of previously excavated pit areas will reduce environmental disturbance if this site is developed.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Development of this deposit would involve dugout pit excavations accomplished with conventional earthmoving techniques and standard equipment. Screening and washing may be used to upgrade the material.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SM		SAND - fine, some silt, brown, damp, occasional boulder (30'' +)		UF		w% 7.7 MA, combined samples 1 & 2 G = 29% S = 46% F = 25% (SM)	B1				1	
1.5													
2	SW		SAND - fine to coarse, some fine to coarse gravel, angular to subrounded, dense					B2				2	
3.0			Bottom of pit				12.3					3	
3													

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°21'44''N, 120°51'57''W		ELEVATION:		N75-95H-B6-1
DRWN. BY: F.B.B.	AIRPHOTO No.: A 11029-242		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 17 M 09 Y 75 TIME: 18:00	FINISH: D 17 M 09 Y 75 TIME: 19:30				

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TEST HOLE No. N75-95H-B6-1

PC-9,SK373

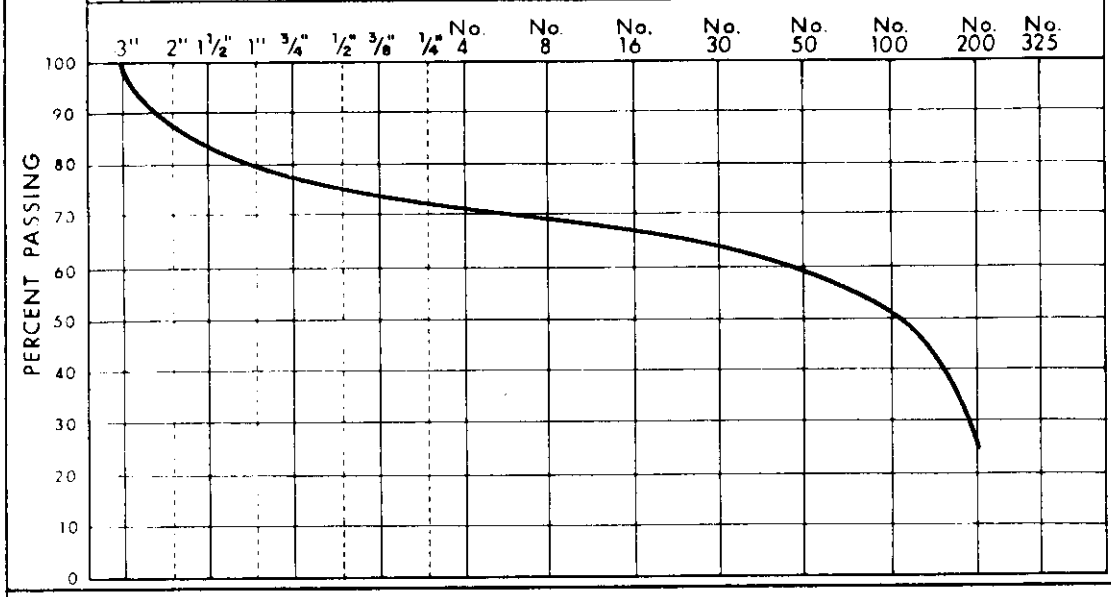
SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B6-1 DEPTH 1.0-3.0

DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 158

GRAVEL SIZES		SAND SIZES			FINES
22%	7 %	3%	7%	36 %	25%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	88.8
1½"	84.1
1"	80.6
¾"	78.2
½"	76.0
⅜"	74.8
¼"	
No. 4	70.8
No. 8	69.4
No. 16	67.6
No. 30	64.2
No. 50	59.2
No. 100	51.5
No. 200	24.5

COMMENTS Moisture contents range from 7.7 to 12.3%

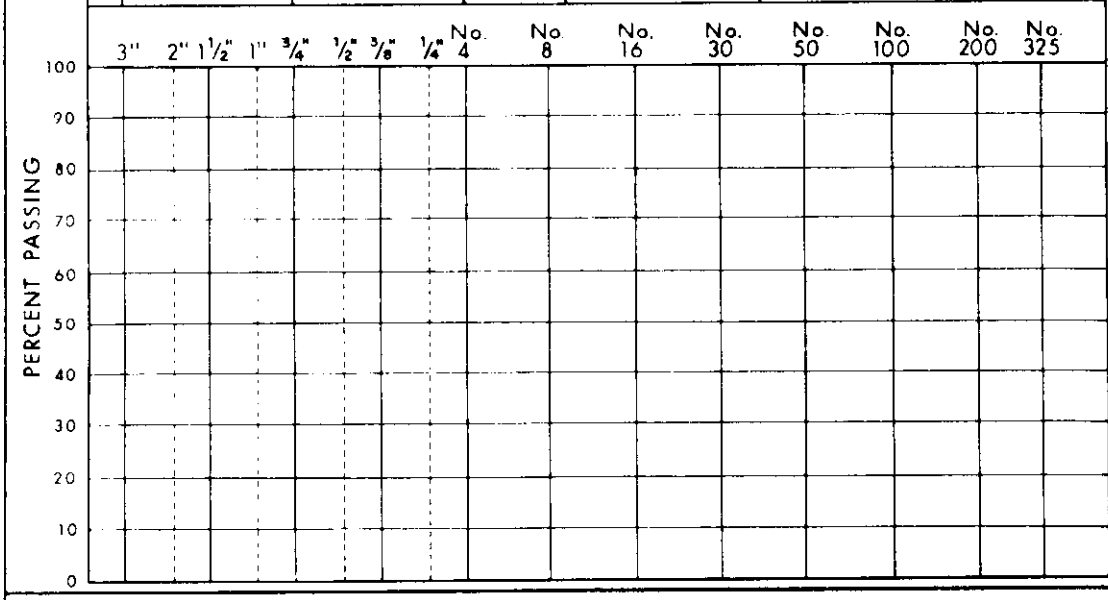
OVERSIZE (>3") = 0.0 %

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. N75-95H-B6

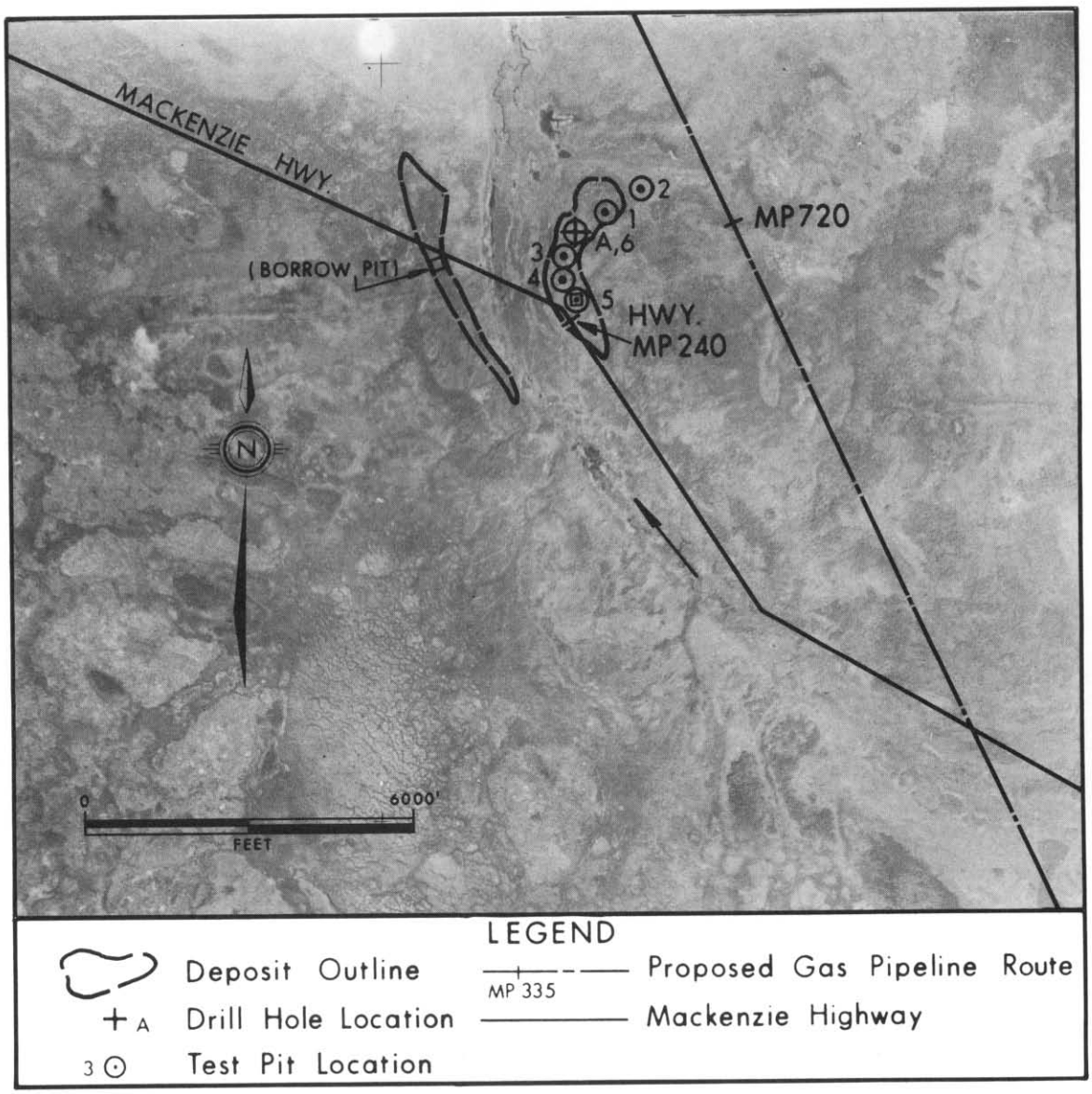
DEPOSIT 95H-B7

Physical Setting: Deposit 95H-B7 consists of two outwash terraces located near M.P. 240 on the Mackenzie Highway.

Material: GRAVEL - well graded with a trace of fines, sand occurs as matrix and as separate lenses.

Volume: 1,400,000 cubic yards.

Assessment: Deposit 95H-B7 is a source of good quality granular material suitable for general fill, embankment fill, building pads and possible concrete aggregate.



Airphoto No. A11019-288
Approximate Scale: 1" = 3250'

Latitude: 61° 21' N.
Longitude: 120° 47' W.

DEPOSIT 95H-B7

PHYSICAL SETTING

Deposit 95H-B7 consists of two outwash terraces located near mile 240 on the Mackenzie Highway. Jean Marie Creek is 5 miles to the north and mile 720 of the proposed gas pipeline is less than a mile to the northeast.

The two terraces border a meltwater channel that crosses a northwest trending drift covered limestone escarpment. The escarpment cuts across the region and extends from Enterprise to the Liard River. Outwash gravels and sands have been deposited in terraces along the meltwater channel and rest directly upon the limestone. A borrow pit in the eastern terrace shows about 40 feet of westward dipping gravel over limestone and the western terrace shows 10 feet of gravel over the bedrock. Similar outwash terraces are present further south along the meltwater channel, but were not investigated during this program.

A veneer of outwash sand and gravel over till and bedrock might also be present adjacent to the eastern terrace. Glacial lake sand and gravel beaches are located immediately west of the deposit.

The terraces are flat lying. Approximately 1 foot of overburden overlies the gravel. The deposit is well drained and unfrozen.

BIOLOGICAL SETTING

A mixed forest of pine, white spruce, aspen and white birch with alder and rose occurs on the site. The Mackenzie Highway passes through the site which has resulted in a reduction of wildlife populations in the immediate area. Bank swallows nest in banks exposed by borrow excavation. No waterfowl habitat exists on the site. The area provides suitable grouse and ptarmigan winter habitat. No suitable fish habitat has been identified near the site.

MATERIAL

Deposit 95H-B7 is a source of good quality granular material. The gravel is subrounded to subangular, well graded with a trace of fines, fine to coarse, and primarily composed of fossiliferous limestone. The material tends to coarsen with depth. The well graded sand in the deposit occurs both within the gravel and as separate lenses.

Petrographic analysis of the coarse fraction showed the main component to be limestone with subordinate quartzite, granite and minor sandstone, siltstone and altered rocks. This composition is of good quality for concrete aggregate. Abrasion resistance was also good. The sulphate solution test was marginal but acceptable.

VOLUME

Assuming an average depth of 9 feet over an area of 96 acres, a total volume of 1.4 million cubic yards of granular material is present.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B7 is a source of good quality granular material which is suitable for general fill, embankment fill in berm construction, building pads and possible concrete aggregate. Further testing for concrete suitability would be required but initial results indicate that fair to good quality concrete aggregate could be produced from this deposit.

Access to the deposit may be achieved via the all weather Mackenzie Highway. A buffer zone between the highway and development areas should be maintained for aeshetic reasons.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially the vegetative cover would be cleared and disposed of in accordance with existing land use regulations. Overburden, if any, will then be stripped and stockpiled around the edge of the excavation.

Development of this deposit would probably involve extending the present gravel pits or starting similar dugout pits in other parts of the deposit. This area could be excavated by using conventional earthmoving techniques and equipment. Natural mixing during excavation will be adequate to obtain good gradations although screening of sand from the material may be required.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SW		SAND – well graded, grey brown, dry		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙		W 1	X			1.0	
1.5			trace fine gravel, sub rounded, brown.									1.5	
2								W 2	X			2.5	
3.0												3.0	
4	CI		CLAY – some fine to coarse sand, trace gravel, medium plastic, dry, brown (till-like)					W 3	X			4.0	
6												5.5	
(7.5)			cobbles (granitic) 8" diameter.					W 4	X			6.5	
8								W 5	X			7.5	bored through cobble
9.0													
10	SC		SAND – fine, trace coarse, brown, clayey					W 6	X			9.5	
12												10.5	
14												13.5	
16								W 7	X			14.5	

LOGGED BY: D.V	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°21'13"N, 120°46'45"W		ELEVATION:		N75-95H-B7-A
DRWN. BY: A.M.	AIRPHOTO No. A 11018-288		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL		AIR TEMP: Approx. 10-14°C		
	METHOD: AIR				
START: D 17 M 09 Y 75 TIME: 14:00		FINISH: D 17 M 09 Y 75 TIME: 15:35		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2

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TEST HOLE No. N75-95H-B7-A

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SC		(SAND)		UF	40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙							
18			water 18.0 ▼										
			19.5		F ?								
20	CI		TILL CLAY – sand, gravel, possible silts low to med. plastic, brown–grey, stiff, indication of coarse gravel and cobbles.										
22													
24													
26													
28			28.0 End of hole									28	

LOGGED BY: D.V	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: J.K.W.	LAT. & LONG: 61°21'13'' N, 120°46'45''	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No. A 11019–288	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	RIG: HELI–DRILL	AIR TEMP: Approx. 10–14°C	ENGINEERS FOR
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 17 M 09 Y 75 TIME: 14:00	FINISH: D 17 M 09 Y 75 TIME: 15:35		TEST HOLE No. N75-95H-B7-A SHEET 2 OF 2

TEST HOLE No. N75-95H-B7-A

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	ML		SILT - little fine sand, roots, dark brown		UF							0	
			0.7										
1	SP		SAND - fine, roots, brown									1	
			1.2										
2	GW		GRAVEL - fine to coarse, subrounded, little coarse to medium sand - layers of fine gravel				MA, combined, samples 1 - 3 G = 35% S = 50% F = 15%	B1 B2				2	
3	CI		3.4 CLAY - little fine gravel, trace fine to coarse sand, medium plastic					B3				3	
4			4.0 Bottom of pit									4	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°21'16''N, 120°46'45''W		ELEVATION:		
DRWN. BY: D.M.	AIRPHOTO No.: A 11019-288		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B7-1
CHKD:	RIG:		AIR TEMP.: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 17 M 09 Y 75 TIME: 13:00		FINISH: D 17 M 09 Y 75 TIME: 13:30			

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TEST HOLE No. N75-95H-B7-1

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	Pt		PEAT - silty, black to dark brown		UF							0	
			1.0										
1	SM		SAND - fine, some silt, brown with black streaks, saturated				MA, G = 0% S = 75% F = 25%	B1	X			1	
			2.0 Bottom of pit										
2												2	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG:	61°21'19"N, 120°46'43"W	ELEVATION:		N75-95H-B7-2
DRWN. BY: F.B.B.	AIRPHOTO No.:	A 11019-288	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C		
	METHOD:	TEST PIT			
START: D 17 M 09 Y 75 TIME: 13:45	FINISH: D 17 M 09 Y 75 TIME: 14:15			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

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TEST HOLE No. N75-95H-B7-2

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1	SW-SM		SAND - fine, trace silt, light brown, damp, occasional medium sand inclusions, occasional fine gravel inclusions		UF		MA, combined samples 1 & 2 G = 45% S = 42% F = 13% (GM-SM)					1	
			1.4					B1					
2	GM-SM		GRAVEL - coarse to fine, angular to sub-rounded, little coarse to fine sand, little silt, cobbles, frequent boulders (24''+)					B2				2	
			2.7 Bottom of pit									2.7	

40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°21'11''N, 120°46'45''W		ELEVATION:		
DRWN. BY: D.M.	AIRPHOTO No.: A 11019-288		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B7-3
CHKD: J.K.W.	RIG:		AIR TEMP: Approx. 10°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 17 M 09 Y 75 TIME: 14:30		FINISH: D 17 M 09 Y 75 TIME: 15:45			

TEST HOLE No. N75-95H-B7-3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %
0	SP-SM	SAND - fine, trace silt, roots, brown, damp, dense	UF
2.2	SC	SAND - fine to medium, brown	
3.75		layer, ½'' thick, of clay, grey	
4.1		medium to coarse sand	
5.8		fine to medium grain, very clayey, brown	
6.0		Bottom of pit	

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: MA combined, samples 1 - 5
G = 0%
S = 78%
F = 22%

SAMPLE TYPE & No.	SAMPLE CONDITION
B1	
B2	
B3	
B4	
B5	

CORE RUN & % RECOVERY | CORE CONDITION | DEPTH (FT.) | REMARKS

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 61°21'09''N, 120°46'44''W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 11019-288	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 10°C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: TEST PIT		
START: D 17 M 09 Y 75 TIME: 16:00	FINISH: D 17 M 09 Y 75 TIME: 17:00		

TEST HOLE No. N75-95H-B7-4

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-B7-4

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	SM		SAND - medium, coarse, fine, little silt, little fine to coarse gravel		UF		MA, sample B1 G = 14% S = 68% F = 18%	B1				1	side pit from 0.0' to 3.0'
1.0	SW		SAND - medium to coarse, and fine to coarse gravel, pebbles subrounded to 1.5'', brown, layered				MA, combined samples 2 - 4 G = 35% S = 62% F = 3%	B2				2	
2								B3				3	pit sloughing in
3								B4				4	
4.0			Bottom of pit										

LOGGED BY:	J.L.M.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	61°21'17''N, 120°46'42''W	ELEVATION:	
DRWN. BY:	F.B.B.	AIRPHOTO No.:	A 11019- 289	PIPE MILEAGE:	
CHKD:	J.K.W.	RIG:		AIR TEMP.:	Approx. 10°C
		METHOD:	TEST PIT		

START: D 17 M 09 Y 75 TIME: 13:45 FINISH: D 17 M 09 Y 75 TIME: 14:15

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-95H-B7-5

SHEET 1 OF 1

PC-9,SK373

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TEST HOLE No. N75-95H-B7-5

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	GC		GRAVEL - fine to coarse, some medium sand, little clay, boulders		UF							0	
1.0													
1	SC		SAND - fine, some gravel, fine to coarse, angular to subrounded, little clay					B1	X			1	
2.0			Bottom of pit									2	
2													

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.L.M.	LAT. & LONG: 61°21'13"N, 120°40'45"W		ELEVATION:		N75-95H-B7-6
DRWN. BY: A.J.B.	AIRPHOTO No.: A 11019-288		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 10°C		
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 17 M 09 Y 75 TIME: 12:30	FINISH: D 17 M 09 Y 75 TIME: 13:00				

335

TEST HOLE No. N75-95H-B7-6

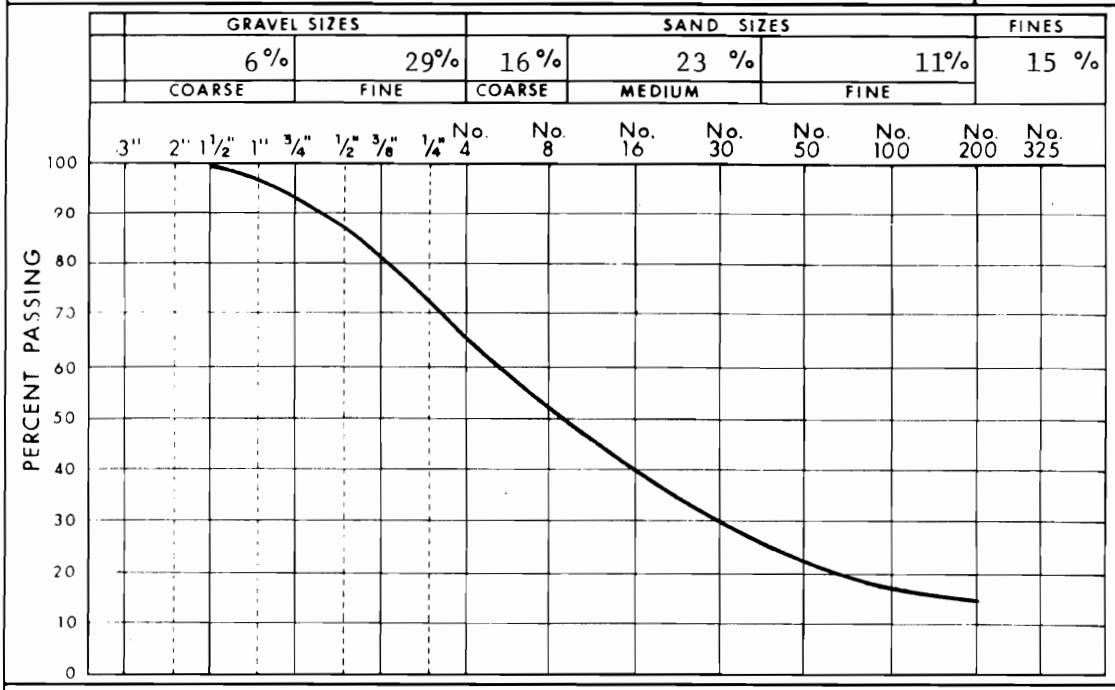
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B7-1 DEPTH 1.0-4.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 29

GRAVEL SIZES		SAND SIZES			FINES
6 %	29%	16 %	23 %	11%	15 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	97.1
¾"	94.1
½"	86.5
⅜"	80.2
¼"	
No. 4	65.4
No. 8	52.4
No. 16	39.8
No. 30	30.3
No. 50	22.6
No. 100	17.9
No. 200	15.2

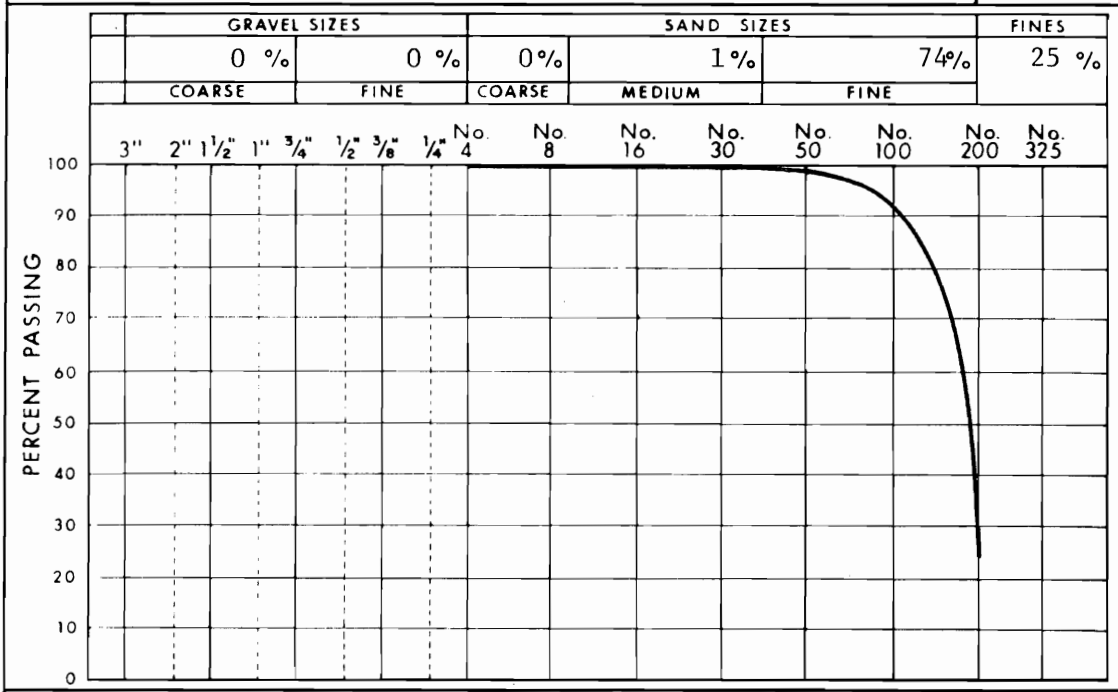
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-95H-B7-2 DEPTH 1.0-2.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 149

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0%	1%	74%	25 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	100.0
No. 8	99.8
No. 16	99.8
No. 30	99.6
No. 50	98.7
No. 100	91.0
No. 200	24.7

COMMENTS

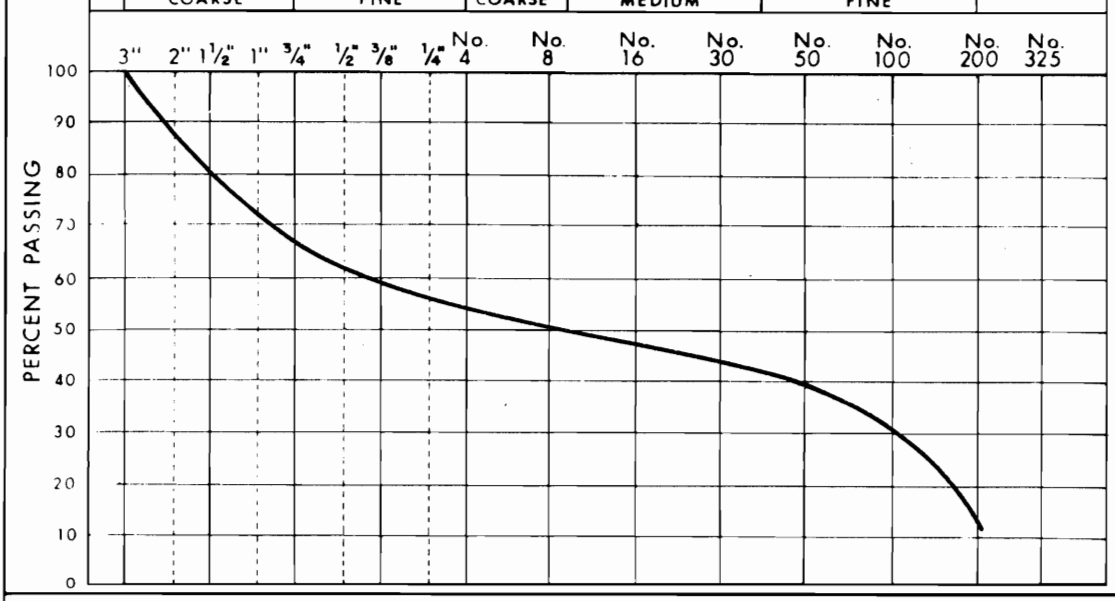
OVERSIZE (>3") = 0.0 %

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B7-3 DEPTH 1.0-3.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 27

GRAVEL SIZES		SAND SIZES			FINES
33 %	12%	5 %	12 %	29%	13%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	88.6
1½"	80.7
1"	72.6
¾"	67.3
½"	61.7
⅜"	59.0
¼"	
No. 4	55.0
No. 8	51.4
No. 16	47.8
No. 30	44.0
No. 50	38.9
No. 100	29.1
No. 200	13.2

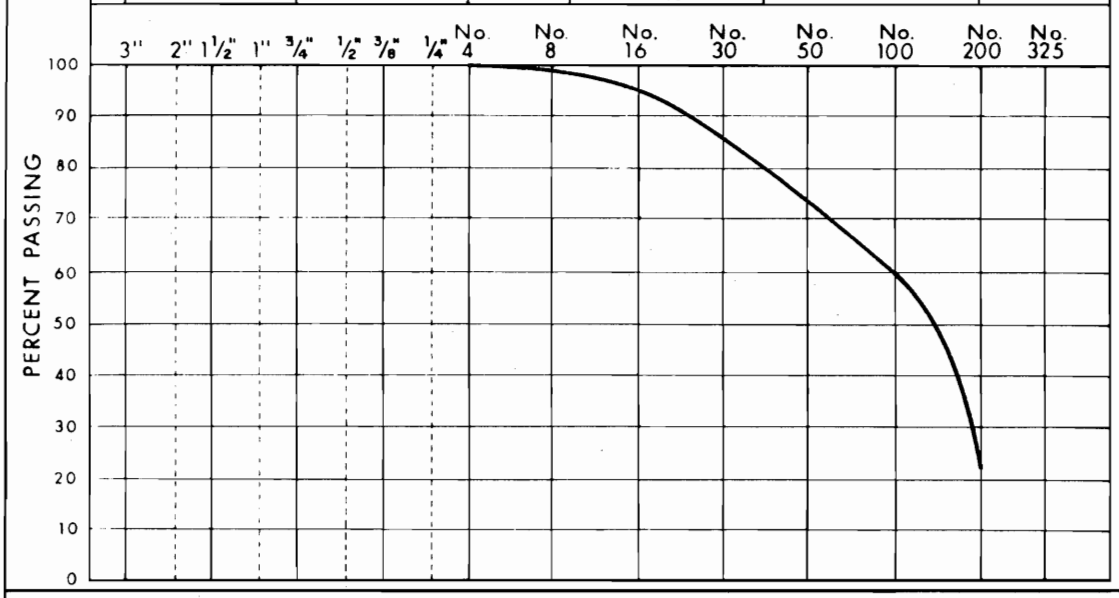
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95H-B7-4 DEPTH 1.0-6.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 181

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	2 %	20 %	56 %	22%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	100.0
No. 8	99.2
No. 16	95.7
No. 30	85.3
No. 50	72.7
No. 100	59.2
No. 200	21.9

COMMENTS

OVERSIZE (>3") = 0.0 %

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B7-5 DEPTH 0.0-1.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 160

GRAVEL SIZES		SAND SIZES			FINES
2%	12 %	16%	36 %	16 %	18 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	100.0
¾"	98.1
½"	96.4
⅜"	94.2
¼"	
No. 4	86.3
No. 8	75.0
No. 16	58.3
No. 30	42.8
No. 50	27.2
No. 100	23.7
No. 200	18.1

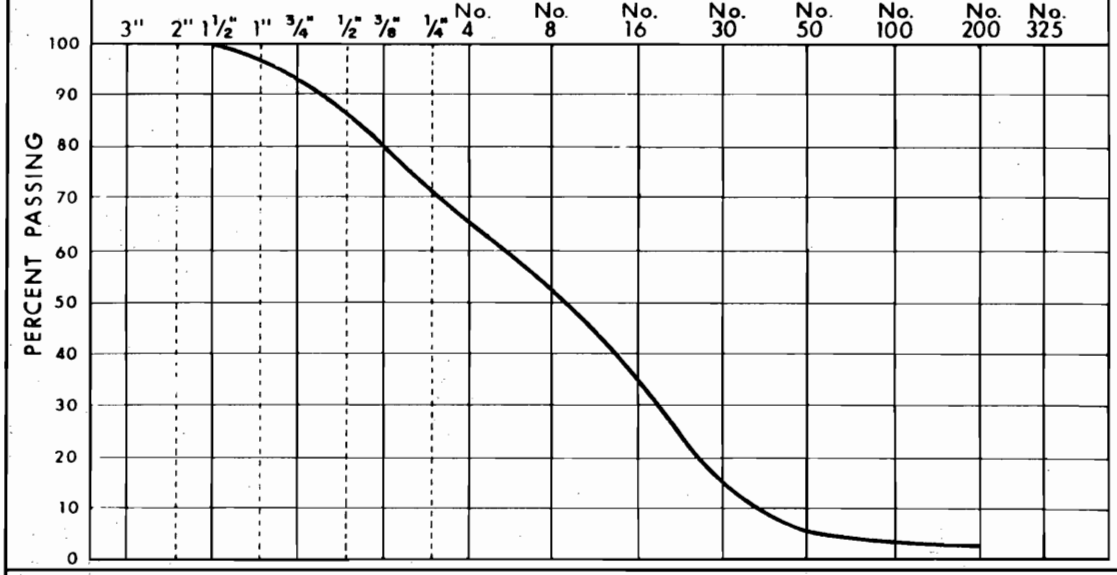
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-95H-B7-5 DEPTH 1.0-4.0
DATE SAMPLED September 17, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 161

GRAVEL SIZES		SAND SIZES			FINES
7 %	28%	16 %	39 %	7 %	3%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	100.0
1"	95.6
¾"	93.1
½"	86.1
⅜"	80.7
¼"	
No. 4	65.3
No. 8	52.0
No. 16	35.1
No. 30	14.6
No. 50	5.6
No. 100	4.2
No. 200	3.3

COMMENTS

OVERSIZE (>3") = 0.0%

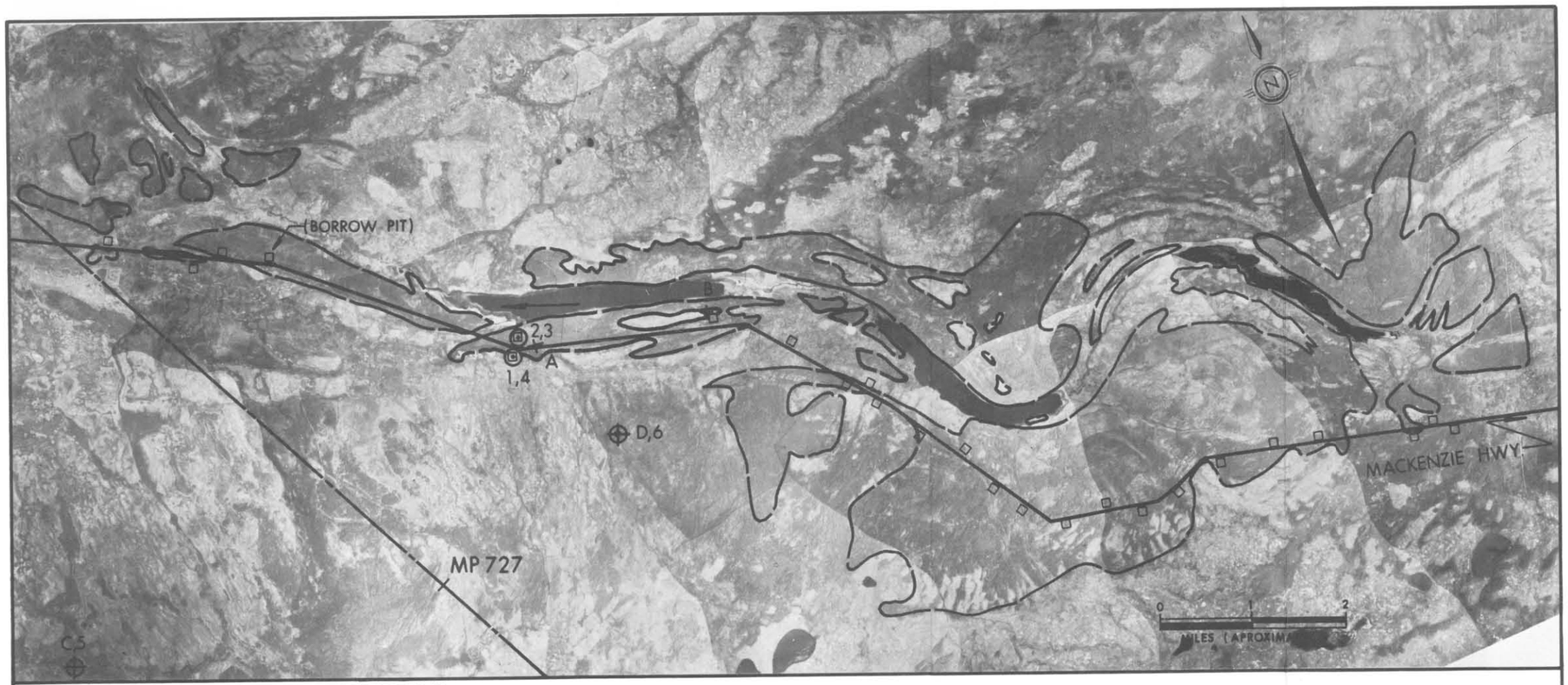
DEPOSIT 95H-B8

Physical Setting: Deposit 95H-B8 is a large and complex outwash plain located along the Mackenzie Highway between miles 222 and 238.

Material: SAND and GRAVEL - well graded, fine to coarse gravel and fine to medium sand.

Volume: 210,900,000 cubic yards.

Assessment: Deposit 95H-B8 is a source of fair to good quality granular material suitable for general fill, backfill, and possibly concrete aggregate subject to further testing.



Airphoto No. A11019-210 to 214 & 257 to 262
Approximate Scale: 1" = 7250' (distorted)

Latitude: 61° 17' N.
Longitude: 120° 37' W.

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-95H-B7-5 DATE SAMPLED September 17, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-4 DATE TESTED March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 7.27 %
FINE AGGREGATE : LOSS = 15.66 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 21.9 %

ORGANIC IMPURITIES TEST

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

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	2.74
Granite		3.45
Sandstone	Medium strong, Good	0.91
Siltstone		1.38
Limestone		13.80
Altered Rock		1.00
Flint	Potentially reactive, Fair	0.10
Soft Sandstone	Friable, Weak, Poor	0.45
Ironstone	Soft, Deleterious	0.21
Clay		0.16
PN = 124	INTERPRETATION : Fair	24.2

COMMENTS : Organic impurities test satisfactory.

NORTHERN Engineering Services Company Limited

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

DEPOSIT No. N75-95H-B7

DEPOSIT 95H-B8

PHYSICAL SETTING

Deposit 95H-B8 is a large and complex, flat to gently sloping outwash plain located along the Mackenzie Highway between miles 222 and 238. The proposed gas pipeline (mile 722) is located near the western edge of the deposit.

The curved shape of the deposit reflects the underlying gently dipping limestone escarpment that cuts through the area and probably influenced deposition of outwash sands and gravels at this location during glaciation. The outline of 95H-B8 includes areas of till and bog as well as outwash materials because low peat filled depressions are intermingled with well drained gravel and sand ridges. An old meltwater channel, occupied presently by 3 lakes, dissects the outwash deposit.

The ground water table is fairly close to the surface in some localities as indicated by water in some of the highway borrow pits. Sandy silt overburden of 1 to 2 feet generally overlies the gravel. Granular material of this deposit is unfrozen.

BIOLOGICAL SETTING

An aspen-white spruce forest is present on a large portion of this extensive site. Portions of the site burned about five years ago and are now vegetated by aspen, white birch, white spruce and pine seedlings with willow, alder, raspberry and cranberry. The Mackenzie Highway passes through the site which has resulted in a general reduction of wildlife populations in the immediate area. The site lies in the Fort Simpson hunting and trapping area. Burned parts of the deposit offer improved browse for moose. There is potential waterfowl and beaver habitat in the adjacent creek and lakes. Fish have been reported in the lakes and the inter-connecting creek, but detailed information is not available.

MATERIAL

This deposit consists of both sand and gravel. The gravel is well graded, fine to coarse with cobbles, subrounded to subangular, occasionally carbonate coated and composed of sedimentary rock types. The main component in the sample tested was limestone with subordinate granite. The minor components are quartzite, sandstone and siltstone. Extensive carbonate coating on the test sample may affect the quality of the coarse aggregate. Good results were obtained from the abrasion and sulphate solution tests. The sand is fine to medium grained and contains some silt.

VOLUME

Using dimensions of a 10 foot depth over 13,072 acres, a total volume of 210.9 million cubic yards may be calculated. These are very approximate figures as the deposit is very extensive and complex.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B8 is a source of fair to good quality granular material suitable for general fill, backfill, and possibly concrete aggregate. Areas to be exploited will be dictated by insitu material quality, material requirements and groundwater table. More extensive testing is required before this material could be used for concrete aggregate.

This deposit is crossed by the CNT line and already contains highway borrow pits so further development is unlikely to have an adverse effect on wildlife in the area. A buffer zone should be maintained between development areas and lakes and streams.

Access to the deposit would be via the all weather Mackenzie Highway and numerous short snow roads.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

The proximity of the highway, pipeline right of way and deposit increases the feasibility of summer development if necessary.

Development would start with clearing the vegetative cover in accordance with existing land use regulations. Overburden then would be stripped and stockpiled around the edge of the site. Extraction would involve down-cutting evenly from the higher well drained areas to the level of the underlying till, bedrock or groundwater table. Conventional earth-moving techniques along with ripping would be adequate for development. Gravelly layers could be stockpiled separately if coarse material is required or blended with the sand for good gradations.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	ML		SILT – little fine sand, trace coarse sand, low plastic, dry, brown, frequent cobbles to 6" diameter. (granitic, limestone)		UF							1.0	
2								W 1	X			2.0	
												3.0	
4								W 2	X			4.0	
6			7.0										
	CI		CLAY – silty, some coarse sand, brown, low to med. plastic, stiff, dry (till-like)									7.5	
8								W 3	X			8.0	
												8.5	
								W 4	X			9.0	
10													
			12.0									12.0	
12			CLAY, trace med. to coarse sand medium plastic, dry.					W 5	X				
			13.0 End of hole									13.0	

LOGGED BY: D.V	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 61°18'54"N, 120°33'02" W.	ELEVATION:			
DRWN. BY: A.M.	AIRPHOTO No.: A 11019-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B8-A	
CHKD:	RIG: HELI-DRILL	AIR TEMP: Approx. 12°C	ENGINEERS FOR		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 17 M 09 Y 75 TIME: 17:10	FINISH: D 17 M 09 Y 75 TIME: 19:05				

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TEST HOLE No. N75-95H-B8-A

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			0.1 Organic cover										
	SW		SAND - fine to coarse, trace fine gravel, sub angular, dry		UF							1	
2			2.5					W1	X			2	
	GW		GRAVEL - fine to coarse, little sand, (trace silt)										
4													
6													
8			8.0 End of hole									8	

LOGGED BY:	D.V.	FACILITY:		PROJECT:	13011
CHKD:	J.K.W.	LAT. & LONG:	61°17'16"N, 120°36'32"W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A11019-Mosaic	PIPE MILEAGE:	
CHKD:		RIG:	HELI-DRILL	AIR TEMP.:	Approx. 12°C
		METHOD:	AIR		

START: D 18 M 9 Y 75 TIME: 10:15 FINISH: D 18 M 9 Y 75 TIME: 10:40

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-95H-B8-B

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-B8-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
	Pt		0.5 PEAT, organic cover		UF							1	
2	Cl		CLAY - trace fine sand, low to med. plastic, brown, moist					W1	X			2	
4												4	
6			6.8					W2	X			5	
	SP		SAND - med. to coarse, dark brown, angular									7	
8			7.9					W3	X			8	
	CL		CLAY - trace coarse sand, low plastic, grey-brown					W4	X			9	
10			10.2									11	
	GC		GRAVEL, fine, and clay, trace coarse sand, low plastic, grey, dense, (till-like)					W5	X			12	
12												13	some indication of possible layered and laminated structure
14								W6	X			14	
16													

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°16'22''N, 120°35'29''W		ELEVATION:		N75-95H-B8-C
DRWN. BY: A.M.	AIRPHOTO No.: A1 1019- Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD:	RIG: HELI-DRILL		AIR TEMP: Approx. 12°C		
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2
START: D 18 M 09 Y 75 TIME: 12:45		FINISH: D 18 M 09 Y 75 TIME: 13:15			

TEST HOLE No. N75-95H-B8-C

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
	GC		GRAVEL - (cont'd)		UF			W7				17	
18													
20													
22								W8				22 / 23	
24													
26												27	
28			28.0 End of hole					W9				28	

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°16'22''N, 120°35'29''W		ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.: A11019-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-95H-B8-C
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 12°C		
	METHOD: AIR				
START: D 18 M 09 Y 75 TIME: 12:45		FINISH: D 18 M 09 Y 75 TIME: 13:15		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-95H-B8-C

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION
0			
2	CI		CLAY - some coarse sand, little fine gravel, trace fine sand, low - medium plastic, brown, dry
4			4.0
4	SW		SAND - fine to medium, trace coarse, dry, brown, trace clay, (trace silt)
16			16.0 End of hole

ICE GRAPHIC LOG

NRC ICE TYPE VISUAL ICE %: UF

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.)
				1
W1	X			2
W2	X			3
				4
W3	X			5
				7
W4	X			9
				10
W5	X			11

REMARKS

LOGGED BY: D. V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG:	61°16'02''N, 120°46'21''W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.:	A11019-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B8-D
CHKD:	RIG:	HELI-DRILL	AIR TEMP:	Approx. 13°C	
	METHOD:	AIR		ENGINEERS FOR	
START: D 18 M 09 Y 75 TIME: 15:00	FINISH:	D 18 M 09 Y 75 TIME: 15:30		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-B8-D

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		0.25 PEAT - organics, roots		UF								
1	SM		SAND - fine, trace silt, light brown, roots				MA, combined samples 1 - 3 G = 45% S = 27% F = 28% (GM)	B1				1	Combined sample 1' - 4' = GRAVEL, coarse to fine, some sand, some silt
			1.8										
2	ML		SILT - trace fine sand, grey, dry					B2				2	
			2.3										
3	GP		GRAVEL - trace sand, coarse to medium, occasional cobble, dense, sub-rounded to subangular, carbonate coatings					B3				3	- gravel breaking up while being picked
4			4.0 Bottom of pit									4	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°17'20"N, 120°36'55"W		ELEVATION:		N75-95H-B8-1
DRWN. BY: G.B.	AIRPHOTO No.: A 11019-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 18 M 09 Y 75 TIME: 10:15		FINISH: D 18 M 09 Y 75 TIME: 12:15			

TEST HOLE No. N75-95H-B8-1

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.3 PEAT - organics, roots		UF							0	
	SM		SAND - fine, some silt, light brown, dry, roots										
1			1.5				MA, combined samples 1 - 3 G = 60% S = 25% F = 15% (GM)	B1				1	
2	GP		GRAVEL - coarse to fine, little cmf sand, dense, dry, brown, trace sand inclusions, occasional cobbles					B2				2	
3			3.3 no coarse gravel from 3.3'					B3				3	
4			4.0 Bottom of pit									4	

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.	
CHKD: J.K.W.	LAT. & LONG: 61°17'28"N, 120°36'49"W	ELEVATION:			
DRWN. BY: G.B.	AIRPHOTO No.: A 11019-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	N75-95H-B8-2	
CHKD:	RIG:	AIR TEMP.: Approx. 13°C	ENGINEERS FOR		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1	
START: D 18 M 09 Y 75 TIME: 12:30	FINISH: D 18 M 09 Y 75 TIME: 14:00				

TEST HOLE No. N75-95H-B8-2

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
	ML		SILT - little fine sand, roots, brown		UF								- side pit
1.0													
2	GW		GRAVEL - fine to coarse, little cmf sand, occasional cobble										
4													
							MA, sample #1 G = 82% S = 15% F = 3% (GW)	B1	X			5	
6			6.0 fine to coarse, and cmf sand, clean									6	
8			some layering of gravel in sand										
							MA, sample #2 G = 62% S = 36% F = 2% (GW)	B2	X			10	
10			11.0 Bottom of pit									11	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°17'28''N, 120°36'49''W		ELEVATION:		N75-95H-B8-3
DRWN. BY: G.B.	AIRPHOTO No.: A 11019-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 16°C		
	METHOD: TEST PIT				
START: D 18 M 09 Y 75 TIME: 14:15		FINISH: D 18 M 09 Y 75 TIME: 15:00		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-B8-3

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	ML		SILT - some fine sand, yellowish brown, soft.		UF								- observation side pit, no samples taken
3.75	GW		GRAVEL - fine to coarse, little medium to coarse sand, brown										
4.5			Bottom of pit									4.5	

LABORATORY TEST DATA scale: 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°17'20"N, 120°36'55"W		ELEVATION:		N75-95H-B8-4
DRWN. BY: A.J.B.	AIRPHOTO No.: A 11019-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 16°C		
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 18 M 09 Y 75 TIME: 17:00		FINISH: D 18 M 09 Y 75 TIME: 17:15			

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TEST HOLE No. N75-95H-B8-4

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	OL		SILT - (organic), black to dark brown, roots, moist.		UF							0	
			1.0										
1	ML		SILT - trace fine sand, roots, moist.				MA, combined samples 1 & 2 G = 0% S = 5% (fine) F = 95%	B1	X			1	
2			2.3 layer of medium sand, trace fine gravel, brown					B2	X			2	
			2.5										
3			3.2 trace gravel									3	
4			4.0 Bottom of pit									4	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 61°16'22"N, 120°35'29"W		ELEVATION:		N75-95H-B8-5
DRWN. BY: N.L.	AIRPHOTO No.: A11019- Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 18 M 09 Y 75 TIME: 18:15		FINISH: D 18 M 09 Y 75 TIME: 19:00			

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TEST HOLE No. N75-95H-B8-5

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 - fibrous, spongy, moist, moss, medium brown		UF								
0.5													
	Cl		CLAY - some cmf sand, trace fine gravel, medium plastic, medium brown, (till-like)										
1								B1				1	
2								B2				2	
2.5			occasional boulder				MA, samples 2 - 4 G = 16% S = 26% F = 58%						
3								B3				3	
4.0			occasional friable siltstone										
4								B4				4	
5												5	
5.3			Bottom of pit									5.3	

LOGGED BY: K.P.F.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 61°16'02''N, 120°46'21''W		ELEVATION:		N75-95H-B8-6
DRWN. BY: F.B.	AIRPHOTO No.: A 11019-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA, ENGINEERS FOR	
CHKD:	RIG:		AIR TEMP.: Approx. 10°C		
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 18 M 09 Y 75 TIME: 16:30	FINISH: D 18 M 09 Y 75 TIME: 18:30				

TEST HOLE No. N75-95H-B8-6

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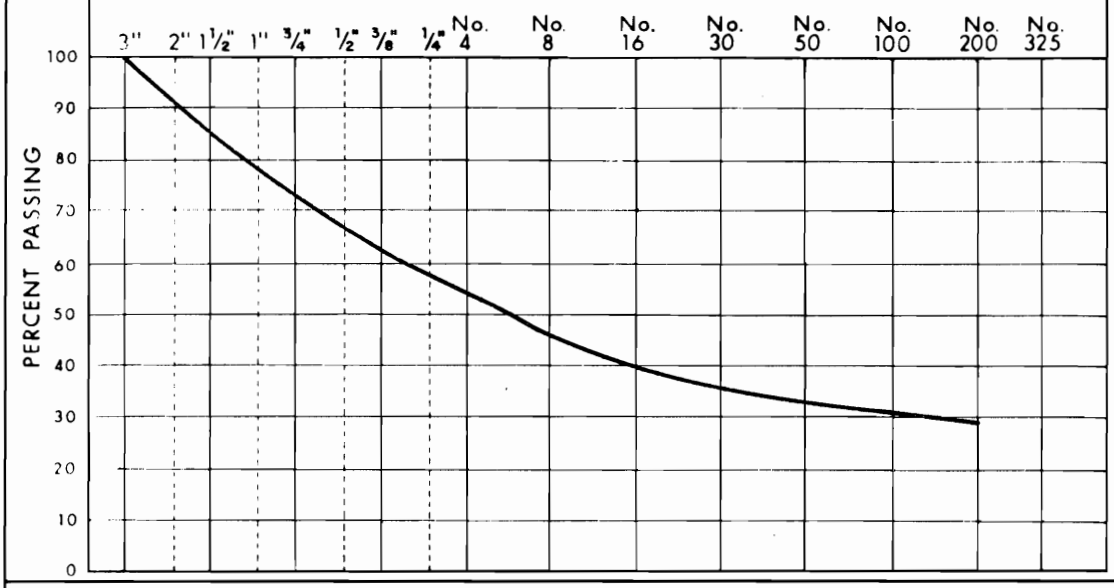
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B8-1 DEPTH 1.0-4.0
DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 12

GRAVEL SIZES		SAND SIZES			FINES
27 %	18 %	10 %	11 %	6 %	28 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	91.2
1½"	87.4
1"	79.3
¾"	73.2
½"	67.3
⅜"	63.1
¼"	
No. 4	55.1
No. 8	46.4
No. 16	39.4
No. 30	35.3
No. 50	33.0
No. 100	31.0
No. 200	28.2

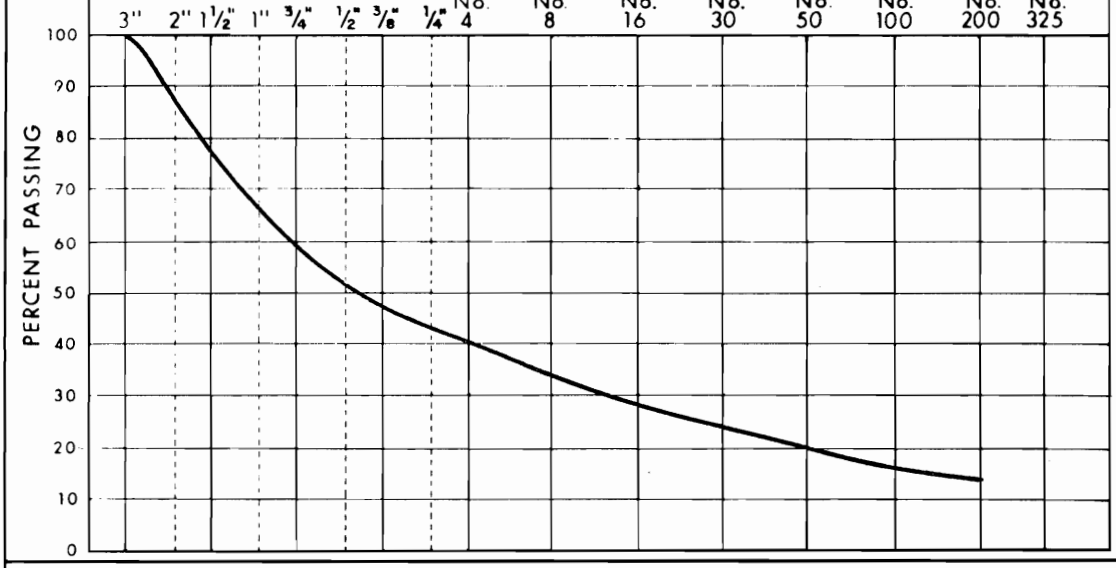
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95H-B8-2 DEPTH 1.0-4.0
DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 17

GRAVEL SIZES		SAND SIZES			FINES
40 %	20 %	8 %	10 %	7 %	15 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	87.5
1½"	79.4
1"	66.0
¾"	59.9
½"	52.0
⅜"	47.4
¼"	
No. 4	40.3
No. 8	32.8
No. 16	28.3
No. 30	24.0
No. 50	20.0
No. 100	17.1
No. 200	14.6

COMMENTS

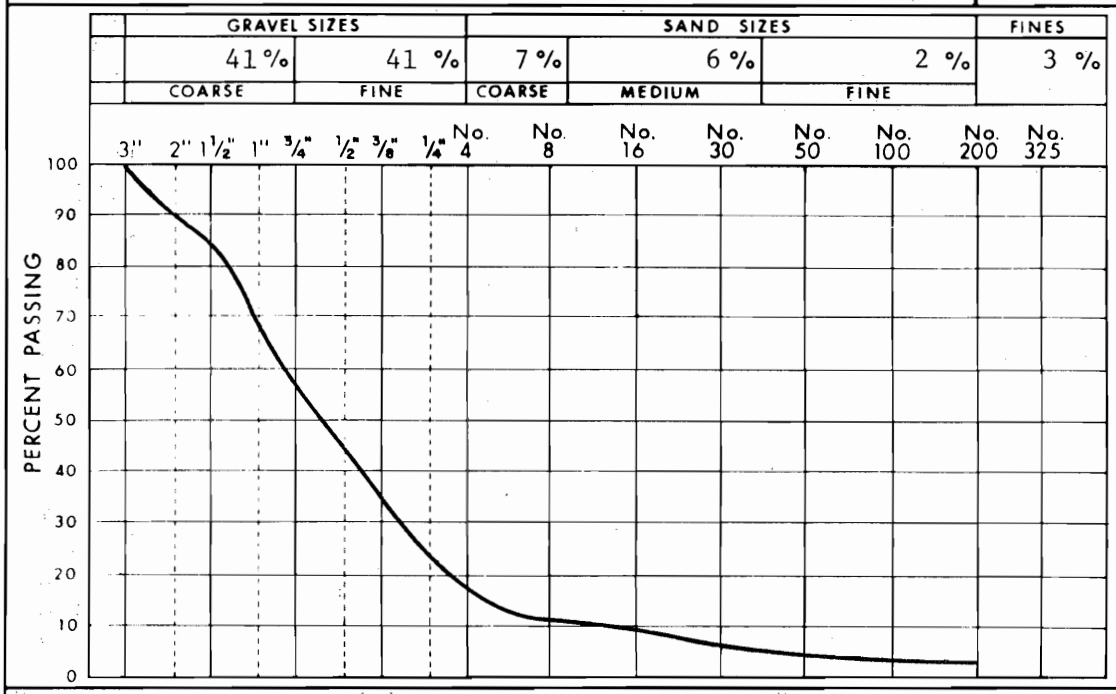
OVERSIZE (>3") = 0.0%

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B8-3 DEPTH 5.0-6.0

DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 40



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.4
1½"	84.6
1"	67.5
¾"	59.3
½"	44.3
⅜"	33.9
¼"	
No. 4	17.9
No. 8	11.8
No. 16	9.2
No. 30	6.3
No. 50	4.4
No. 100	3.6
No. 200	3.1

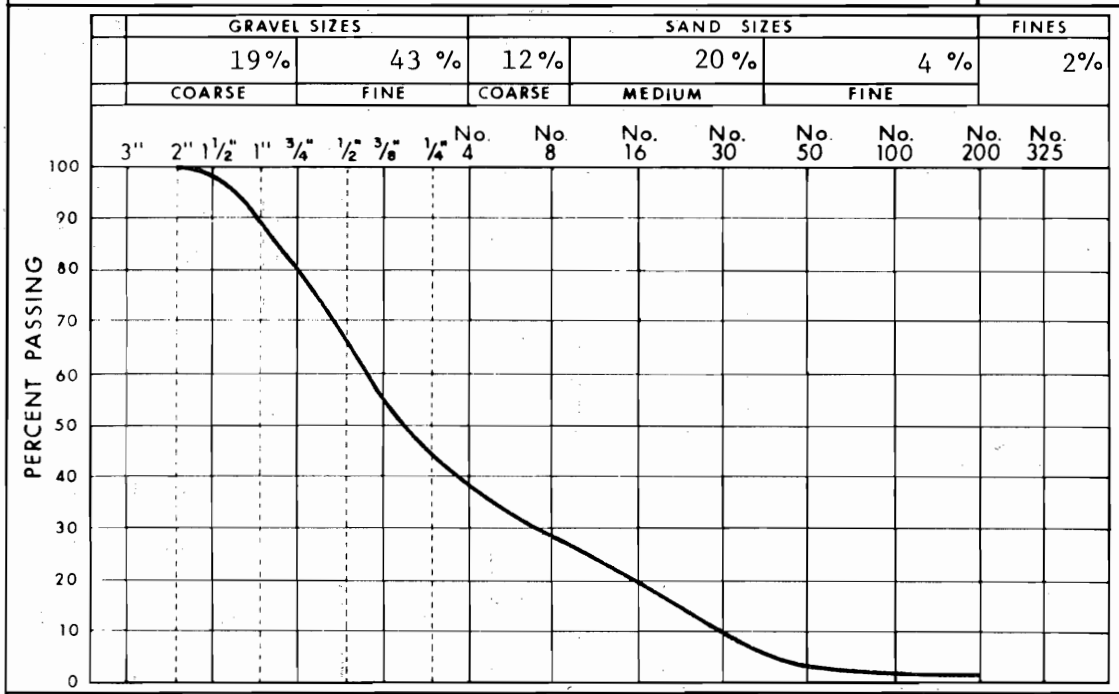
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95H-B8-3 DEPTH 10.0-11.0

DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 39



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	98.8
1"	88.5
¾"	80.6
½"	95.7
⅜"	55.2
¼"	
No. 4	38.0
No. 8	28.2
No. 16	19.3
No. 30	0.0
No. 50	3.4
No. 100	2.6
No. 200	2.2

COMMENTS

OVERSIZE (>3") = 0.0 %

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

NORTHERN Engineering Services Company Limited

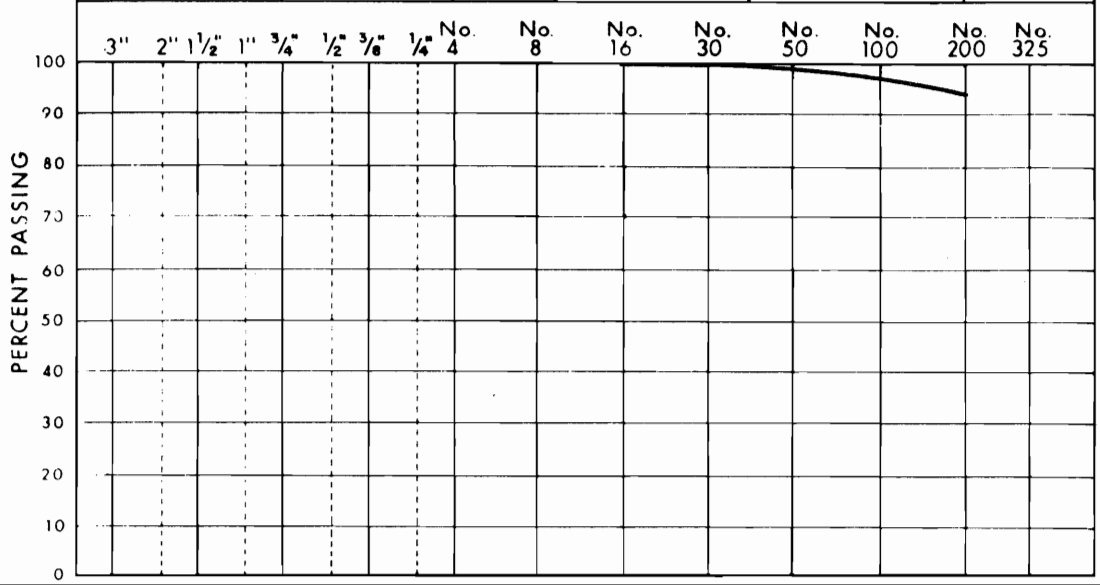
DEPOSIT No. N75-95H-B8

SIEVE ANALYSIS REPORT

SAMPLE N75-95H-B8-5 DEPTH 1.0-3.0
DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 221

GRAVEL SIZES		SAND SIZES			FINES
0 %	0%	0 %	0 %	5 %	95%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	100.0
No. 30	99.7
No. 50	99.0
No. 100	97.9
No. 200	94.5

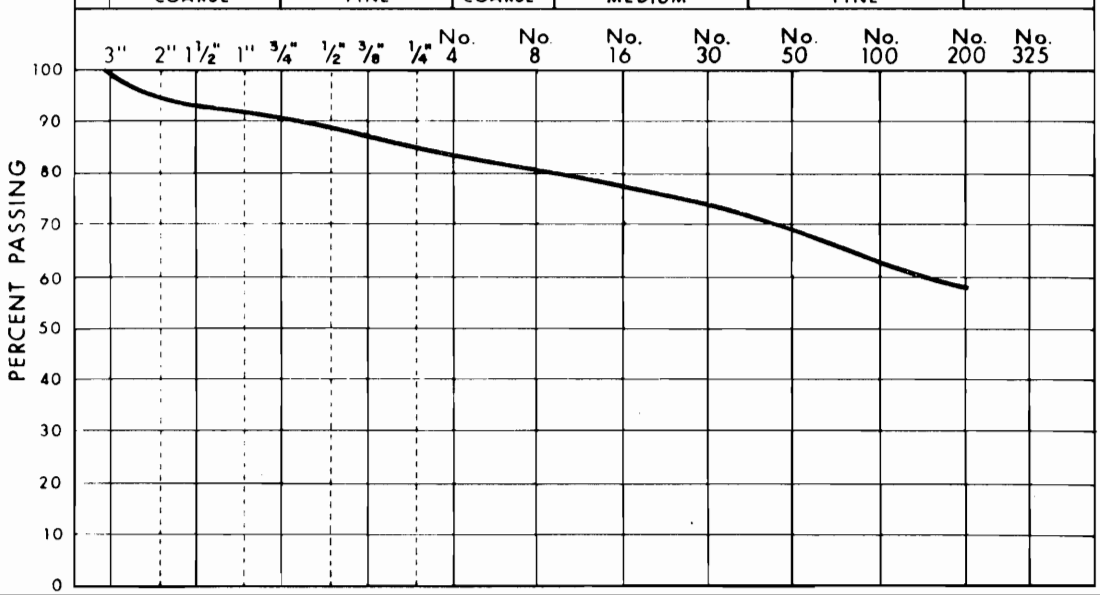
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-95H-B8-6 DEPTH 2.0-5.0
DATE SAMPLED September 18, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 18

GRAVEL SIZES		SAND SIZES			FINES
9 %	7 %	4 %	8 %	14 %	58 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	94.1
1½"	92.9
1"	92.3
¾"	91.0
½"	89.3
⅜"	87.4
¼"	
No. 4	84.1
No. 8	80.8
No. 16	77.6
No. 30	74.2
No. 50	69.3
No. 100	62.8
No. 200	57.9

COMMENTS

OVERSIZE (>3") = 0.0%

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

NORTHERN Engineering Services Company Limited

DEPOSIT No.
N75-95H-B8

SUMMARY OF LABORATORY TEST DATA FOR SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-95H-B8-2 DATE SAMPLED September 18, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-4 DATE TESTED March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 4.67 %
FINE AGGREGATE : LOSS = 8.11 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 22.5 %

ORGANIC IMPURITIES TEST

NUMBER : 2+
COAL REMOVED : -
COAL & ROOTLETS REMOVED : -
COAL CONTENT : -
SIGNIFICANCE :

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	3.20
Granite		13.35
Sandstone	Strong, Good	2.63
Siltstone		2.35
Limestone	Soft, Strong, Good	37.55
Soft Sandstone	Soft, Friable, Poor	0.31
Clay	Friable, Weak, Deleterious	0.01
Ironstone		0.30
PN = 107	INTERPRETATION : Excellent	59.7

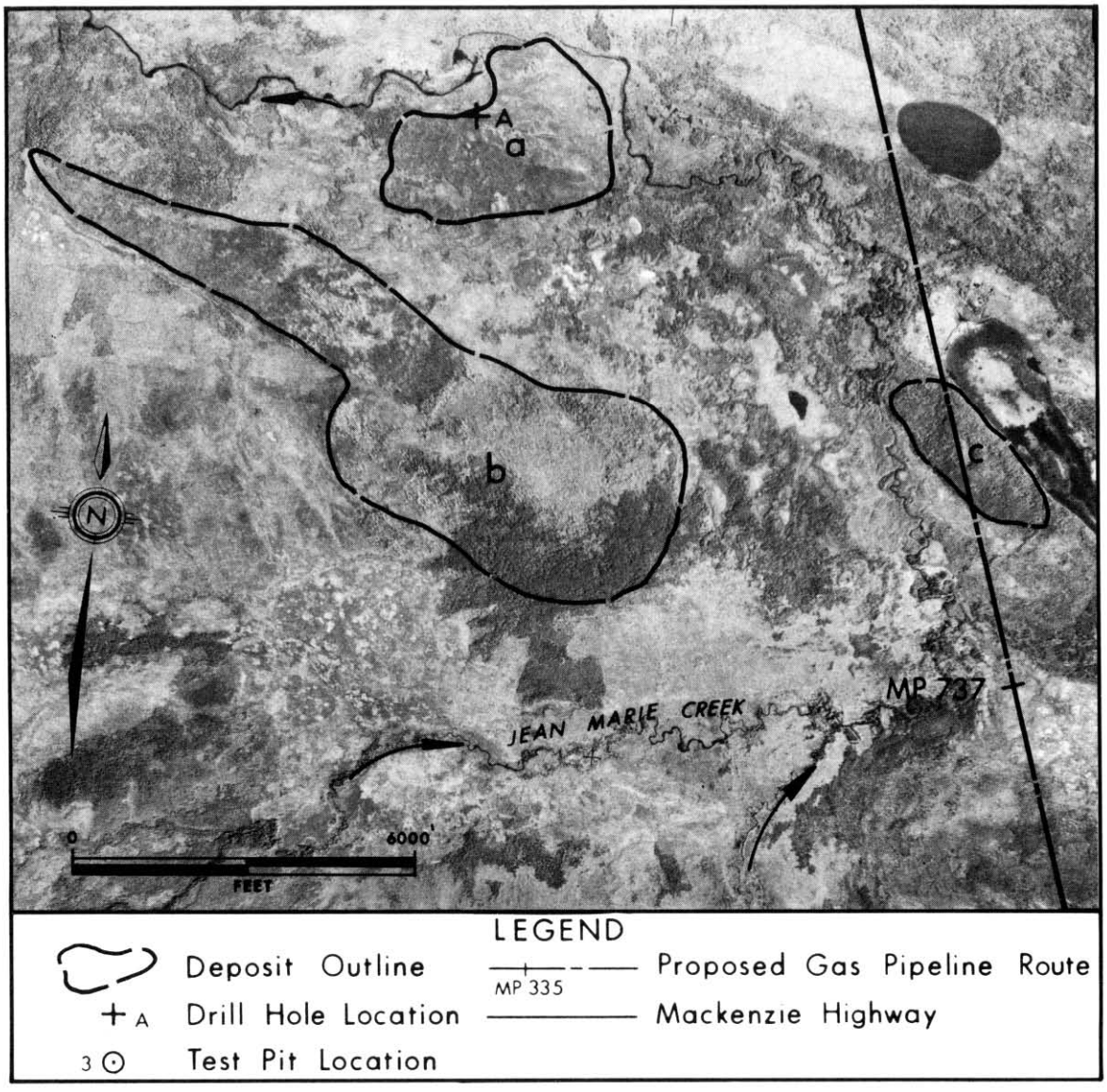
COMMENTS : Organic impurities test satisfactory.
Extensive carbonate coating may reduce quality to fair.

Physical Setting: Deposit 95H-B9 consists of shallow bedrock located near the proposed pipeline crossing of Jean Marie Creek.

Material: LIMESTONE - well bedded, argillaceous and sandy.

Volume: 39,200,000 cubic yards.

Assessment: Deposit 95H-B9 is a source of good quality bedrock suitable for general fill, backfill, building pads and possibly concrete subject to testing. Crushing and screening is required.



Airphoto No. A11001-295
Approximate Scale: 1" = 3200'

Latitude: 61° 09' N.
Longitude: 120° 37' W.

DEPOSIT 95H-B9

PHYSICAL SETTING

Deposit 95H-B9 consists of shallow bedrock southeast of Deep Lake near Jean Marie Creek. The proposed gas pipeline runs immediately east of Jean Marie Creek and crosses section "c" of the deposit near mile 736.

The deposit includes two 50 foot high bedrock cored hills which are indicated on the attached airphoto as sections "b" and "c". These hills have been shaped into drumlinoid forms by glacier ice and have been covered by till at the same time. The thickness of till over the bedrock in these hills is unknown because they were not drilled during this investigation.

Section "a" of the deposit is shallow, flat lying bedrock adjacent to Jean Marie Creek. It is covered by a thin layer of silt and sand. A drill hole in section "a" encountered sandy limestone of the Upper Devonian Tetcho Formation. Artesian water was found 16 feet below the surface in the limestone.

All three sections of the deposit are well drained, but the surrounding till plain and meltwater channels are poorly drained.

BIOLOGICAL SETTING

The vegetation along Jean Marie Creek consists of aspen, pine, white spruce and white birch with an alder and lichen understory. Moose tracks and beaver activity were observed in the area during the 1975 survey. Jean Marie Creek has spring spawning runs of yellow walleye, long-nose sucker and northern pike, and a fall run of whitefish. The site lies in the Fort Simpson hunting and trapping area.

MATERIAL

The bedrock has been mapped by Douglas (1959, 1973) as a well bedded, yellowish grey, medium grained, argillaceous and sandy limestone. Till overburden of unknown thickness is present on the hill in sections "b" and "c" of the deposit. A thin cover of silty overburden is found in section "a" near Jean Marie Creek.

VOLUME

Using an average thickness of 25 feet over an area of 973 acres, 39.2 million cubic yards of near surface bedrock is present.

DEVELOPMENT AND REHABILITATION

Deposit 95H-B9 is a source of good quality bedrock material. Crushed and screened it would be suitable for general fill, backfill in pipeline construction and building pads. Testing is required prior to its use as concrete aggregate. Quarry locations would be dictated by haul distances, overburden thickness, insitu material quality, material requirements and environmental concerns.

Access to the deposit would be via a snow road or the pipeline right of way.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between development areas and Jean Marie Creek. McCart et. al. (1974) consider this creek to be sensitive from May to November.

Initially development would start with harvesting and disposing of vegetative cover in accordance with existing land use regulations. Overburden would then be stripped and stockpiled at the base of the excavation. Quarrying would involve cutting into the side of hills in sections "b" and "c" or developing a dugout style quarry in section "a". This could be accomplished by using conventional blasting techniques and earthmoving equipment. A crushing and screening plant would be required to produce adequate material sizes and gradations.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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
	ML		SILT – little fine sand, low plastic, brown		UF			W1				1.0	
1.3												1.5	
2	BR		LIMESTONE – weak					W2				2.0	WALMAC bit bored fairly easily through limestone
4													W2, W3, W4 rock chips
6			18/09/75 17:50 hrs. 6.5 ▼									6.5	— — 17:50
								W3				7.0	
8												8	
14												14	
			18/09/75 17:30 hrs. 16.0 ▼										
15.7			damp chips										
16.0			water flowed from hole									16.5	free water at 16' at about 17:30, after shut down, water rose to 6.5' by 17:50
								W4				17.0	
17.5			End of hole										
18													

LOGGED BY:	D.V.	FACILITY:		PROJECT:	13011
CHKD:	J.K.W.	LAT. & LONG:	61°09'13''N, 120°37'25''W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 11001-295	PIPE MILEAGE:	
CHKD:		RIG:	HELI-DRILL	AIR TEMP.:	Approx. 13°C
		METHOD:	AIR		

START: D 18 M 9 Y 75 TIME: 17:10 FINISH: D 18 M 9 Y 75 TIME: 17:35

1975 BORROW INVESTIGATION

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

TEST HOLE No. N75-95H-B9-A

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-95H-B9-A

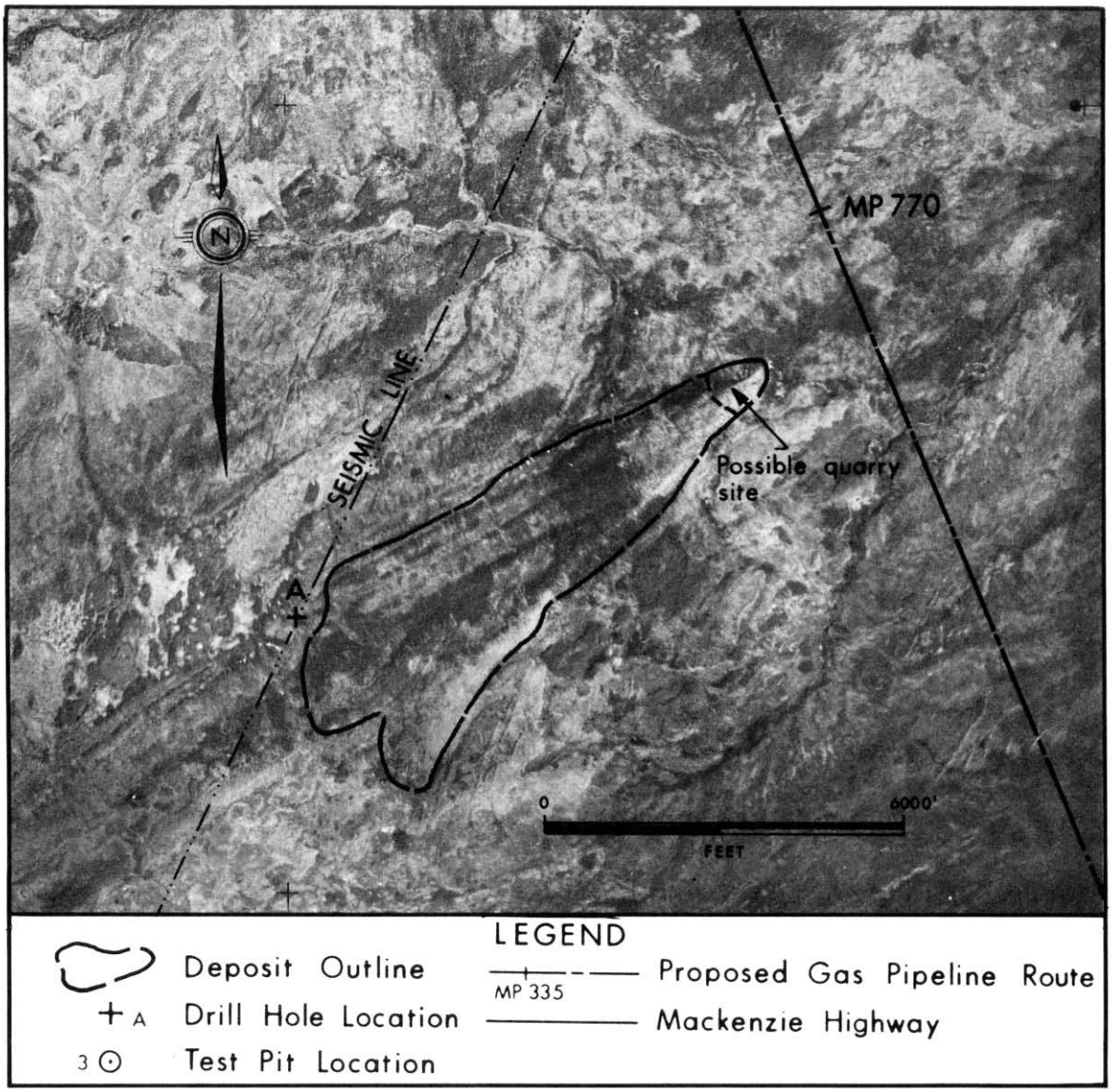
DEPOSIT 95A-B1

Physical Setting: Deposit 95A-B1 is a till covered bedrock high located 16 miles north of Trainor Lake. The proposed pipeline route at M.P. 770 passes near the deposit.

Material: TILL - sandy, overlies bedrock.
SHALE and SANDSTONE -

Volume: Unlimited volume.

Assessment: Deposit 95A-B1 is a source of fair quality crushable bedrock and unfrozen till suitable for general fill. Thick till overburden may preclude bedrock use.



Airphoto No. A12493-358
Approximate Scale: 1" = 3050'

Latitude: 60° 40' N.
Longitude: 120° 16' W.

DEPOSIT 95A-B1

PHYSICAL SETTING

Deposit 95A-B1 is a drift covered bedrock ridge located 16 miles north of Trainor Lake. The proposed gas pipeline passes near the northeast end of the deposit at milepost 770. Bedrock maps indicate that this ridge conists of Cretaceous shale. It may be capped by Cretaceous sandstone or fairly resistant shale because it has not been eroded to the same extent as the surrounding area. Glaciers flowing from the northeast have deposited and sculptured till which lies on top of the bedrock. The till is fairly thick (at least 28 feet in drill holes near the southwest end) and numerous crevasse fillings are also found in the till plain area next to the bedrock high.

Drainage of the deposit is good, but poorly drained bogs exist close by. Till which overlies the bedrock is unfrozen.

BIOLOGICAL SETTING

A black spruce forest with Labrador tea, alder and moss dominates the site. Large mammal habitat is marginal, but the area provides good red squirrel habitat. No waterfowl, raptor nesting or fish habitat were identified at the site.

MATERIAL

Low quality fill material may be obtained from the unfrozen till which mantles bedrock of this deposit. The sandstone and shale which core the ridge may also provide fill material if overburden is not too thick to permit development of a bedrock quarry.

VOLUME

The ridge would provide an extensive amount of unfrozen till and shale or sandstone bedrock.

DEVELOPMENT AND REHABILITATION

Deposit 95A-B1 is a source of fair quality crushable bedrock and unfrozen till suitable for general fill. The bedrock is probably not too resistant and may degrade rapidly if used for construction purposes. Further investigation would be needed to accurately define areas of shallow bedrock and zones where better quality resistant shale or sandstone are present. The sandy till which mantles the bedrock could also be used for general fill.

Access may be achieved via the pipeline right of way and then by a short snow road to the deposit. A seismic line crosses the west side of the deposit.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

Initially, tree and vegetative cover along the access route and at the quarry site would be harvested and disposed of in accordance with existing land use regulations. The overburden could then either be stockpiled at the site for future use or transported directly to the right of way for immediate use as fill.

Development of this deposit would probably involve quarrying into the side of the ridge near the pipeline. Care should be taken so as not to initiate slope movement due to the removal of material at the toe. Blasting and standard rock quarry and earthmoving equipment should be adequate to develop this site.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	SW		SAND - fine to med., trace coarse, (possible trace silt or clay), grey brown, dry		UF			W1				1	
2.0												2	
2	SC		SAND - clayey, little fine gravel, brown, (till-like)					W2				3	
4												5	
6								W3				6	
8													
10													
12								W4				12	
14												13	
16								W5				15	Sample 5 probably slough

LOGGED BY: D.V.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 60°39'57''N, 120°16'12''W		ELEVATION:		N75-95A-B1-A
DRWN. BY: A.M.	AIRPHOTO No.: A12493-358		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 22°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2
START: D 19 M 9 Y 75 TIME: 14:25	FINISH: D 19 M 9 Y 75 TIME: 15:40				

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TEST HOLE No. N75-95A-B1-A

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
18	SC		(SAND) con't		UF			W5				17	
			(19.0)									19	
20	GW		GRAVEL - coarse, subangular, wet					W6				20	
			(21.0)										
22	GC		GRAVEL - coarse to fine, clayey, some sand, grey - brown, wet, (till-like)										material came up as a slurry
24								W7				24	
26												26	
			28.0 End of hole									28	
28													

LOGGED BY: D.V	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 60°39'57''N, 120°16'12''W		ELEVATION:		N75-95A-B1-A
DRWN. BY: A.M.	AIRPHOTO No.: A 12493-358		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD:	RIG: HELI-DRILL		AIR TEMP.: Approx. 22°C	ENGINEERS FOR	
	METHOD: AIR			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 2
START: D 19 M 09 Y 75 TIME: 14:25		FINISH: D 19 M 09 Y 75 TIME: 15:40			

373

TEST HOLE No. N75-95A-B1-A

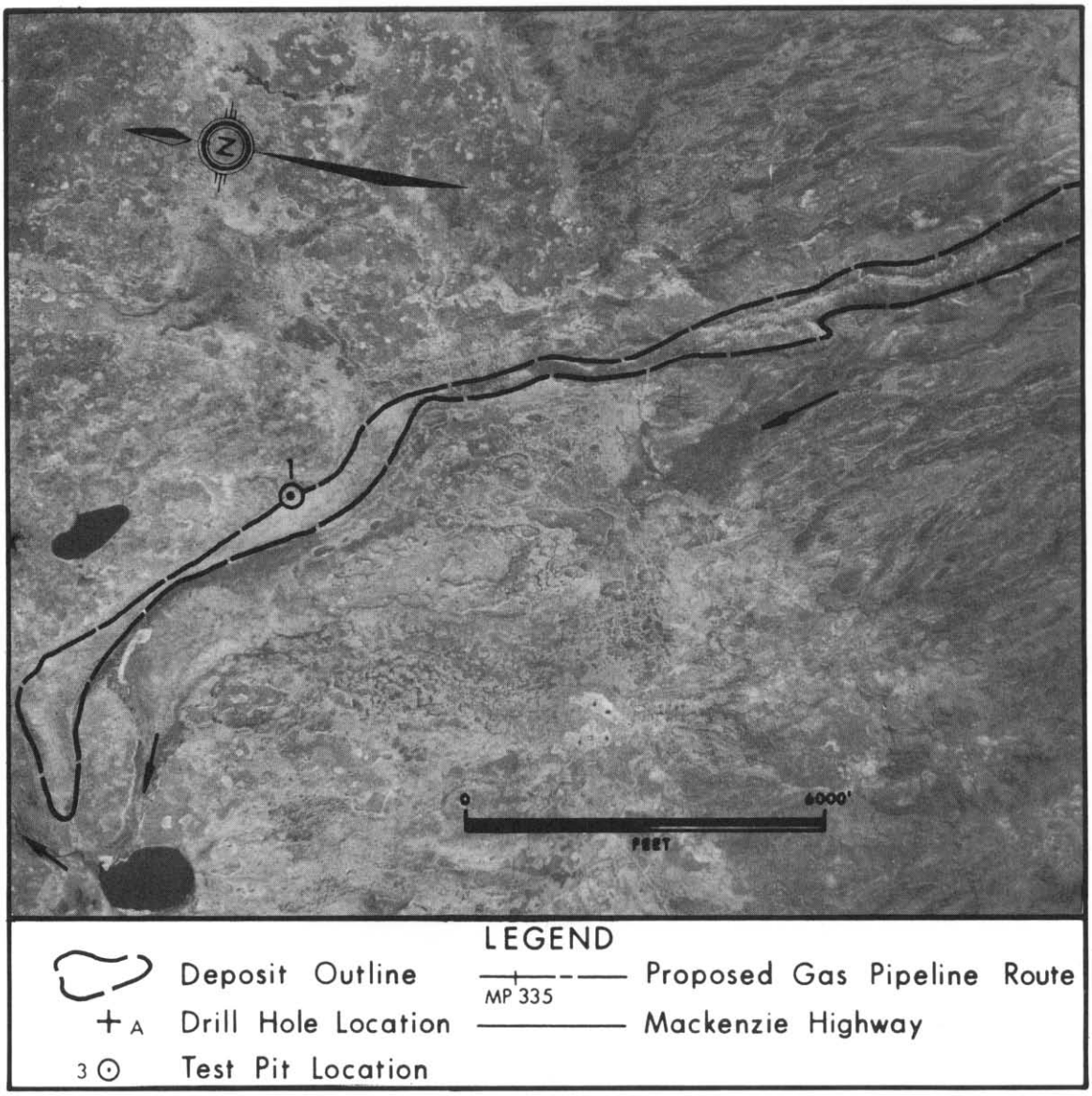
PC-9,SK373

Physical Setting: Deposit 85D-B1 is a moraine ridge located 7 miles west-northwest of Dogface Lake.

Material: TILL - clay, trace gravel; fine sand and silt overburden.

Volume: 4,800,000 cubic yards.

Assessment: Deposit 85D-B1 contains no granular material, is suitable only for marginal fill, therefore it is not recommended for development.



Airphoto No. A13161-30
Approximate Scale: 1" = 3000'

Latitude: 60° 22' N.
Longitude: 119° 24' W.

DEPOSIT 85D-B1

PHYSICAL SETTING

Deposit 85D-B1 is a moraine ridge located 7 miles west-northwest of Dogface Lake and 18 miles northeast of the proposed gas pipeline.

The Geological Survey of Canada mapped this ridge as an esker (GSC Open File 158 - Map 85D). However, test pitting seems to indicate that it is a moraine ridge with a thin cover of sand. The moraine ridge is 4 miles long and ranges in width from 500 to 1000 feet. The ridge stands approximately 20 feet above the surrounding terrain.

Drainage on the ridge is good, but the surrounding till plain is poorly drained. Test pits show the deposit to be unfrozen.

BIOLOGICAL SETTING

A pine and aspen forest dominates the site. Moose are present during the summer but it is not good winter range. Black bear droppings were observed at the site. No suitable fish or waterfowl habitat is available at the site. The site occurs in the Hay River hunting and traping area.

MATERIAL

This deposit is a moraine ridge consisting of clay till overlain by 2 feet of fine sand and silt. The till is red to grey-brown with a trace of fine to medium, subrounded to subangular gravel.

VOLUME

Assuming an average ridge height of 18 feet and a triangular cross section over an area of 331 acres, a total volume of 4.8 million cubic yards of clay till can be calculated.

DEVELOPMENT AND REHABILITATION

Deposit 85D-B1 contains no granular material. However, although the till may be used for marginal fill applications, this deposit is not recommended for development because of long haul distance to the pipeline.

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
1	SM		SAND - fine, and silt, light brown		UF	▲ Dry density (pcf) ⊙ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	MA, P200 = 37%	B1				1	
2			2.0									2	
	CI		CLAY - little fine gravel, medium plastic, subrounded to subangular, red, grey, and brown				MA, P200 = 62%	B2					
			2.75 Bottom of pit									2.75	

LOGGED BY:	J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD:	G.M.H.	LAT. & LONG:	60°21'55"N, 119°23'28"W	ELEVATION:	
DRWN. BY:	F.B.	AIRPHOTO No.:	A 13161-30	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD:	J.K.W.	RIG:		AIR TEMP.: Approx. 18°C	ENGINEERS FOR
		METHOD:	TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START:	D 19 M 09 Y 75 TIME: 14:30	FINISH:	D 19 M 09 Y 75 TIME: 15:15		

TEST HOLE No. N75-85D-B1-1

TEST HOLE No. N75-85D-B1-1

SHEET 1 OF 1

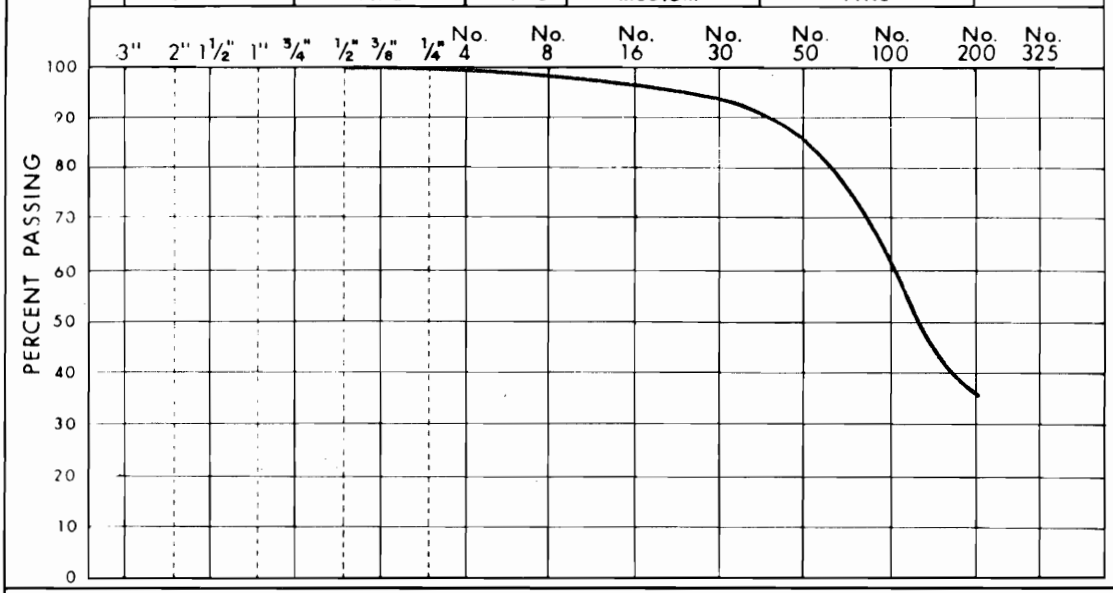
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-85D-B1-1 DEPTH 1.0-2.0
DATE SAMPLED September 19,1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 14

GRAVEL SIZES		SAND SIZES			FINES
0%	0 %	2%	9 %	52 %	37%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	100.0
⅜"	99.7
¼"	
No. 4	99.5
No. 8	98.4
No. 16	96.6
No. 30	93.7
No. 50	85.7
No. 100	62.6
No. 200	36.9

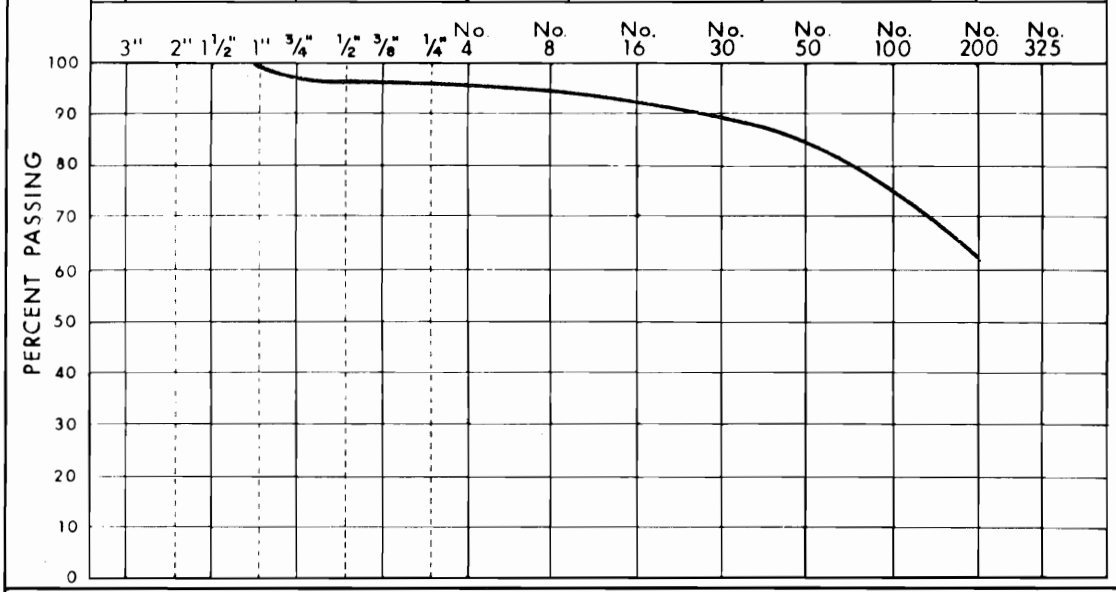
COMMENTS

OVERSIZE (>3") = 0.0 %

SAMPLE N75-85D-B1-1 DEPTH 2.0-2.75
DATE SAMPLED September 19, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 13

GRAVEL SIZES		SAND SIZES			FINES
2 %	2%	3 %	6 %	25 %	62 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	100.0
¾"	97.7
½"	97.0
⅜"	97.0
¼"	
No. 4	96.0
No. 8	94.4
No. 16	92.2
No. 30	89.8
No. 50	84.9
No. 100	74.4
No. 200	62.2

COMMENTS

OVERSIZE (>3") = 0.0 %

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

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-85D-B1

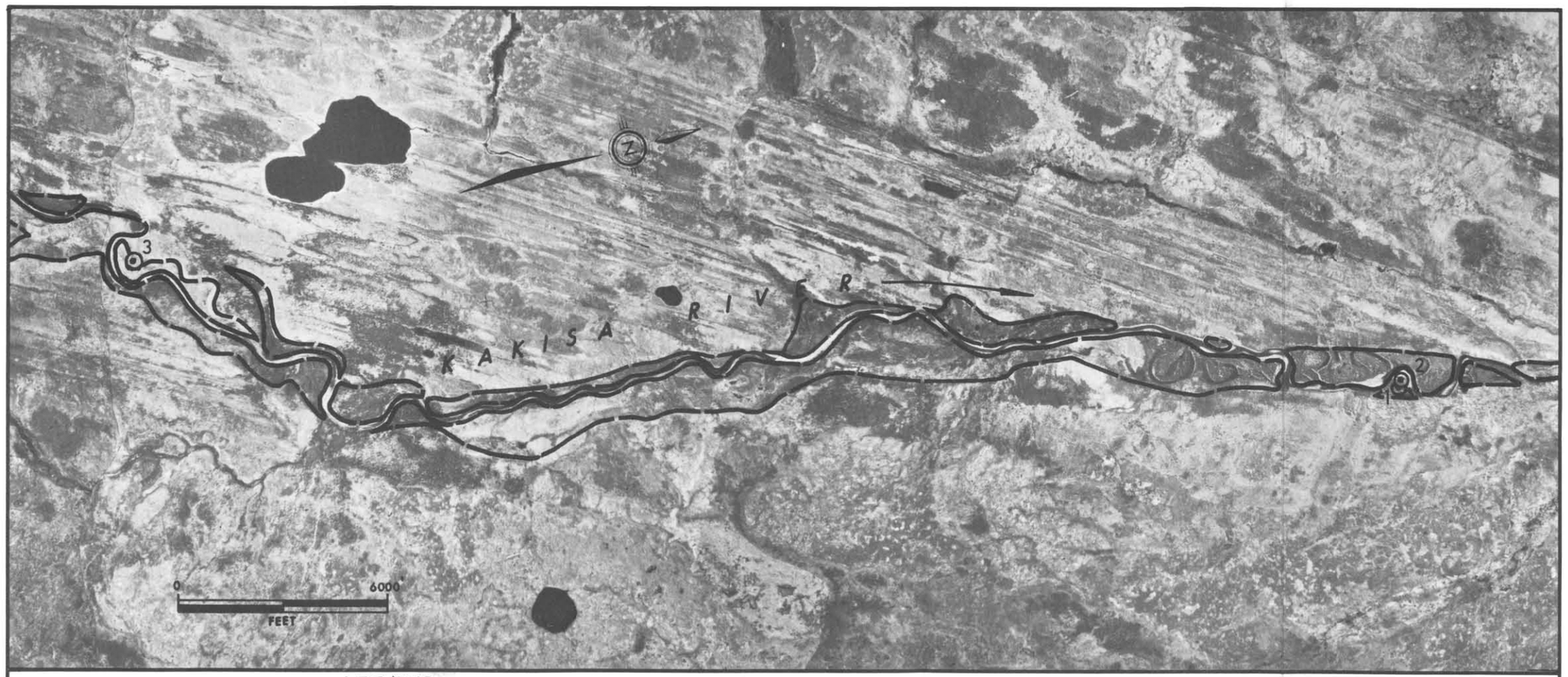
DEPOSIT 85D-B2

Physical Setting: Deposit 85D-B2 is a series of terraces along the Kakisa River. The proposed pipeline route passes within 2 miles of the southeastern end of the deposit.

Material: SAND and GRAVEL - stratified or sand with gravel pockets.

Volume: 31,000,000 cubic yards.

Assessment: Deposit 85D-B2 is a source of fair to good quality granular material suitable for general fill, embankment fill, building pads, and possible concrete aggregate.



Airphoto No. A12544-3, 4, 91, 92; A12539-265, 266
Approximate Scale: 1" = 3700'

Latitude: 60° 20' N.
Longitude: 119° 43' W.

PHYSICAL SETTING

Deposit 85D-B2 consists of a series of sand and gravel terraces located along the Kakisa River. The proposed gas pipeline runs within 2 miles of the area.

The terraces of alluvial origin extend over a length of 30 miles. The central and southern terraces were investigated during this borrow study. The lower terraces generally stand from 10 to 25 feet above the river level and are about 1500 feet wide. In some localities 2 terrace levels are present.

The terraces are well drained. The groundwater table is shallow and there is little overburden on the terraces.

Kakisa River runs north-northeast through fluted till plain deposits of this region. The regional drainage is poor with water trapped between the till ridges.

BIOLOGICAL SETTING

The southern section of the deposit supports a riparian forest of white spruce, pine and aspen. The understory consists of alder, willow, rose and cinquefoil with Saskatoon dominating the moderate to steep slopes. The northern section of the site is similar but with balsam poplar and highbush cranberry. The area provides good summer but marginal winter habitat for moose. Woodland caribou are present along the river in winter and black bear in summer. The area is good habitat for red squirrel, marten, mink, beaver and otter. Waterfowl nesting occurs along the river. Large trees in the area provide important raptor habitat. The Kakisa River has excellent spawning potential throughout its length, is a summer feeding area for pike, lake chub, and trout perch, and is possibly used for fall spawning runs.

MATERIAL

Parts of the deposit are stratified sand and gravel and other parts are sand with pockets of gravel. The gravel is fine to coarse, subrounded to subangular, well graded, brown and composed of granite and limestone with subordinate quartzite, sandstone and siltstone. The sand is poorly graded, fine grained and silty.

VOLUME

Assuming a 15 foot depth and an areal extent of 1282 acres, 31 million cubic yards of granular material is present in the deposit.

DEVELOPMENT AND REHABILITATION

Deposit 85D-B2 is a source of fair to good quality granular material suitable for general fill, embankment fill in berm construction, building pads and possible concrete production. Location of areas to be exploited will be dictated by environmental considerations, haul distances, access, insitu material quality and material requirements. It should be noted that the Kakisa River valley is an environmentally sensitive area with wildlife using the valley year round. Kakisa River itself is particularily sensitive from May to November (McCart et al., 1974).

Access may be achieved along the pipeline right of way and then along the Kakisa River valley, via snow and ice roads, a distance of about 2 miles to the deposit.

No biological factors were identified during the field reconnaissance which would preclude development of this deposit. Further field investigations will be required to collect additional environmental, land use and socio-economic information prior to final selection and development of the deposit.

A buffer zone should be maintained between development areas and the Kakisa River to prevent siltation since this river is particularly important to fish resources in the area and supports a downstream domestic fishery.

Initially, tree and vegetative cover would have to be harvested and disposed of in accordance with existing land use regulations. Any overburden would then be stripped from the area to be excavated and stockpiled around the edge of the excavation site.

Development of this deposit would involve a dugout type pit, generally parallel to and back from the river at least 300 feet. Pit depth would be limited by groundwater or the actual granular deposit thickness. This type of development could be accomplished using conventional earthmoving techniques. Washing and screening of material may be required to produce quality construction aggregate. Concrete suitability tests on a sample from test pit number 2 indicated that material from this site could provide good to excellent concrete aggregate.

A progressive rehabilitation plan will be developed for each deposit. The objective of the plan will be to stabilize disturbed areas to prevent erosion and, depending on subsequent use of the site, perform such work as is required to visually integrate the site into the surrounding landscape. The plan will outline the sequence of rehabilitation procedures to be used at each stage of development and at the abandonment of the site. This may include procedures such as: selective grading and shaping; selective stripping and replacing of top soil and overburden; installation of physical erosion control structures and materials; seeding and mulching; and the planting of trees and shrubs.

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	SM		SAND - fine, some silt, roots, brown, damp		UF							0	
1												1	
2							MA, G = (negl) S = 79% F = 21%	B1				2	
3			3.25 Bottom of pit									3	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: J.K.W.	LAT. & LONG: 60°21'22''N, 119°42'37''W		ELEVATION:		
DRWN. BY: F.B.	AIRPHOTO No.: A 12544-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA	N75-85D-B2-1
CHKD:	RIG:		AIR TEMP.: Approx. 13°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 19 M 09 Y 75 TIME: 11:15		FINISH: D 19 M 09 Y 75 TIME: 12:00			

TEST HOLE No. N75-85D-B2-1

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)	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1	GW		GRAVEL - fine to coarse, subrounded to subangular, some fine sand, (trace silt), brown, damp		UF	40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	MA, combined samples 1 & 2 G = 70% S = 28% F = 2% (GW)	B1				1	
2			(trace sand, medium to coarse at 0.5')					B2				2	
			2.8 Bottom of pit									2.8	

LOGGED BY: J.L.M.	FACILITY:		PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 60°21'22"N, 119°42'37"W		ELEVATION:		N75-85D-B2-2
DRWN. BY: F.B.B.	AIRPHOTO No.: A 12544-Mosaic		PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA	
CHKD: J.K.W.	RIG:		AIR TEMP.: Approx. 16°C	ENGINEERS FOR	
	METHOD: TEST PIT			CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1
START: D 19 M 09 Y 75 TIME: 12:00		FINISH: D 19 M 09 Y 75 TIME: 12:30			

TEST HOLE No. N75-85D-B2-2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %
1	SM		SAND - fine to medium, some silt, brown, damp		UF
			1.4 medium, trace coarse, damp, brown to grey		
2			2.0		
	GW		GRAVEL - fine to coarse, subrounded to subangular, and cmf sand,* brown, damp		
			2.5 Bottom of pit		
			* borderline gravel/sand		

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
W% MA, sample #1 G = 0% S = 77% F = 23%						
13 (SM) MA, sample #2 G = 52% S = 45% F = 3%	B1				1	
3 (GW)	B2				2	Sample #2 + 3" = 9.3%
					2.5	

LOGGED BY: J.L.M.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 60°16'05"N, 119°45'57"W	ELEVATION:	
DRWN. BY: F.B.	AIRPHOTO No.: A 12544-Mosaic	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY ALBERTA
CHKD: J.K.W.	RIG:	AIR TEMP.: Approx. 16°C	ENGINEERS FOR
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 19 M 09 Y 75 TIME: 13:20	FINISH: D 19 M 09 Y 75 TIME: 13:40		

TEST HOLE No. N75-85D-B2-3

SHEET 1 OF 1

PC-9,SK373

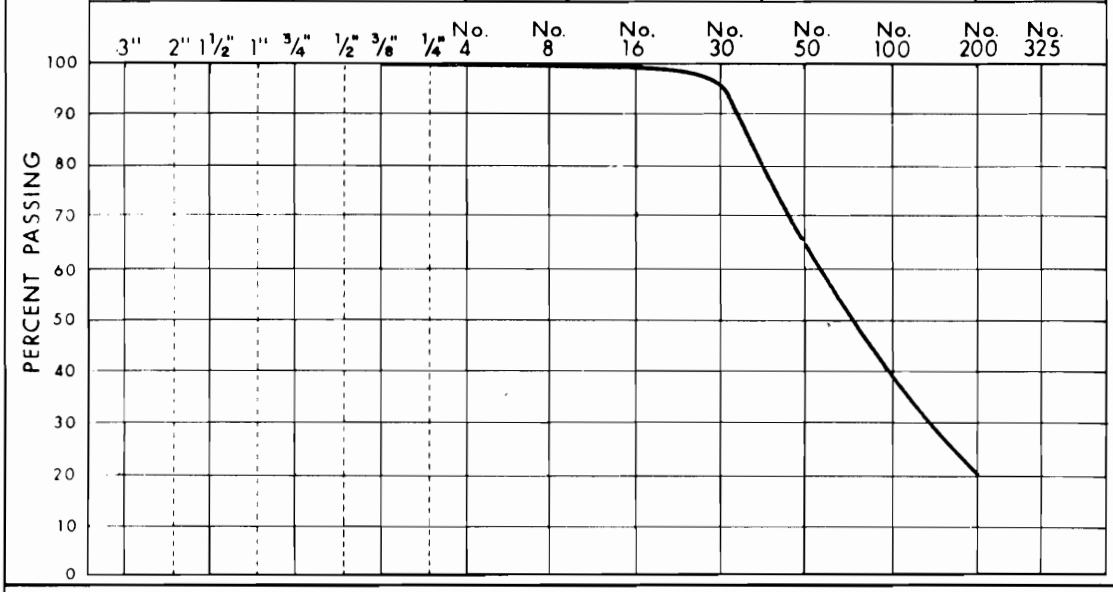
SIEVE ANALYSIS REPORT

SAMPLE N75-85D-B2-1 DEPTH 2.0-3.0

DATE SAMPLED September 19, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 7

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0 %	19 %	60 %	21 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	100.0
¼"	
No. 4	99.8
No. 8	99.7
No. 16	99.4
No. 30	95.6
No. 50	65.6
No. 100	39.3
No. 200	20.8

COMMENTS

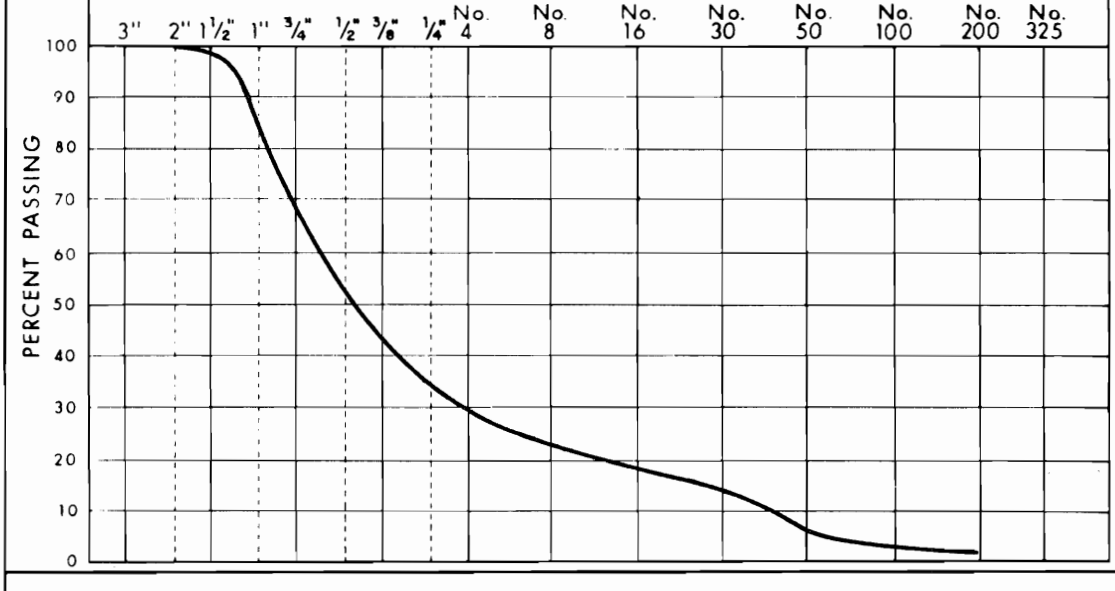
OVERSIZE (>3") = 0.0%

SAMPLE N75-85D-B2-2 DEPTH 1.0-2.75

DATE SAMPLED September 19, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 173

GRAVEL SIZES		SAND SIZES			FINES
31 %	39 %	8 %	12 %	8 %	2%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	100.0
1½"	99.1
1"	82.1
¾"	69.4
½"	53.6
⅜"	44.1
¼"	
No. 4	30.0
No. 8	23.5
No. 16	18.8
No. 30	13.7
No. 50	7.0
No. 100	2.7
No. 200	1.8

COMMENTS

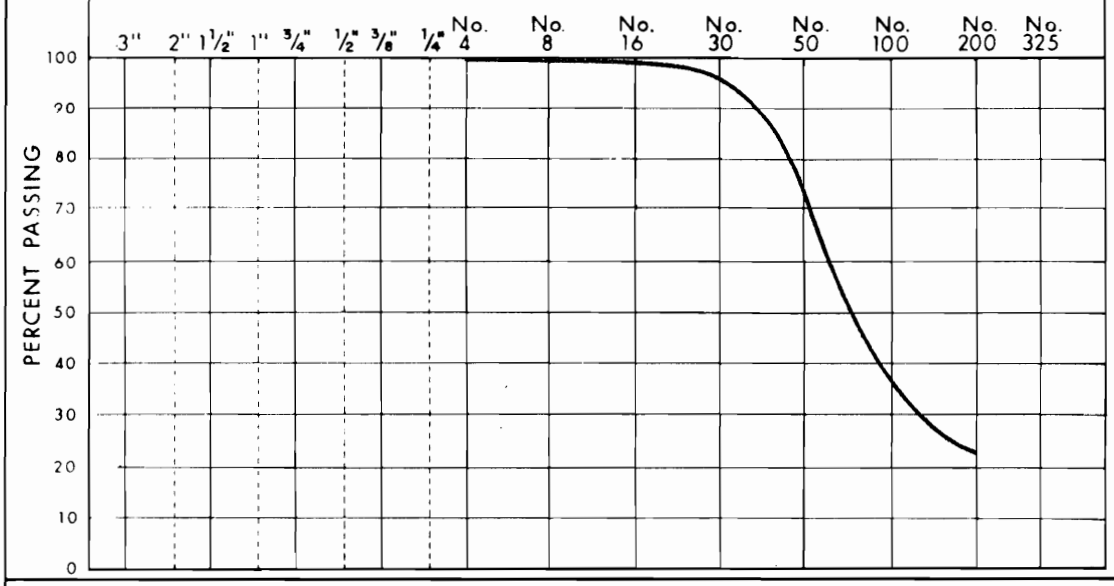
OVERSIZE (>3") = 0.0 %

SIEVE ANALYSIS REPORT

SAMPLE N75-85D-B2-3 DEPTH 1.0-2.0
DATE SAMPLED September 19, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 37

GRAVEL SIZES		SAND SIZES			FINES
0 %	0 %	0 %	16 %	61 %	23 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	100.0
No. 8	99.9
No. 16	99.4
No. 30	95.7
No. 50	73.2
No. 100	36.9
No. 200	22.6

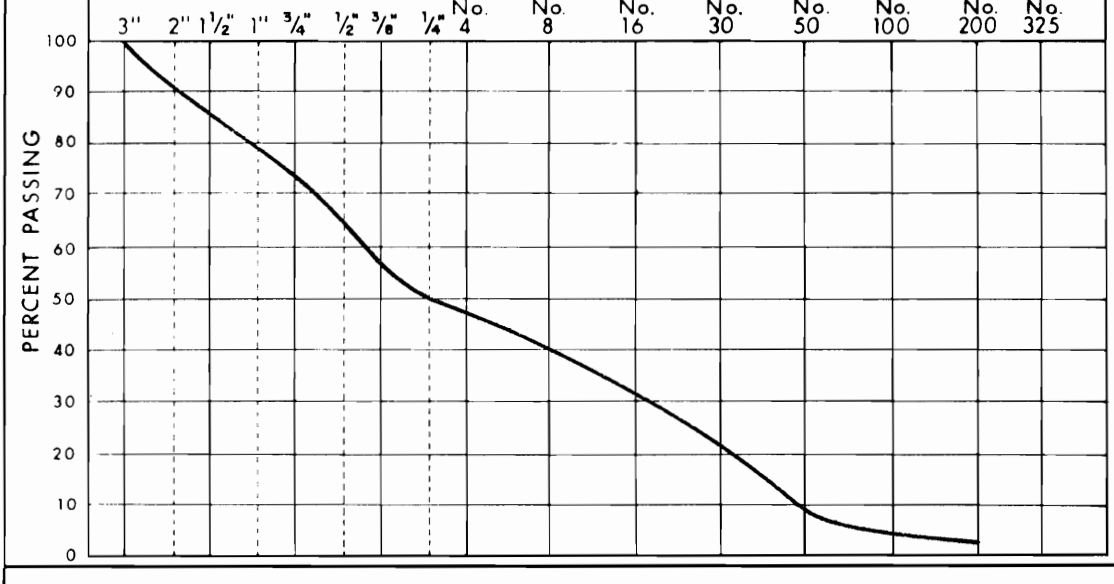
COMMENTS Moisture content of 13.3%

OVERSIZE (>3") = 0.0 %

SAMPLE N75-85D-B2-3 DEPTH 2.0-2.5
DATE SAMPLED September 19, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 36

GRAVEL SIZES		SAND SIZES			FINES
26 %	26 %	10 %	23 %	12 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.8
1½"	86.0
1"	79.8
¾"	73.6
½"	64.1
⅜"	57.8
¼"	
No. 4	48.4
No. 8	39.8
No. 16	32.1
No. 30	21.3
No. 50	9.2
No. 100	4.5
No. 200	3.0

COMMENTS Moisture content of 3.0%

OVERSIZE (>3") = 9.3 %

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-85D-B2-2 DATE SAMPLED September 19, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1-3 DATE TESTED March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 2.74 %
FINE AGGREGATE : LOSS = 10.44 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 24.9 %

ORGANIC IMPURITIES TEST

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

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

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	7.01
Granite		23.95
Sandstone	Strong, Hard, Good	6.65
Siltstone		7.40
Limestone	Strong, Good	22.70
Chert	Potentially reactive, Fair	0.02
Flint		0.27
Soft Sandstone	Soft, Friable, Poor	1.10
PN = 109	INTERPRETATION : Excellent	69.1

COMMENTS : Organic impurities test satisfactory.

NORTHERN Engineering Services Company Limited

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

DEPOSIT No. N75-85D-B2

12. BIBLIOGRAPHY

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Prepared by:

G.V. Minning, P.Geol.
Northern Engineering Services Company Limited

T.J. Fujino, P.Eng.
R.M. Hardy & Associates Limited

J.K. Ward
Northern Engineering Services Company Limited

Approved by:

P. Hoekstra, Ph.D., P.Geoph.
Manager, Geology and Geophysics
R.M. Hardy & Associates Limited

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 - 21.

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 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: Remarks: 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.

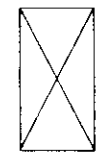
Example: Sample A2: – designates the second sample attempted in the test hole. This sample was taken off an auger.

(b) Sample Condition (Column 10)

The condition of each sample attempted is designated by one of the following symbols at the appropriate depth interval:



undisturbed



disturbed



not recovered

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, is 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 more than half by weight 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 more than half by weight 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 in 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 per cent
"some"	35 to 20 per cent
"little"	20 to 10 per cent
"trace"	10 to 1 per cent

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" (e.g., 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 significant 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 per cent 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 per cent and 20 per cent 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 per cent and 10 per cent 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 per cent (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 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:

(1) 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.

(2) 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".

(3) 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.

(4) 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 density (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 $85^{o}C$ instead of $105^{o}C$[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 reported as either "dry density" which is the weight of soil solids per unit volume, or as "bulk density" which is the total weight 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:

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, i.e., 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	per cent 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

3. Classification of Construction Materials

3.1 Granular Material Uses

The following is a description of materials that was used within the "Materials" and "Development and Rehabilitation" sections 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 consisting generally 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 occurence of deleterious materials such as weathered stones or shale fragments negates its use as concrete aggregate. This material will provide good quality embankment fill for pipeline berms and building pads; base and surface course 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 sandy silt 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.

4. Soil Drainage Classes

4.1 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 test hole site locations. The soil drainage classes are defined in terms of:

(i) actual moisture in excess of field moisture capacity, and

(ii) the extent 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 through out

(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.

5. Topography

5.1 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 handlevel 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 Experiment 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.

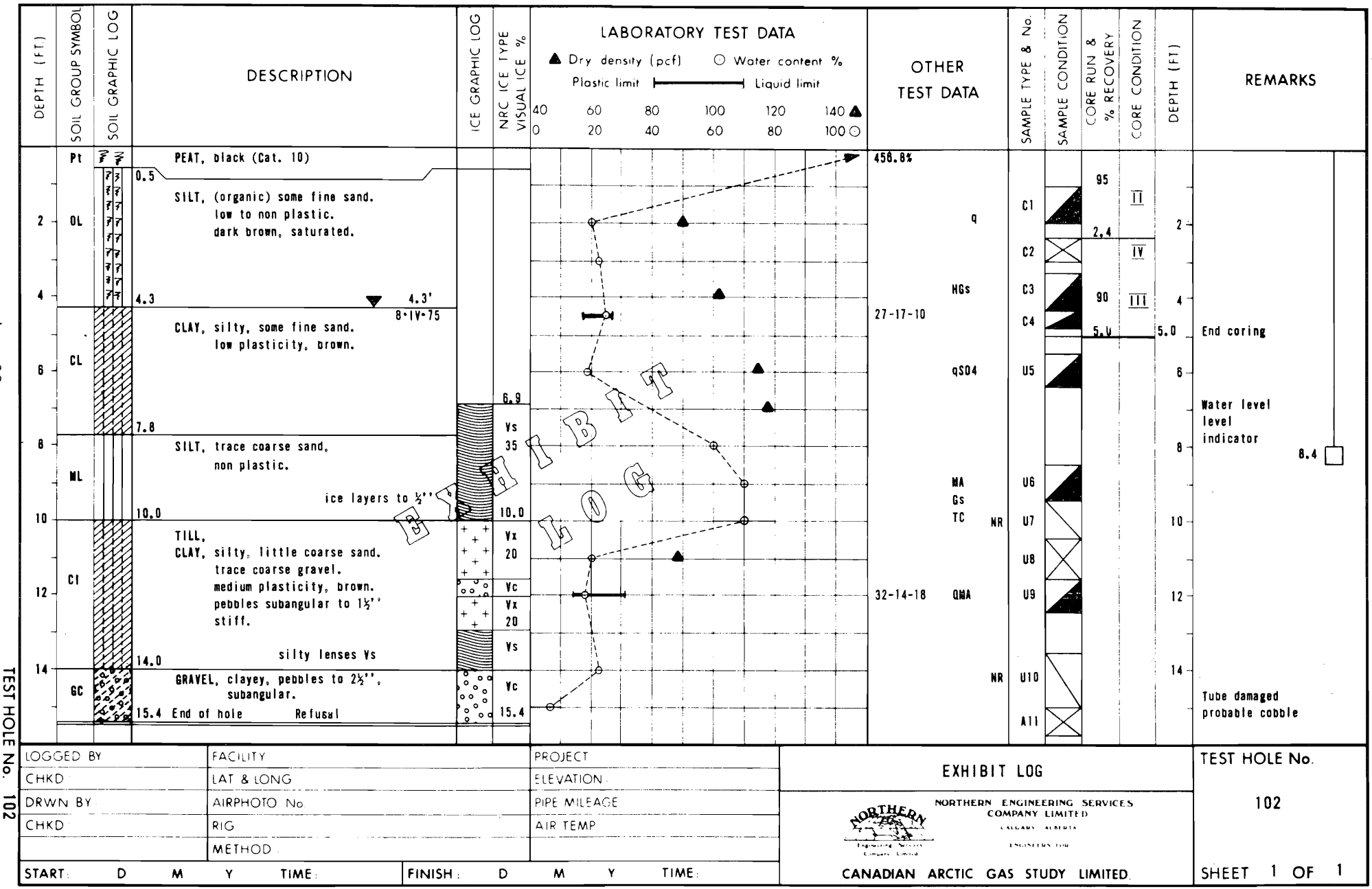
3. American Society for Testing and Materials, Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", Fourth Ed. pp 221-233, December 1964.

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



LOGGED BY	FACILITY	PROJECT	EXHIBIT LOG
CHKD	LAT & LONG	ELEVATION	
DRWN BY	AIRPHOTO No.	PIPE MILEAGE	NORTHERN ENGINEERING SERVICES COMPANY LIMITED, CALGARY, ALBERTA, ENGINEERS
CHKD	RIG	AIR TEMP	
	METHOD		CANADIAN ARCTIC GAS STUDY LIMITED
START: D M Y TIME:	FINISH: D M Y TIME:		

TEST HOLE No. 102

SHEET 1 OF 1

A - 22

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	FACILITY	PROJECT	TEST HOLE No.
CHKD	LAT & LONG	ELEVATION	
DRWN BY	AIRPHOTO No	PIPE MILEAGE	
CHKD	RIG	AIR TEMP	
	METHOD		
START: D M Y TIME:	FINISH: D M Y TIME:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED	SHEET OF

TEST HOLE No.
PLATE 2

SOIL CLASSIFICATION SYSTEM

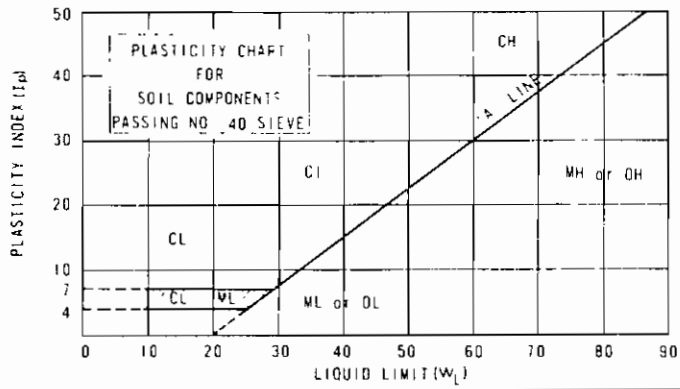
MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL MATERIALS	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO 200 SIEVE)	GRAVELS MORE THAN HALF OF COARSE FRACTION LARGER THAN NO 4 SIEVE	CLEAN GRAVELS (NO APPRECIABLE FINES)	GW		WELL GRADED GRAVELS, AND 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 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 P I LESS THAN 4
			GC		CLAYEY GRAVELS GRAVEL SAND (SILT, CLAY MIXTURES		ATTERBERG LIMITS ABOVE A LINE OR P I MORE THAN 7
	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 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 P I LESS THAN 4
			SC		CLAYEY SANDS SAND (SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE A LINE OR P I 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			50 35	and
coarse	3 inch	3/4 inch		
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

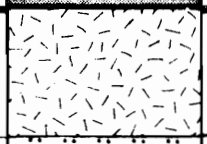
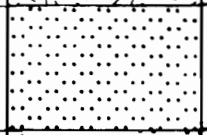
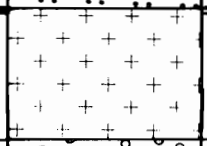
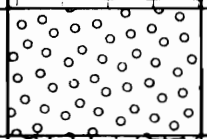
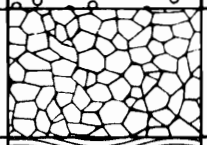
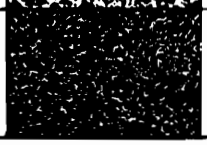
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TABLE 1

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

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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
- 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

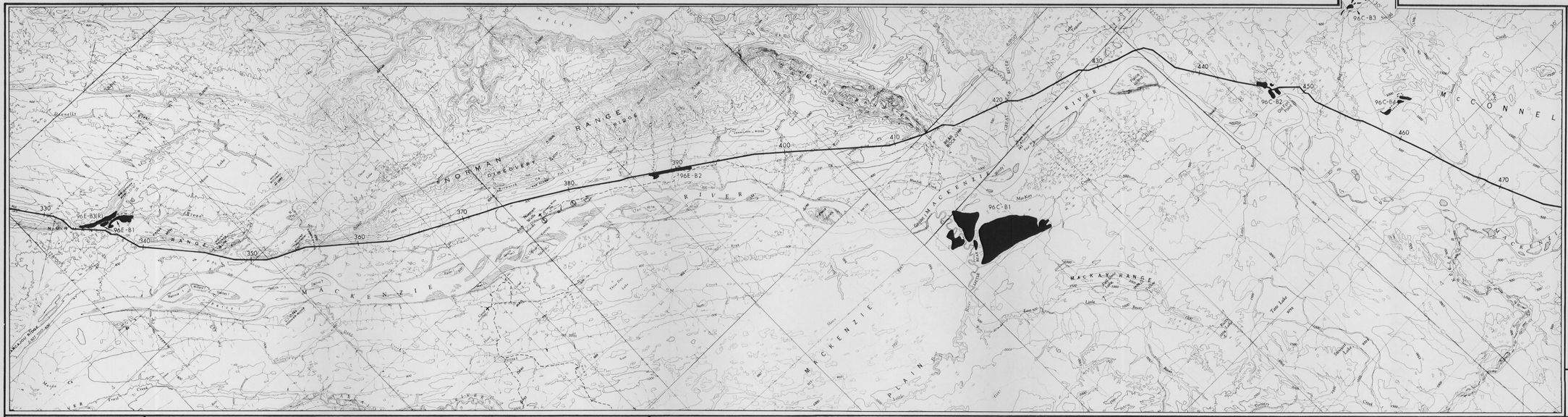
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5 0 5 10 15 20 25 30 KILOMETRES

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.:	1B-0211-1006



LEGEND

	DEPOSIT OUTLINE
96E-B1	NESCL DEPOSIT NUMBER
1078-B17 (R)	RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
200	PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

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MAY 1975

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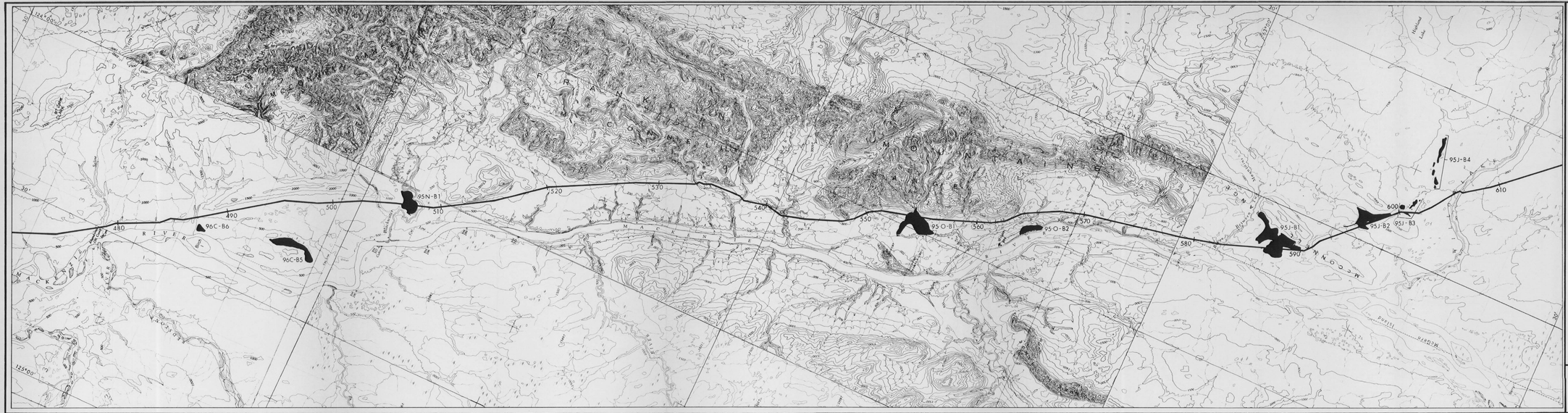
MILES 5 0 5 10 15 20

KILOMETRES 5 0 5 10 15 20 25 30

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CHECKED BY:	
APPROVED BY:	
PROJ. MANAGER:	

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CALGARY, ALBERTA
CONSULTANTS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

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DATE:	
PROJ. NO.:	13011
DWG NO.:	IB-0211-1007



LEGEND

	DEPOSIT OUTLINE
96E-B1	NESCL DEPOSIT NUMBER
107B-B17 (R)	RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
200	PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

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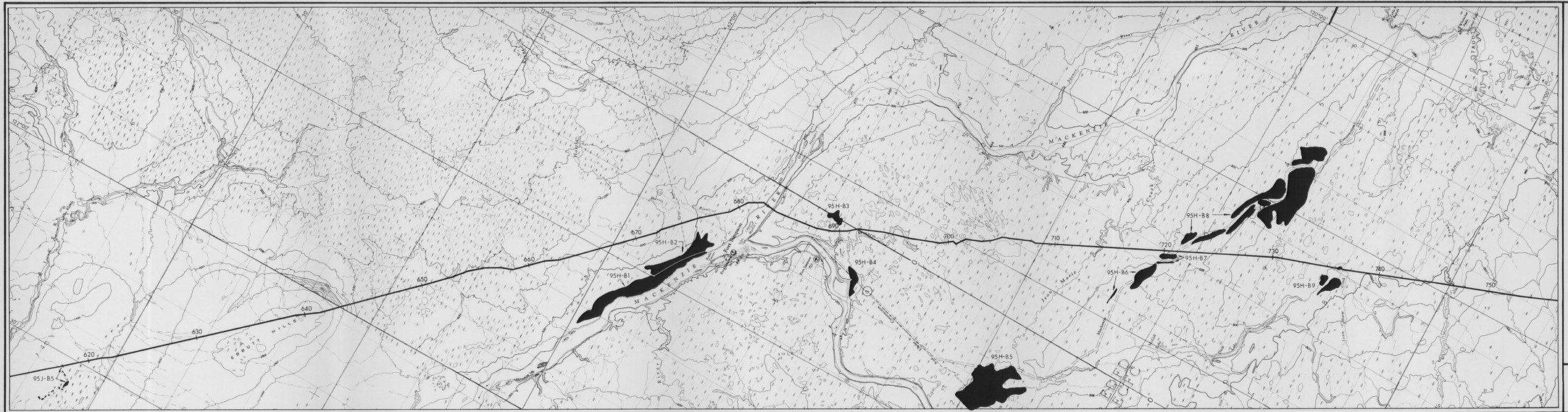
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APPROVED BY:	
PROJ. MANAGER:	

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PROJ. NO.:	13011
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LEGEND

	DEPOSIT OUTLINE
96E-B1	NESCL DEPOSIT NUMBER
107B-B17 (R)	RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
200	PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

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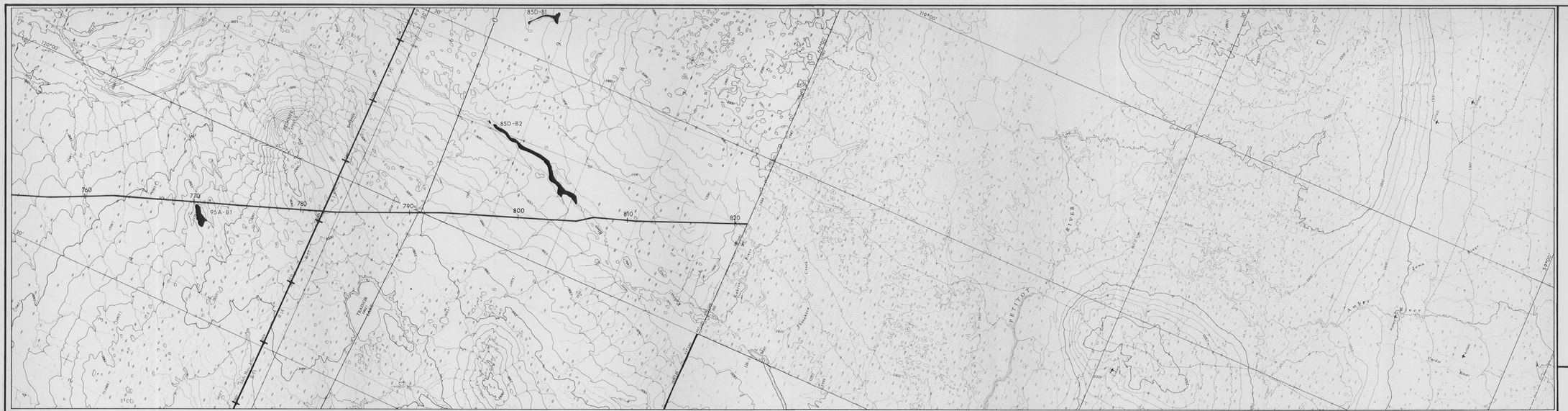
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MAY 1975

SCALE 1:250,000

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5 0 5 10 15 20 25 30 KILOMETRES

LEGEND

- DEPOSIT OUTLINE
- 96E-B1 — NESCL DEPOSIT NUMBER
- 107B-B17 (R) — RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
- 200 — PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

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PROJ. NO.:	13011
DWG. NO.:	1M-0211-1002

DATE DUE SLIP

SEP - 6 2001

RET'D OCT 15 2001

MAY 15 2004

RET'D MAR 15 2006

APR 3 - 2006

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