DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

FORT NORMAN, N.W.T.

COMMUNITY STUDY AREA

PEMCAN SERVICES "72"

PEMCAN SERVICES Copy # 33

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

FORT NORMAN, N.W.T.
COMMUNITY STUDY AREA

TABLE OF CONTENTS

1. "Granular Material" is defined as all naturally occurring unconsolidated material, and bedrock which can be processed for suitable engineering construction.

2. Compilation and evaluation of the Geological Survey of Canada's surficial geology and granular material maps and all other relevant information prior to the undertaking of the field investigation.

3. Location, testing and classification of all granular and potential bedrock quarry materials within the specified search area and recommendations for their best use.

The data compiled for each site will include:

a) The quantity and quality of usable material available, and recommendations as to its suitability as a construction material. Recommendations shall be substantiated by including results of tests on applicable material samples; these tests include:

Grain size distribution
Petrographic analysis
Moisture content
Ice content
Organic content
Hardness test

(In addition to the above tests, PEMCAN Services "72" recommended the use of Los Angeles Abrasion tests on samples from potentially high priority granular material and bedrock quarry sites).

b) The location of borrow pits, and recommendations for development.

c) Recommendations on the most efficient sequence of development where several pits can be developed in the same general area.

d) Evaluate the best access routes from prospective sites to the center of each community or to existing or proposed utilities.

e) Recommendations for development, exploitation, disposal of overburden and waste, and restoration of proposed borrow pits in such a manner to minimize terrain disturbance.

4. Development of a method of mapping, rating and reporting the deposits within the Study Area.

5. Identification on the plan of granular deposits exposed in, or along banks of streams and rivers adjacent to the communities but exclusion of such deposits in the material availability for the community unless no other sources of granular materials are available.

6. If satisfactory granular materials are not available within the designated Study Area around the communities, then recommendations pertaining to either alternate sources outside of these areas, or bedrock quarry development will be required.

The successful completion of this study was enhanced by the cooperation and contributions of the respective Territorial Land Use Agents and other Federal and Territorial Government personnel including the Federal Department of Public Works and their respective consultants. In particular, we wish to acknowledge the assistance, guidance and liaison provided by Mr. H.D. Dekker, Chairman, and other members of the Granular Materials Working Group.

INVESTIGATION PROCEDURE

Pertinent geological information was compiled for the Study from correlation of previous reports of investigations conducted within the Study Area. These included Geological Survey of Canada reports and open files; pipeline route investigations, previous PEMCAN studies and field investigations, and personal communication with noted authorities of the region. The surficial geology map shown in Figure 1 has been derived from both the aforementioned information and field observation data.

Airphoto interpretation of prospective granular material sites was undertaken prior to the field work with J.D. Mollard and Associates Ltd. Recent airphotos, scaled at 1":3,000', provided by The Department of Indian Affairs and Northern Development, were utilized to outline sites, estimate the areal extent of sources and note locations of test hole and required access roads. Pertinent parts of these airphotos have been reproduced and used as location plans for catalogued sites. Air mosaics showing revised route location for the Mackenzie Valley Highway were provided by The Federal Department of Public Works or their respective engineering consultants.

The preliminary field work, carried out in September and October, 1972, commenced with aerial reconnaissance in order to assess prospective sites. Selected sites were then investigated by means of test pits which were excavated manually, logged and sampled to depths of six feet below the ground surface. Natural outcrops were also catalogued and respective samples secured. On the basis of the airphoto interpretation and preliminary field reconnaissance, Sites FN 8, FN 10, FN 13, FN 17, FN 19, FN 26, FN 27, FN 28, FN 29, and FN 30 were investigated in further detail during the winter drilling program in January and February, 1973. Additional field test drilling of Sites FN 6, FN 8, FN 25, FN 29, FN 30 and FN 31, was conducted by the engineering consultant for The Federal Department of Public Works, in conjuction with their geotechnical study for the Mackenzie Highway route in this area. The data from their investigation has been incorporated into this report.

The potential quantities of available granular materials, availability of existing access

roads, drainage conditions, wildlife implications and the distance from the community were considered for selecting sites for more detailed investigations. Smaller or more marginal deposits have been recorded but were not studied in detail because of remoteness from the community or planned utilities. These sites, including those ultimately assessed as "Not Recommended", are identified in Figure 2 by the suffix "X" behind the site number.

A total of thirty-one sites were catalogued in the ten mile radius of Fort Norman (Figure 2). Of these, sixteen sites were investigated to a greater detail by means of test pits and thirteen sites by means of drill holes. Additional sites were investigated by Geological Survey of Canada personnel and partial information from their studies is incorporated in this report. Sixteen sites that are not recommended for development are identified in Figure 2 by the suffix "X" behind the site number.

Material samples secured from outcrops, test pits and drill holes were shipped to Calgary for laboratory analyses which included grain size distribution, petrographic analysis moisture content determination and hardness tests. In specific cases the samples or combined samples were tested for resistance to mechanical abrasion.

Results of the investigation are summarized in this report and detailed information of the studied sites is compiled in the section on Site Description. The areal extent of the individual deposits are based on airphoto interpretation, field reconnaissance and field drilling records. Except on sites where drill holes had penetrated the total depth of the granular deposit, the average thickness of individual deposits was generally estimated from morphological and geological features or with respect to thickness indicated by natural outcrops. However, the estimated volumes should be conservative since adjustments were made for variables such as drainage conditions and sloping ground along the outer limits of the deposit.

Test pit logs, drill hole logs, outcrop descriptions and laboratory test results are attached to the individual Site Descriptions. Symbols, terminology and classification systems used are explained in the glossary.

GEOMORPHOLOGY

The Fort Norman Study Area lies within two physiographic subdivisions; namely:

- Mackenzie Plain - which covers approximately eighty percent of the mapped terrain.

- Franklin Mountains - which extends into the northwest sector of the Study Area around the Bear Rock massif.

The Mackenzie Plain has a very low relief, and is characterized by frequent muskeg bogs northeast and southeast of Fort Norman. River channels and relatively infrequent and short erosional gullies are the only major features which disturb the generally flat surface of the plain.

The rugged Bear Rock massif is characterized by incised erosional gorges and accumulations of eroded and broken material at the base of the steep rock faces.

The bedrock within the Mackenzie Plain consists of greenish grey Devonian and Cretaceous shales, siltstones and mudstone. Weakly cemented sands and gravels, probably of Tertiary age, are indicated between the Great Bear and Mackenzie Rivers. The bedrock is only exposed in deeply cut river channels and is mostly covered with relatively thick layers of morainal deposits. These are almost continuously topped by glaciolacustrine sediments in the eastern half of the Study Area and by extensive glaciofluvial deposits in the southwest section. West of Bear Rock the Plain is primarily covered with morainal deposits which are partially topped with glacial outwash material. Water courses have produced fluvial plains and flat surfaced terraces above present channels. Wind action has reworked surficial layers of former lake basins and has locally redeposited these fine grained materials into sand plains and dunes.

The Bear Rock massif and its northwesterly extension consists of Devonian, Ordovician and Silurian limestones and dolomites and Cretaceous shales. Karst erosion is common in the carbonate rocks. Rock walls are usually mantled with scree and talus accumulations along the base and alluvial fans have been formed at the mouths of some of the erosional gorges. Main landforms and geologic features are illustrated by Figure 1.

A shallow to moderately thick organic soil layer topped with several inches of peat and moss is normally encountered outside of rugged and recently eroded land surfaces. Low and poorly drained terrain usually contains thicker organic sections.

Glaciolacustrine deposits, consisting of silts, fine grained sands and occasional clay layers, as well as morainal deposits containing heterogeneous mixtures of silt, clay and sand interspersed with some pebbles and cobbles are very poor sources of granular deposits. Alluvial floodplains and terraces, with the exception of Little Bear River, consist primarily of silty and sandy materials with gravel beds at depth. All of these deposits usually have high water or ice content, especially if covered by thick layers of organic soil.

Cretaceous shales, siltstones and mudstones, underlying the major part of the Study Area are, in general, too weak and incompetent for manufactured aggregates for construction purposes.

In the Study Area there are six main geomorphologic forms in which natural granular materials occur:

- Alluvial plains and terraces along the Little Bear River contain good quality sandy gravels. Some alluvial terrace and stream bed deposits in and adjacent to the Great Bear and Mackenzie Rivers contain beds or pockets of gravel at depth.

- Alluvial fans in the vicinity of the Bear Rock contain granular deposits ranging from silty sand to coarse gravel with rock blocks.

- Talus and scree deposits mantling the base of Bear Rock consist of variously sized limestone fragments and blocks with sand and silt sized particles.

- Dunes and eolian sands covering the glaciolacustrine plain northeast of Fort Norman contain poorly graded, fine to medium grained sand.

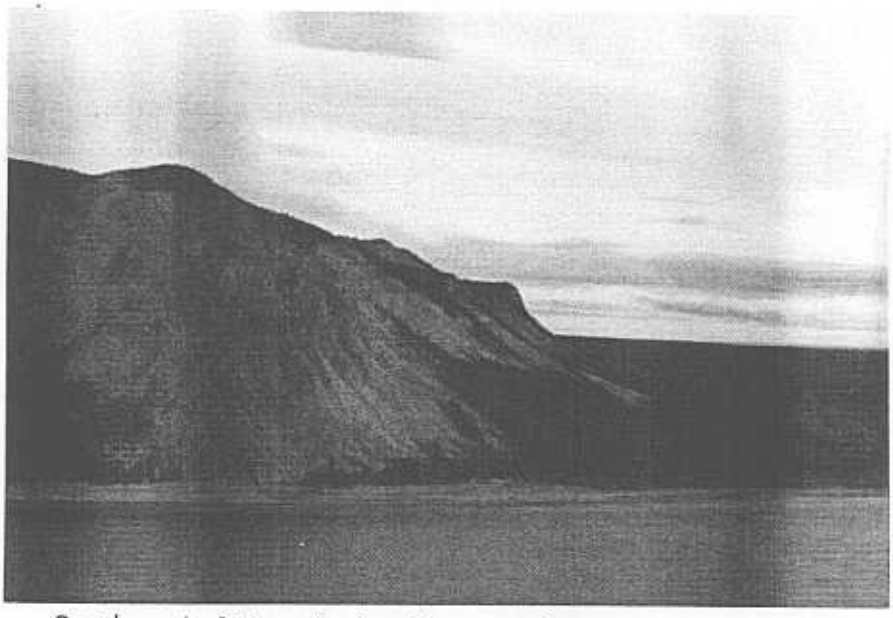
- Glaciofluvial outwash plains and channel deposits between the Little Bear and Mackenzie Rivers and west of Bear Rock contain predominantly sandy gravel of excellent quality with some sandy beds.

- The esker complex west of the Bear Rock contains both sand and gravel.

Carbonate rocks exposed in the Franklin Mountains are generally suitable for manufactured aggregates. Tertiary sands and gravels exposed at two locations in the steep valley walls of the Great Bear and Mackenzie Rivers represent another potential source of granular material.

The Study Area lies within the discontinuous permafrost zone. Excess ice is, however, relatively widespread in fine grained, poorly drained, glaciolacustrine deposits east and south of Fort Norman, where thermokarst features are common. These deposits can contain as much as twenty percent excess ice. Little or no excess ice exists in coarse and well drained glaciofluvial deposits. The average depth of the seasonal freezing and thawing cycles is about two to three feet, but a minimum depth of one foot in clayey soils to as much as twenty feet in clean gravels is indicated.

TERRAIN PHOTOGRAPHS



South end of Bear Rock. Scree, talus and cone deposits are located on the eastern flank (Ref. Sites FN 2, FN 3)

Glaciofluvial plain on the west side of Little Bear River (Ref. Site FN 19).

ENVIRONMENT

The ten mile Study Area around the community of Fort Norman encompasses all of the lands that are included in the "Proposed Development Control Zone" as shown in Figure 2. It is proposed by the respective Federal and Territorial Governments, that management of lands within this Zone will be transferred from Federal to Territorial Government control. Federal projects such as buildings, highways, and airports would be excluded from this transfer.

The Fort Norman Study Area is geographically located in an area that offers considerable use and development of both water and land environments. The area is particularly enhanced by the Mackenzie and Great Bear Rivers, which add aesthetic and recreational values to the region. Along the western side of the Study Area, Bear Rock adds scenic values as it rises some 1,000 feet above the surrounding floodplain and muskeg terrain.

Terrain sensitivity and reaction to modification is generally related to the type of terrain which in turn reflects the material type and ground ice conditions within the various terrain features that characterize the Study Area.

Relatively flat, low-profiled and generally fine grained terrain types, such as silt-clay plains, beaches, river deposits and organic terrain usually contain moderate to high ground ice content and can be readily disturbed because of low strength and high compressibility values. Vegetated sites are susceptible to subsidence, slumping and gullying if the vegetation is removed or highly compressed and distrubed. Thermokarst subsidence, undercutting and channel shifting can also be expected, especially in fine river deposit terrain.

Hummocky and rolling terrain as characterized by the till plains in the Study Area generally contain moderate ground ice content. Localized contrasts in material type and ice content is oftentimes evident between well drained slopes and low depressions. This terrain in general exhibits minor to moderate susceptibility to thermokarst, ground ice

slumping and gullying. Usefulness of till material as fill is usually limited by its ice content.

Upland mountainous terrain, characterized by rock outcrops or bedrock thinly covered with a veneer of debris, as on Bear Rock, usually contains minimal ice content within the bedrock except for shale where fractures may be ice filled to depths in excess of 100 feet. The overlying debris usually contains low to moderate ice content. Creep, slides and rock falls are common on steep slopes in this terrain as are mudflows and flash floods.

In general, the more favourable granular material sites in the Fort Norman Study Area tend to be located on fairly well drained geomorphic features that contain relatively moderate amounts of ground ice. Therefore, properly managed development procedures should minimize the detrimental terrain reaction to acceptable levels. In many cases, the access routes to these sites will traverse areas of low wet terrain that generally will contain higher ice contents and will therefore, be more susceptible to adverse reaction when disturbed. In these cases, sound development procedures such as the incorporation of protective measures for retainment of vegetation ground-insulation layers and the establishment of adequate fill materials for access roads will limit detrimental terrain reaction to satisfactory levels.

Vegetation

In the section of the Mackenzie Valley within the Study Area, the Boreal forest region of Canada is restricted to a narrow band that extends along the Inner Mackenzie Valley. The Fort Norman Study Area lies within the northern reaches of this Boreal forest zone.

In the Study Area the dominant tree species are black and white spruce, tamarack, birch, willows and alder. Poplar is near its northern limit in the Fort Norman area and is only occasionally seen. The ground cover is predominantly mosses, lichens, sedges,

herbs and shrubs. The vegetation ranges from commercial growths on river islands and alluvial flats to scrubby growth and treeless muskeg.

Poorly drained alluvial sites commonly support growths of black spruce, tamarack, willows and occasional alder. Permafrost muskegs are generally treeless or support dwarfed growths of black spruce. Well drained sites support black and white spruce, birch, and occasionally alder.

Benchland areas that are underlain by fine-grained materials with shallow permafrost generally support poor growths of willow, alder and in some cases, black and white spruce. Well drained benchland areas generally support well developed growths of birch and spruce.

Mountain slope vegetation ranges from spruce growth near the base to spruce and some birch on the overburden-covered flanks.

In the Fort Norman Study Area, natural regrowth of vegetation on existing cutlines and clearings suggests that in general, regeneration of disturbed areas will occur especially if the nutrient zones within the topsoil layer are left undisturbed. In cases where borrow pit developments are abandoned, it may be feasible to artificially reseed and fertilize the area with annual and perennial stocks in order to promote growth cover prior to reestablishment of natural vegetation.

Wildlife

Wildlife species of both Arctic tundra and Boreal forest utilize the Fort Norman Study Area and adjacent regions. For the most part the utilization of this area by waterfowl, wildlife and fishery resources is based upon seasonal migration patterns that generally follow the Mackenzie River Valley (Figure 2). There are no known critical wildlife areas in the Fort Norman Study Area; however, the entire Study Area is classified as an important wildlife region by the Canadian Wildlife Service.

The Study Area lies within the broad flyway that is utilized by various waterfowl during spring and fall migration (Figure 2). The central portion of the Study Area including the Mackenzie River, the sandy islands and both bank areas is utilized as a spring staging area for snow geese, whistling swans, white-fronted geese and various ducks.

Wildlife resources are both hunted and trapped in portions of the Fort Norman Study Area. The eastern section of the Study Area is noted for fall moose hunting on the banks and islands of the Mackenzie River. This same area is occasionally hunted and trapped for beaver, marten and muskrat. Most of the Study Area on the south bank of the Mackenzie River is within a region that is noted as an excellent beaver habitat (Figure 2). This same area is trapped for beaver, muskrat, marten and fox in the fall and is hunted for beaver and muskrat in the spring. These trapping and hunting areas are utilized for the most part, by residents of Fort Norman.

Fishery resources in the Study Area are predominantly those found in the Mackenzie and Great Bear Rivers and include both resident species and those that seasonally migrate through the respective river systems. The Great Bear River is particularly important to fishery resources as potential spawning gravels occur along the entire length of the river. The area around the mouth of the Great Bear River is noted for its importance as a domestic fishing area to the residents of Fort Norman (Figure 2). The area immediately upstream from the mouth of the Brackett River is reported to contain spawning gravels that are utilized by grayling.

The Great Bear River is also noted for its sport and recreational values in the region. Canoe trips on the Great Bear River between Fort Franklin and Fort Norman offer excellent sport fishing and recreation.

RECOMMENDATIONS AND CONCLUSIONS

The recommendations and conclusions, which are presented herewith, have been based on airphoto interpretation, office literature studies, preliminary field reconnaissance work and detailed field drilling data.

The approximate quantities of granular materials required for the Fort Norman community, as specified in the Terms of Reference received from The Department of Indian Affairs and Northern Development, are outlined as follows:

Fine grained aggregates (Sand)..... 25,000 cubic yards.
Coarse grained aggregates (Gravel).....35,000 cubic yards.
Material suitable for building pads,
roads, airstrips, etc. .....600,000 cubic yards.

The results of the completed study indicate that the availability of quality granular materials is limited in the Fort Norman Community Study Area, especially on the north side of the Mackenzie River and the east side of the Great Bear River where the Fort Norman townsite is located.

The following sites from within the total Community Study Area are recommended for the granular material requirements of Fort Norman:

Site FN 19: Located approximately 11 miles southwest of Fort Norman less than 1 mile inland from the south bank of the Mackenzie River, Site FN 19 consists of a large glacial outwash plain, several square miles in area, which extends eastward from the Little Bear River channel. This extensive glacial outwash deposit is estimated to contain several million cubic yards of medium grained, well graded, clean gravels which are considered suitable for use in most construction requirements. Production of quality concrete aggregates would be possible if the pit run gravels are properly

processed by crushing and screening to required specifications.

The development of the glacial outwash gravels from Site FN 19 for the granular material requirements of Fort Norman community will entail the crossing of the Mackenzie River thus restricting the transportation of materials to the winter and summer months. Such procedures will necessitate barge hauling during summer and truck haul utilizing an ice bridge during the winter season. Therefore, holding stockpiles for various aggregate types will be required to ensure a continual supply of material during the spring break-up and winter freeze-up periods.

Any proposed borrow pit development for the removal of granular materials should be commenced at the northern extremities of FN 19 where reasonable land access can be attained to the southern shoreline of the Mackenzie River. These new access roads from the site area to the southern shoreline of the Mackenzie River will traverse partially thermal sensitive terrain and, therefore, should be constructed to an all weather status if any extensive quantities of materials are to be removed.

Although Site FN 19 is located at an appreciable distance from Fort Norman, the availability of extensive quantities of excellent quality gravels rates this site as a major and primary source of granular materials for the community of Fort Norman. The detailed assessments and recommendations for the proposed development and exploitation of granular materials from Site FN 19 are outlined in the Site Description section of the report.

Site FN 29: Located approximately $8\frac{1}{2}$ miles north of Fort Norman, immediately adjacent to the existing winter road and proposed Mackenzie Highway right-of-ways, Site FN 29 consists of shallow glacial outwash deposits

along the western flanks of the Bear Rock escarpment. The recoverable depth of gravels in the glacial outwash deposit is generally in excess of 10 feet and is overlain with an overburden varying in thickness from a few inches to 4 feet.

This glacial outwash deposit is estimated to contain in excess of 300,000 cubic yards of well graded, fine grained gravels which are considered suitable for building pads, road bases, airstrips and base course aggregates. Careful and selective excavation of the in situ gravel deposit may provide material which could be suitably processed for marginal surface course aggregates.

Although good current and future access to Site FN 29 is available for the development of borrow pits, the subsequent transportation of granular materials to Fort Norman will entail a crossing of the Great Bear River which will likely restrict the exploitation of this site to the winter months. Therefore, the exploitation of gravels from Site FN 29 may be better suited for the construction requirements of local utilities.

The detailed assessments and recommendations for the proposed development and exploitation of granular materials from Site FN 29 outlined in the Site Description section of the report.

Sites FN 1 & FN 25:

The material at these two sites consists of limestone bedrock, and would entail a quarry operation with related blasting and crushing techniques to manufacture aggregates for various construction requirements. It is considered that all types of construction aggregates could be produced in unlimited quantities. The material from the surficial, weathered and fragmented zone meets the requirements for general fill while better quality aggregates can be produced from fresh limestone beds at greater

depths below existing rock faces.

The best quarry locations, based upon the quality of extractable limestone, and the general access to exposed rock outcrops are in the northern portion of Site FN 1 and the southern portion of Site FN 25. These locations are immediately adjacent to the existing winter road and proposed Mackenzie Highway right-of-ways. However, any exploitation of manufactured granular materials from these sites for the requirements of Fort Norman will entail a major crossing of the Great Bear River which will restrict the removal of material to the winter months.

The detailed assessments and recommendations for the proposed development and exploitation of granular materials from Sites FN 1 and FN 25 are outlined in the Site Description section of the report.

In addition, it should be noted that other sites such as FN 13, FN 14, FN 23 and FN 31 consisting of fine sands and small pockets of silty gravels may be exploited for augmenting the local requirements for very marginal fill material. The detailed assessments of these sites are outlined in the Site Description section of this report.

Site locations and physical and environmental data on each site within the Fort Norman Study Area are tabulated and presented in map form on Figures 1 and 2 respectively. A synopsized tabulation of pertinent information for each site is tabulated and noted on Figure 2.

The table in Figure 2 presents a tabulation of pertinent data relative to the sites investigated within the Study Area. Each potential site is evaluated in terms of material type, suitability of material, estimated volume, recoverable depth, overburden characteristics, ground ice content, drainage, method of extraction, haul distance, environmental considerations and assessment.

ESTIMATED VOLUME is calculated by means of various parameters including drill hole and test pit data, airphoto interpretation and geomorphology. Adjustments have been made for irregular topography and stream dissection.

RECOVERABLE DEPTH is determined by various methods including drill hole and test pit data, geomorphology and in the case of bedrock, projected stratigraphic thickness.

GROUND ICE CONTENT is reported as high, medium or low by visual inspection of both samples and test pit walls.

METHOD OF EXTRACTION refers to the type of equipment required for development and exploitation of granular materials. "Conventional" as used, indicates the utilization of standard excavation equipment such as bulldozers, overhead loaders, backhoes and light rippers.

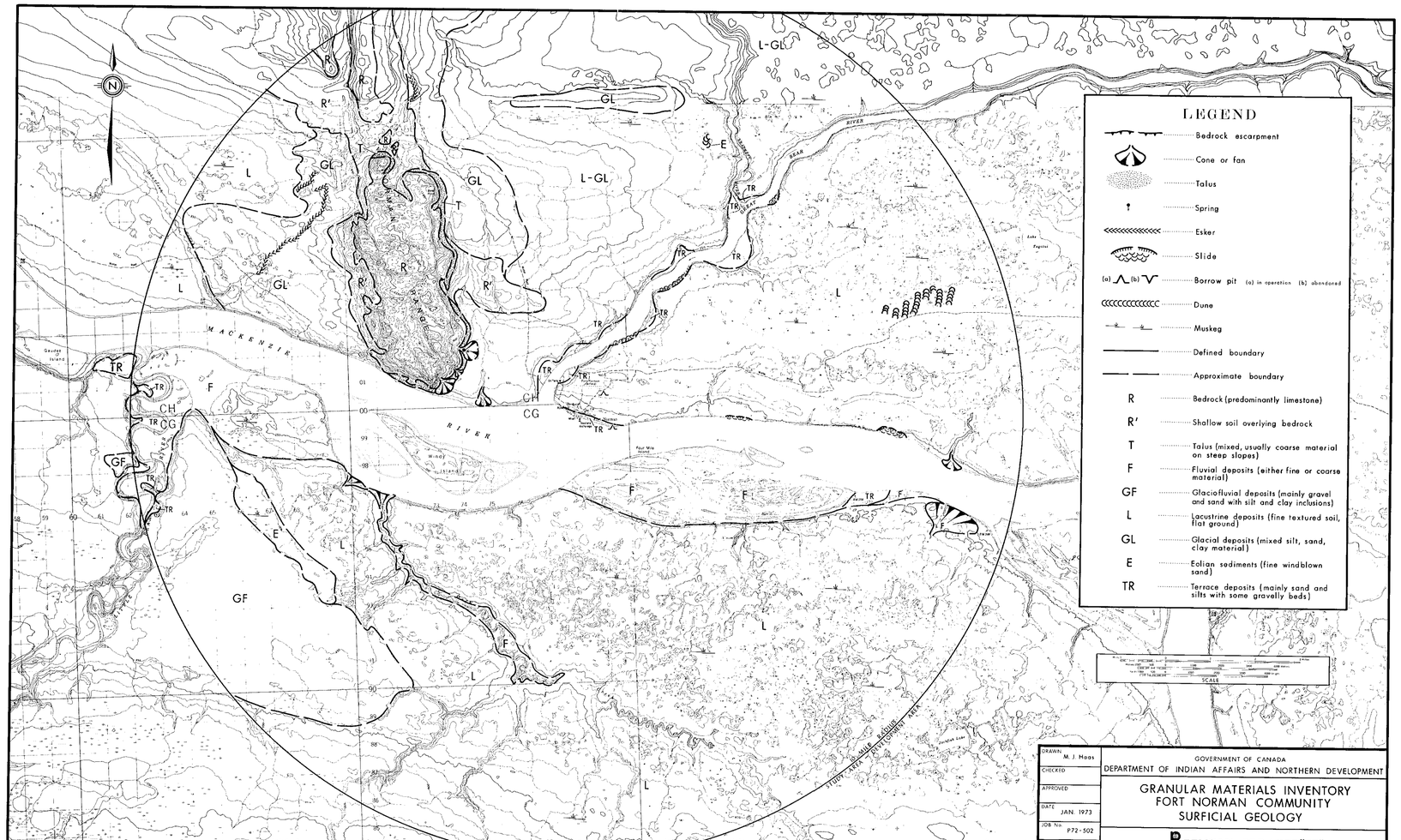
HAUL DISTANCE is the distance along existing and/or proposed access from the site to the community centre.

ENVIRONMENTAL CONSIDERATIONS include any salient factors related to wildlife, waterfowl and fishery resources, archeological sites and potential terrain sensitivity of the site and adjacent areas including proposed access routes. If any environmental implications are considered to exist at a particular site they are synopsized in this column. Further comments on the importance of these conditions as related to potential development are made within the text of the respective sites in the Site Description section of the report.

ASSESSMENT OF SITE relates to the evaluation of each site in terms of recommendations for development, nondevelopment or possible future development of potentially recoverable granular materials at each site investigated in the Study Area.

These recommendations are based upon an assessment of all known data on each respective site including location, access, physical characteristics, environmental considerations,

development procedures and quantity, quality and suitability of material as related to projected granular material requirements for the community.



LEGEND

- Bedrock escarpment
- Cone or fan
- Talus
- Spring
- Esker
- Slide
- (a) (b) Borrow pit (a) in operation (b) abandoned
- Dune
- Muskeg
- Defined boundary
- Approximate boundary
- R — Bedrock (predominantly limestone)
- R′ — Shallow soil overlying bedrock
- T — Talus (mixed, usually coarse material on steep slopes)
- F — Fluvial deposits (either fine or coarse material)
- GF — Glaciofluvial deposits (mainly gravel and sand with silt and clay inclusions)
- L — Lacustrine deposits (fine textured soil, flat ground)
- GL — Glacial deposits (mixed silt, sand, clay material)
- E — Eolian sediments (fine windblown sand)
- TR — Terrace deposits (mainly sand and silts with some gravelly beds)

DRAWN	M. J. Haas
CHECKED	
APPROVED	
DATE	JAN. 1973
JOB No.	P72-502
SCALE	As Shown

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY
FORT NORMAN COMMUNITY
SURFICIAL GEOLOGY

PEMCAN SERVICES "72"

FILE No. | FIGURE 1 | REVISION

SITE NO.	MATERIAL TYPE		SUITABILITY OF MATERIAL	ESTIMATED VOLUME (cu. yds.)	EST'D. RECOV. DEPTH (feet)	OVERBURDEN			GROUND ICE (Content)	DRAINAGE	METHOD OF EXTRACTION	HAUL DIST. (miles)	ENVIRONMENTAL CONSIDERATIONS	ASSESSMENT OF SITE
	DESCRIPTION	SYM.				TYPE	DEPTH (feet)	DISPOSAL						
FN 1	Bedrock; Limestone	—	All Construction Materials	Unlimited	+500	Colluvium	+1	Strip & Waste	Very Low	Formation is Well Drained	Quarry; Crushing & Blasting	3	South End: Waterfowl Migration & Staging Area	Possible Future Development
FN 2X	Limestone Fragments	—	General Fill	N.D.	—	None	—	—	Low at +5	Good to East	Conventional	2½	No Critical Wildlife Areas	Not Recommended
FN 3X	Limestone Fragments	—	Marginal General Fill	N.D.	—	None	—	—	Medium at +5'	Good to Southeast	Conventional	2½	No Critical Wildlife Areas	Not Recommended
FN 4	Limestone Fragments	—	General Fill	1,000,000	+5	Topsoil	½	Strip & Stockpile	None	Good to Southeast	Conventional	2½	No Critical Wildlife Areas; Adjacent to River	Possible Future Development
FN 5X	Sand; silty	SP	General Fill	10,000	20	Topsoil	½	Strip	None	Good	Conventional	10	No Critical Wildlife Areas	Not Recommended
FN 6X	Sand; silty, gravel pockets	SP-SM	General Fill	N.D.	—	Topsoil, organic	1	Strip & Stockpile	Low	Good to South	Conventional	½	No Critical Wildlife Areas	Not Recommended
FN 7X	Gravel; sandy	GM	General Fill	25,000	3	Topsoil & Silt	+2	Strip & Stockpile	None	Poor to West	Conventional	1½	No Critical Wildlife Areas	Not Recommended
FN 8	Gravel; medium grained	GW-SW	All Construction Aggregates	N.D.	+40	Topsoil & Silty Clay	+40	Strip, Waste & Stockpile	N.D.	Good	Conventional	4	No Critical Wildlife Areas	Extensive Overburden Depth; Development Uneconomic
FN 9X	Silt	ML-MH	Not Suitable	N/A	—	—	—	—	High at 2½	Fair	—	6	No Critical Wildlife Areas	Not Recommended
FN 10	Sand; silty, gravel pockets	SM	Marginal General Fill	400,000	6	Topsoil & Peat	+1	Strip & Waste	Medium to High	Fair to Southeast	Conventional	4½	No Critical Wildlife Areas; Adjacent to River	Possible Future Development
FN 11X	Sand; fine, silty	SP	Marginal General Fill	N.D.	+15	Topsoil	+½	Strip & Stockpile	Medium	Fair	Conventional	7	No Critical Wildlife Areas	Not Recommended
FN 12X	Gravel & Sand	GW-SW	All Construction Aggregates	N.D.	+40	Topsoil & Silty Sands	+20	Strip, Waste & Stockpile	N.D.	Fair to Southwest	Conventional	6	No Critical Wildlife Areas	Not Recommended
FN 13	Sand; silty, gravel pockets	SM-SP	General Fill	1,000,000	+15	Topsoil; silt	+1	Strip, Waste & Stockpile	Medium to High	Fair to West	Conventional	5	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
FN 14	Sand; fine	SP	Marginal General Fill	300,000	+10	Topsoil & Silt	+½	Strip, Waste & Stockpile	None	Fair	Conventional	½	No Critical Wildlife Areas	Active; Continue Development
FN 15X	Silt	ML	Not Suitable	N/A	—	Topsoil	½	—	None	Poor	—	2½	No Critical Wildlife Areas	Not Recommended
FN 16	Sand; fine	SP	General Fill	1,000,000	+20	Topsoil	½	Strip & Stockpile	None	Good	Conventional	8	No Critical Wildlife Areas, Sensitive Terrain	Possible Future Development
FN 17X	Silt	ML	Not Suitable	N/A	—	Topsoil	+½	—	Medium to High	Very Poor	—	9	No Critical Wildlife Areas	Not Recommended
FN 18X	Silt; sandy	ML	Not Suitable	N/A	—	Topsoil	+1	—	N.D.	Fair	—	8	Adjacent to Active Stream Channel	Not Recommended
FN 19	Gravel; well graded	GW	All Construction Aggregates	Unlimited	+20	Topsoil & Silt	+½	Strip, Waste & Stockpile	Low	Good	Conventional	11	Broad Flyway for Waterfowl; Spawning Gravels	Recommended for Development
FN 20X	Silt & Sand; gravel layers	SM-GW	Very Marginal General Fill	N.D.	+15	Topsoil	+1	Strip & Stockpile	N.D.	Fair to North	Conventional	10½	Broad Waterfowl Flyway	Not Recommended
FN 21X	Gravel	GW	All Construction Aggregates	N.D.	5	None	—	—	N.D.	—	Conventional with Dredging	10	Within Active Stream Channel	Not Recommended
FN 22	Sand; some gravel & silt	SM-GM	General Fill	100,000	+5	Topsoil; organic	+½	Strip & Stockpile	Medium at 1'	Very Poor	Conventional with Thawing	7	No Critical Wildlife Areas	Possible Future Development
FN 23	Sand & Gravel	SW-GW	General Fill	5,000	5	Silt	1	Strip & Waste	None	Good to West	Conventional	½	Not Severe; In Broad Flyway of Waterfowl	Active; Controlled Periodic Exploitation
FN 24X	Silt & Clay; Burned	—	Not Suitable	N/A	—	Topsoil	+1	—	N.D.	Good to West	—	1½	On Bank of Mackenzie River	Not Recommended
FN 25	Bedrock; Limestone	—	All Construction Aggregates	Unlimited	+50	Colluvium	+2	Strip & Waste	Very Low	Good to West & East	Quarry; Blasting & Crushing	10	No Critical Wildlife Areas	Possible Future Development
FN 26	Sand & Gravel	SM-GW	Base & Surface Courses General Fill	2,000,000	20	Topsoil & Silt	+½	Strip, Waste & Stockpile	Low to Medium	Good	Conventional	11	No Critical Wildlife Areas	Possible Future Development
FN 27	Sand; silty	SM-SP	Marginal General Fill	700,000	+10	Topsoil & Silt	6	Strip, Waste & Stockpile	Medium	Fair to South	Conventional with Thawing	9	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
FN 28X	Silt	ML	Not Suitable	N/A	—	Topsoil & Peat	+1	—	Medium	Good to Southwest	—	11	No Critical Wildlife Areas	Not Recommended
FN 29	Gravel & Sand	GW-SW	General Fill	300,000	+10	Topsoil & Silt	+1½	Strip, Waste & Stockpile	Low	Fair to West	Conventional	10	No Critical Wildlife Areas	Possible Future Development
FN 30X	Sand; silty	SM-SP	Marginal General Fill	N.D.	—	Topsoil & Peat	+½	Strip & Stockpile	Low to Medium	Poor	Conventional with Thawing	1	No Critical Wildlife Areas	Not Recommended
FN 31	Sand; gravel pockets	SW-GP	General Fill	75,000	+3	Topsoil & Silt	+2	Strip, Waste & Stockpile	Low	Poor	Conventional	2½	No Critical Wildlife Areas	Possible Future Development

Notes:

— ESTIMATED VOLUME (N/A): Not applicable because the site does not contain materials of granular quality.

— GROUND ICE (content): Rating and depth figures are inferred from specific test pits or drill holes.

— DRAINAGE: Rating as shown generally refers to drainage conditions within the site.

— METHOD OF EXTRACTION: "Conventional" indicates use of standard excavation equipment such as dozers, overhead loaders, backhoes, light rippers.

— HAUL DISTANCE: Is distance from site to community along existing or required access.

— ENVIRONMENTAL CONSIDERATIONS: Sensitive Terrain refers to thermal and/or erosional sensitivity at or adjacent to the site (Ref.: Text).

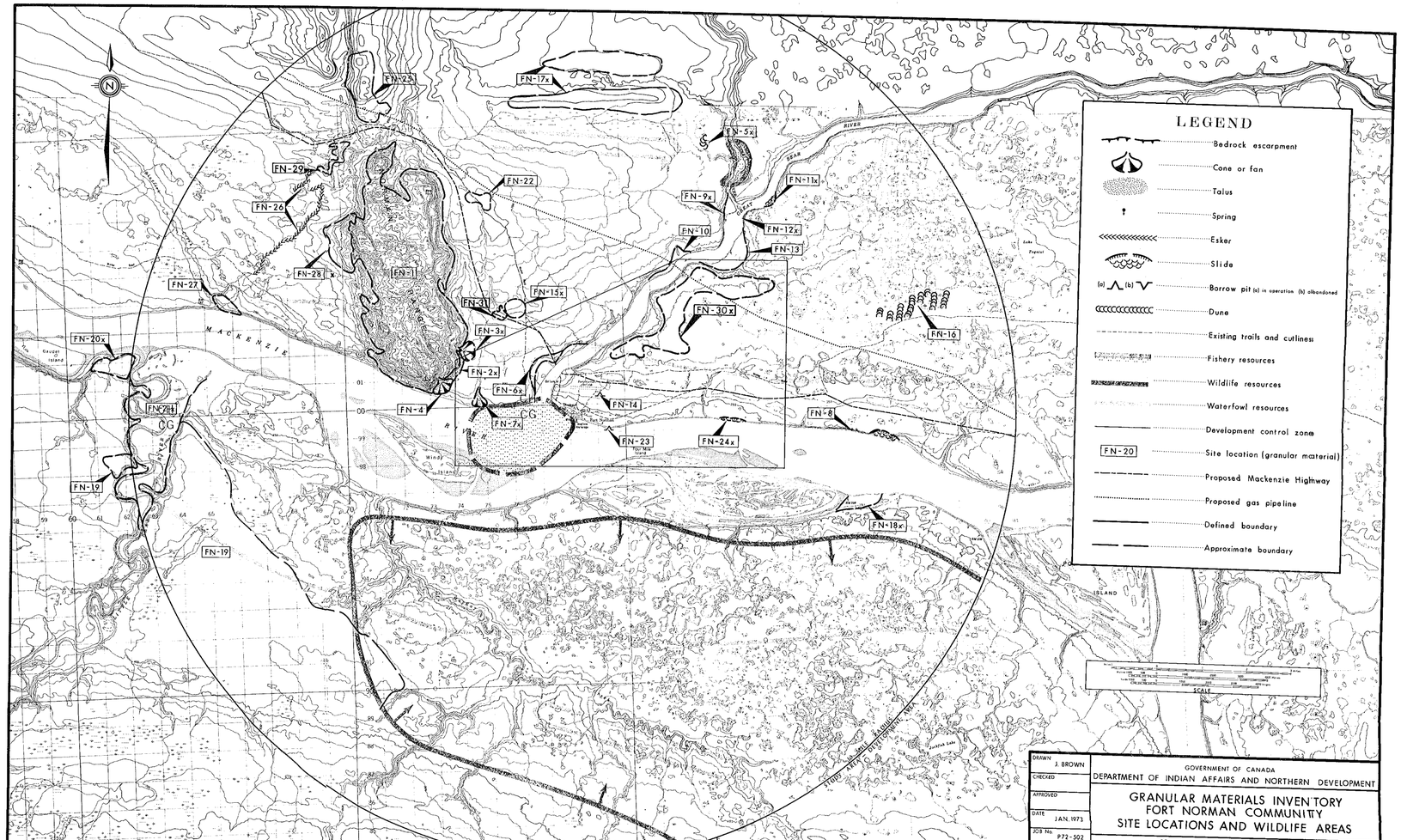
— SITE ASSESSMENT: "Active" indicates site is currently or periodically being used.

— N.D.: Not determined.

SITE NO	MATERIAL TYPE DESCRIPTION	SYM	SUITABILITY OF MATERIAL	ESTIMATED VOLUME (cu yds)	ESTD RECOV. DEPTH (feet)	OVERBURDEN TYPE	OVERBURDEN DEPTH (feet)	OVERBURDEN DISPOSAL	GROUND ICE (Content)	DRAINAGE	METHOD OF EXTRACTION	HAUL DIST. (miles)	ENVIRONMENTAL CONSIDERATIONS	ASSESSMENT OF SITE
FN 1	Bedrock: Limestone	—	All Construction Materials	Unlimited	+500	Colluvium	+1	Strip & Waste	Very Low	Formations Well Drained	Quarry: Crushing & Blasting	3	South End: Waterfowl Migration & Staging Area	Possible Future Development
FN 2X	Limestone Fragments	—	General Fill	N.D.	—	None	—	—	Low at +5	Good to East	Conventional	2½	No Critical Wildlife Areas	Not Recommended
FN 3X	Limestone Fragments	—	Marginal General Fill	N.D.	—	None	—	—	Medium at +5	Good to Southeast	Conventional	2½	No Critical Wildlife Areas	Not Recommended
FN 4	Limestone Fragments	—	General Fill	1,000,000	+5	Topsoil	½	Strip & Stockpile	None	Good to Southeast	Conventional	2½	No Critical Wildlife Areas. Adjacent to River	Possible Future Development
FN 5X	Sand; silty	SP	General Fill	10,000	20	Topsoil	½	Strip	None	Good	Conventional	10	No Critical Wildlife Areas	Not Recommended
FN 6X	Sand; silty, gravel pockets	SP-SM	General Fill	N.D.	—	Topsoil, organic	1	Strip & Stockpile	Low	Good to South	Conventional	½	No Critical Wildlife Areas	Not Recommended
FN 7X	Gravel, sandy	GM	General Fill	25,000	3	Topsoil & Silt	+2	Strip & Stockpile	None	Poor to West	Conventional	1½	No Critical Wildlife Areas	Not Recommended
FN 8	Gravel, medium grained	GW-SW	All Construction Aggregates	N.D.	+40	Topsoil & Silty Clay	+40	Strip, Waste & Stockpile	N.D.	Good	Conventional	4	No Critical Wildlife Areas	Extensive Overburden Depth; Development Uneconomic
FN 9X	Silt	ML-MH	Not Suitable	N/A	—	—	—	—	High at 2'	Fair	—	6	No Critical Wildlife Areas	Not Recommended
FN 10	Sand; silty, gravel pockets	SM	Marginal General Fill	400,000	6	Topsoil & Peat	+1	Strip & Waste	Medium to High	Fair to Southeast	Conventional	4½	No Critical Wildlife Areas; Adjacent to River	Possible Future Development
FN 11X	Sand; fine, silty	SP	Marginal General Fill	N.D.	+15	Topsoil	+½	Strip & Stockpile	Medium	Fair	Conventional	7	No Critical Wildlife Areas	Not Recommended
FN 12X	Gravel & Sand	GW-SW	All Construction Aggregates	N.D.	+40	Topsoil & Silty Sands	+20	Strip, Waste & Stockpile	N.D.	Fair to Southwest	Conventional	6	No Critical Wildlife Areas	Not Recommended
FN 13	Sand; silty, gravel pockets	SM-SP	General Fill	1,000,000	+15	Topsoil, silt	+1	Strip, Waste & Stockpile	Medium to High	Fair to West	Conventional	5	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
FN 14	Sand; fine	SP	Marginal General Fill	300,000	+10	Topsoil & Silt	+½	Strip, Waste & Stockpile	None	Fair	Conventional	½	No Critical Wildlife Areas	Active; Continue Development
FN 15X	Silt	ML	Not Suitable	N/A	—	Topsoil	½	—	None	Poor	—	2½	No Critical Wildlife Areas	Not Recommended
FN 16	Sand; fine	SP	General Fill	1,000,000	+20	Topsoil	½	Strip & Stockpile	None	Good	Conventional	8	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
FN 17X	Silt	ML	Not Suitable	N/A	—	Topsoil	+½	—	Medium to High	Very Poor	—	9	No Critical Wildlife Areas	Not Recommended
FN 18X	Silt; sandy	ML	Not Suitable	N/A	—	Topsoil	+1	—	N.D.	Fair	—	8	Adjacent to Active Stream Channel	Not Recommended
FN 19	Gravel, well graded	GW	All Construction Aggregates	Unlimited	+20	Topsoil & Silt	+½	Strip, Waste & Stockpile	Low	Good	Conventional	11	Broad Flyway for Waterfowl; Spawning Gravels	Recommended for Development
FN 20X	Silt & Sand; gravel layers	SM-GW	Very Marginal General Fill	N.D.	+15	Topsoil	+1	Strip & Stockpile	N.D.	Fair to North	Conventional	10½	Broad Waterfowl Flyway	Not Recommended
FN 21X	Gravel	GW	All Construction Aggregates	N.D.	5	None	—	—	N.D.	—	Conventional with Dredging	10	Within Active Stream Channel	Not Recommended
FN 22	Sand; some gravel & silt	SM-GM	General Fill	100,000	+5	Topsoil; organic	+½	Strip & Stockpile	Medium at 1'	Very Poor	Conventional with Thawing	7	No Critical Wildlife Areas	Possible Future Development
FN 23	Sand & Gravel	SW-GW	General Fill	5,000	5	Silt	1	Strip & Waste	None	Good to West	Conventional	½	Not Severe; In Broad Flyway of Waterfowl	Active; Controlled Periodic Exploitation
FN 24X	Silt & Clay; Burned	—	Not Suitable	N/A	—	Topsoil	+1	—	N.D.	Good to West	—	1½	On Bank of Mackenzie River	Not Recommended
FN 25	Bedrock; Limestone	—	All Construction Aggregates	Unlimited	+50	Colluvium	+2	Strip & Waste	Very Low	Good to West & East	Quarry, Blasting & Crushing	10	No Critical Wildlife Areas	Possible Future Development
FN 26	Sand & Gravel	SM-GW	Base & Surface Courses General Fill	2,000,000	20	Topsoil & Silt	+½	Strip, Waste & Stockpile	Low to Medium	Good	Conventional	11	No Critical Wildlife Areas	Possible Future Development
FN 27	Sand; silty	SM-SP	Marginal General Fill	700,000	+10	Topsoil & Silt	6	Strip, Waste & Stockpile	Medium	Fair to South	Conventional with Thawing	9	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
FN 28X	Silt	ML	Not Suitable	N/A	—	Topsoil & Peat	+1	—	Medium	Good to Southwest	—	11	No Critical Wildlife Areas	Not Recommended
FN 29	Gravel & Sand	GW-SW	General Fill	300,000	+10	Topsoil & Silt	+½	Strip, Waste & Stockpile	Low	Fair to West	Conventional	10	No Critical Wildlife Areas	Possible Future Development
FN 30X	Sand; silty	SM-SP	Marginal General Fill	N.D.	—	Topsoil & Peat	+½	Strip & Stockpile	Low to Medium	Poor	Conventional with Thawing	1	No Critical Wildlife Areas	Not Recommended
FN 31	Sand; gravel pockets	SW-GP	General Fill	75,000	+3	Topsoil & Silt	+2	Strip, Waste & Stockpile	Low	Poor	Conventional	2½	No Critical Wildlife Areas	Possible Future Development

Notes:

- ESTIMATED VOLUME (N/A): Not applicable because the site does not contain materials of granular quality
- GROUND ICE (content): Rating and depth figures are inferred from specific test pits or drill holes.
- DRAINAGE: Rating as shown generally refers to drainage conditions within the site
- METHOD OF EXTRACTION: 'Conventional' indicates use of standard excavation equipment such as dozers, overhead loaders, backhoes, light rippers.
- HAUL DISTANCE: is distance from site to community along existing or required access.
- ENVIRONMENTAL CONSIDERATIONS: Sensitive Terrain refers to thermal and/or erosional sensitivity at or adjacent to the site (Ref. Text)
- SITE ASSESSMENT: 'Active' indicates site is currently or periodically being used.
- N.D. Not determined.



DRAWN	J. BROWN
CHECKED	
APPROVED	
DATE	JAN. 1973
JOB No.	P72-502
SCALE	As Shown
FILE No.	
FIGURE	2
REVISION	

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY FORT NORMAN COMMUNITY SITE LOCATIONS AND WILDLIFE AREAS

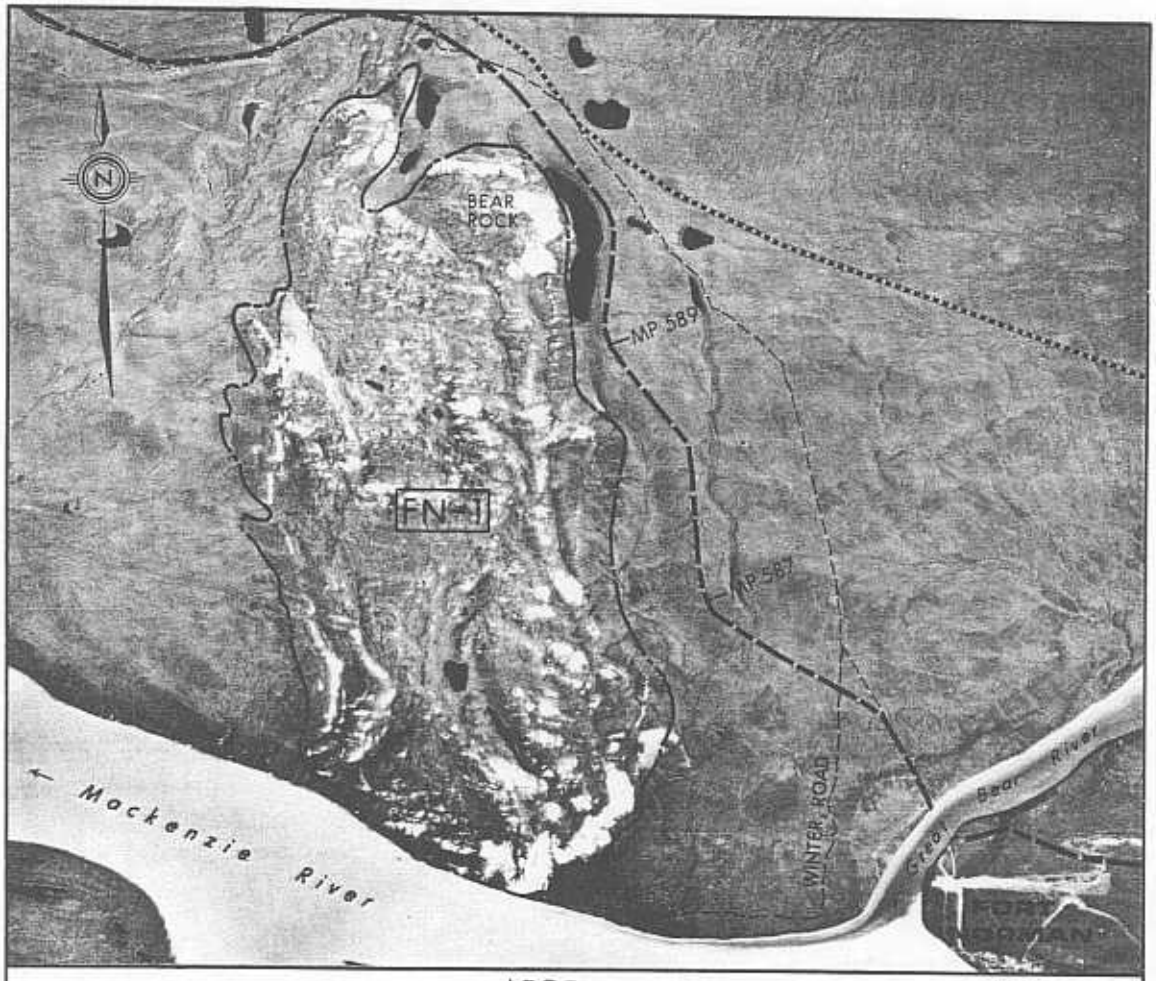
PEMCAN SERVICES "72"

SITE DESCRIPTIONS - FORT NORMAN STUDY AREA

SITE NO. FN 1

Located approximately 3 miles west of Fort Norman, Site FN 1 encompasses the rugged and pronounced bedrock formation known as Bear Rock at the southern extremities of the Norman Range.

Type of Material:	Limestone; dolomitic, weathered and fractured.
Estimated Volume:	Unlimited in terms of requirements for Fort Norman
Assessment:	Granular materials for various categories of construction requirements can be produced. The exploitation of this site will entail a quarry operation.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A21526/105 Approximate scale: 1" = 12,000'

ENVIRONMENT

The southern edge of Site FN 1 is located approximately 3 miles west of Fort Norman and constitutes the northern shoreline of the Mackenzie River. This site represents the southern extremities of the Norman Range and is a pronounced major landform in this area cartographically designated as Bear Rock. Site FN 1 encompasses an area approximately 7 miles in length by $2\frac{1}{2}$ miles in width.

This ridge is basically comprised of Devonian and Ordovician dolomitic limestone with subordinate inclusions of gypsum and anhydrite. The carbonate rock complex is mantled on the east side by Cretaceous shales. The bedrock exposures are usually weathered and extensively fractured which has resulted in deposition of eroded material in screes, talus slopes, and cones along the steep perimeter of the site area.

Residual soil and colluvium in localized depressions on the top of the ridge support very sparse growths of dwarfed spruce and tamarack. These deposits have apparently sealed some depressions within the rugged top of the rock outcrop resulting in two larger and numerous small lakes. Precipitated water and seepage from lakes percolates through carbonate rocks causing karst erosion. The seepage at the toe of the rock massif is masked by screes and a major spring was noted on the east side. The eastern and western upslope flanks of the site area support light stands of spruce interspersed with occasional tamarack and birch.

The extreme southern end of the site is within the broad migration and staging route that is utilized by various waterfowl species during spring and fall movements in the Mackenzie Valley.

The existing access to the site area entails a major river crossing of Great Bear River and a winter road to the northern extremity of the site area. Utilization of the existing winter road for access places the expoitable portion of Site FN 1 approximately 7 miles from Fort Norman. The routes of both the proposed gas pipeline and Mackenzie Highway traverse adjacent to the northern extremity of Site FN 1. Southern and southwestern flanks of this rock massif are relatively easily accessible from the Mackenzie River.

DEVELOPMENT

Site FN 1 may represent a very significant source of granular materials for the requirements of Fort Norman because of the scarcity of alternate sources in the northern sector of the Study Area.

The following broad and general comments relative to development of this site for granular materials are outlined herewith:

- Quarry operations including extensive blasting and crushing of the limestone material will be required for the extraction of granular materials.

- In view of the difficult existing access which entails a major river crossing of Great Bear River, potential quarry sites with immediate access to the Mackenzie River, in order to utilize barge haul of granular deposits, may be desirable. Several suitable quarry locations with good access to the Mackenzie River are available along the southwest periphery of Bear Rock.

- Steep and high rock faces forming the east side of the massif are not suitable for locating quarry operations.

- The best quarry locations, based upon quality of extractable limestone, general access to exposed rock outcrops and approachability are in the northern portion of the site area generally adjacent to the existing winter road. When the proposed Mackenzie highway becomes completed, this area would become very attractive for any future quarry operation.

- Selective quarrying can be anticipated. The material from the surficial, weathered and fragmented zone meets the requirements for general fill while better quality aggregates can be produced from fresh limestone beds at greater depths below existing rock faces.

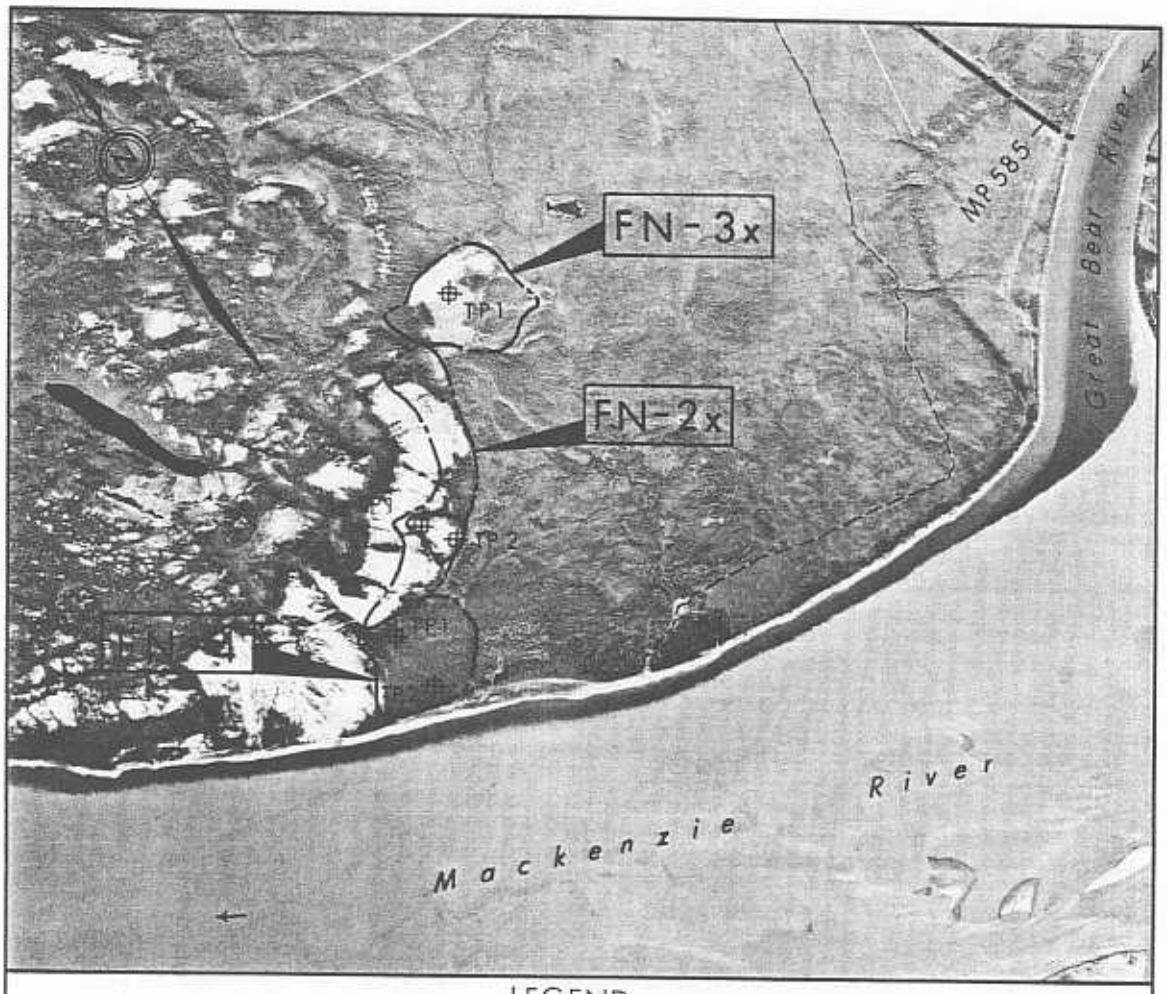
ABANDONMENT AND REHABILITATION

In general, if a well organized and controlled operation is maintained during the development and extraction of material from the quarry, then the problems related to abandonment and rehabilitation would, for the most part, be managed. Any stripped waste material should be placed adjacent to the quarry base and the stockpiled material may be spread evenly over the quarry floor when a specific section of the quarry has been completed and abandoned.

SITE NO. FN 2X

Located approximately $2\frac{1}{2}$ miles west of Fort Norman along the southeastern toe slopes of Bear Rock, Site FN 2X consists of a small alluvial cone flanked by talus slopes.

Type of Material:	Limestone fragments and blocks, trace of sand
Estimated Volume:	Not established
Assessment:	Fair quality material for general fill. This site is not recommended for development because of the difficult access.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/146

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 2X is located approximately $2\frac{1}{2}$ miles west of Fort Norman, and consists of an alluvial cone flanked by a series of talus slopes along the toe of the southeast steep escarpment of Bear Rock. This site covers an area approximately 3000 feet in length and 500 feet in width. The southern edge of the site is located approximately $\frac{1}{2}$ mile from the northern Mackenzie River bank.

The material in the cone and talus consists of very coarse and blocky limestone fragments on the surface with occasional blocks 1 to 3 cubic feet in size. The material beneath the coarse surface layer is finer graded with maximum particle size, generally less than 6 inches; however, the sand portion of the in situ material is less than 10 per cent.

The site area is well drained and the general surface drainage is in an easterly direction into the watershed of a small stream which flows into the Mackenzie River. The upper slopes of the cone and talus are completely devoid of trees and vegetation cover. Light spruce growth is evident along the outer perimeter of the site area.

There are no known critical wildlife areas in the immediate vicinity of the site.

There is no existing access to this site and any planned land access would entail the crossing of the Great Bear River. Access to the site by water would entail a land crossing of about $\frac{1}{2}$ mile from the north shoreline of the Mackenzie River.

DEVELOPMENT

Site FN 2X is not recommended for development for the following reasons:

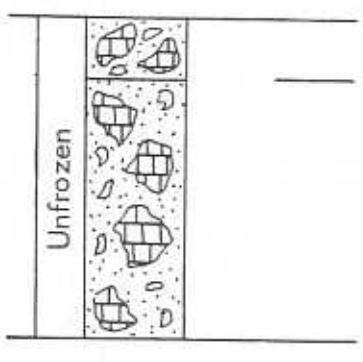
- There is no existing access to the site area, and any new land access which would be constructed in the future would involve the crossing of Great Bear River and one other unnamed stream.

- The material available at this site is very coarse and would entail processing by crushing or selective screening even for utilization for general fill.

- Although frozen material was not encountered in the test pits to the depths investigated, local people indicate that these deposits are quite often frozen at very shallow depths for most of the year. Therefore, removal of the fragmented limestone material may be difficult.

DETAILED TEST PIT LOG

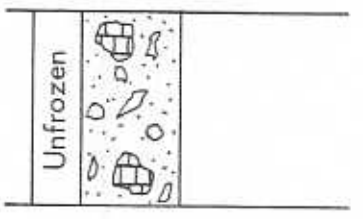
FN 2X/TP 1



Limestone and dolomite fragments, angular, mostly to 5 inch diameter, occasional blocks.

Limestone and dolomite angular fragments, predominantly up to 3 inch in diameter, in sandy and silty matrix

FN 2X/TP 2



Limestone and dolomite angular fragments, with infrequent large blocks, predominantly to 5 inch diameter size.

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 2X/TP 1

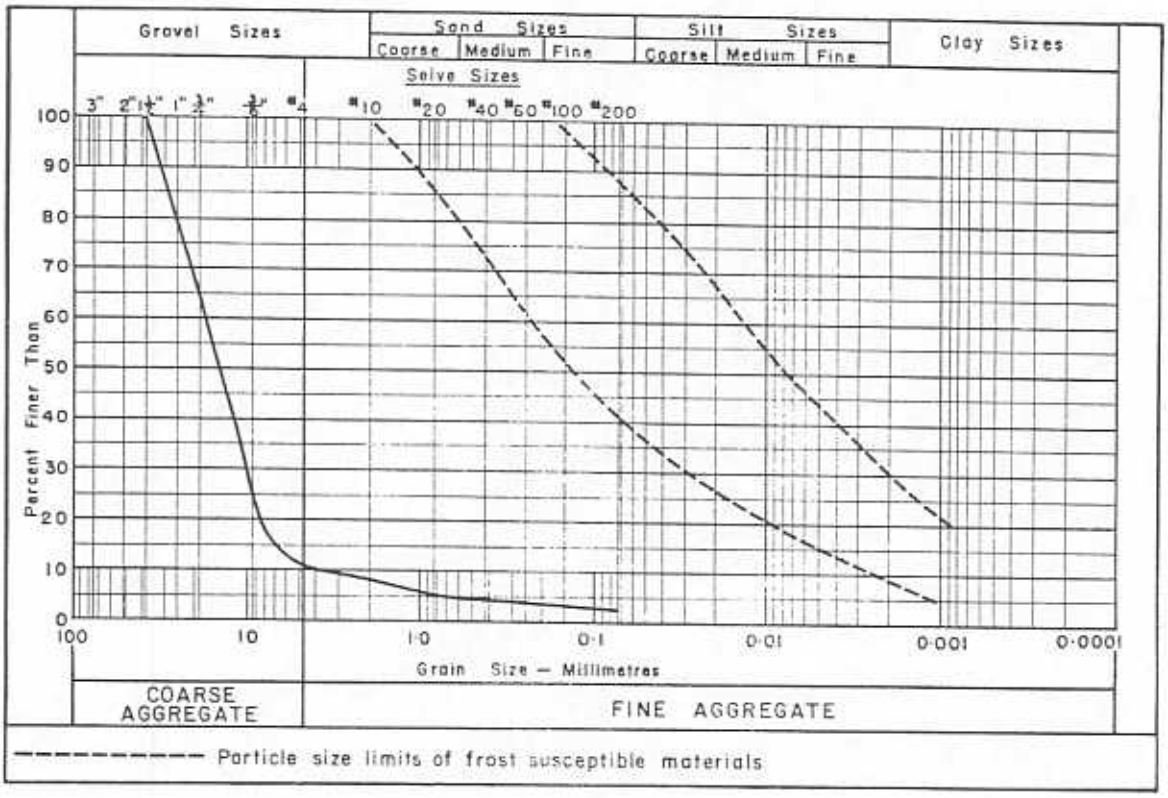
Sample Depth (Feet): 2.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone and dolomite	95.8 %
Quartzites	0.8 %
Limestone & dolomite (porous)	4.1 %

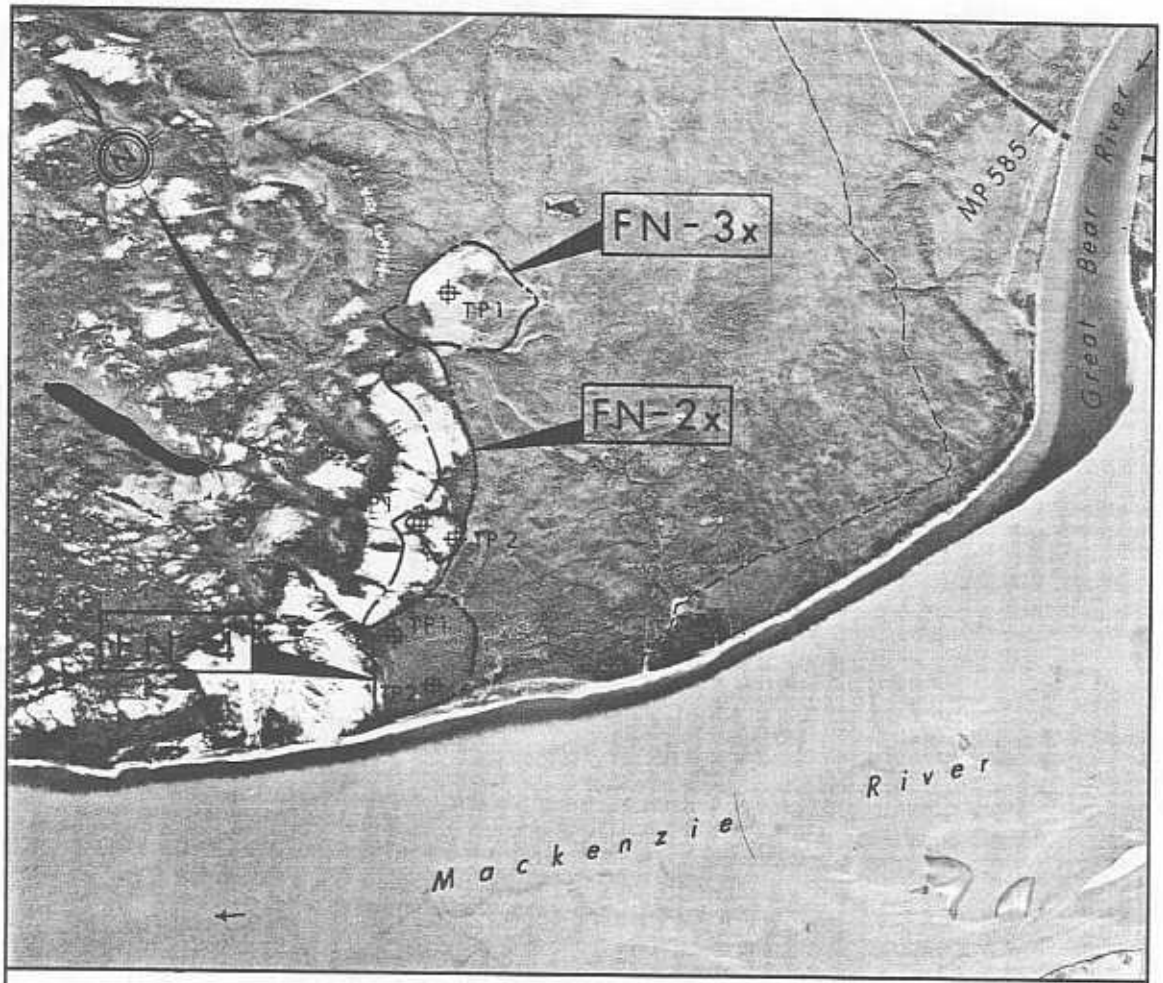
SITE NO. FN 3X

Located approximately $2\frac{1}{2}$ miles west of Fort Norman at the base of an erosional gully incised in the southeast escarpment of Bear Rock, Site FN 3X consists of a flat alluvial fan.

Type of Material: Limestone; weathered and finely fragmented.

Estimated Volume: Not established.

Assessment: This site is not recommended for development because of the difficult access and very low quality of recoverable granular materials.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/146

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 3X is located approximately $2\frac{1}{2}$ miles west of Fort Norman along the southeastern toe slope of Bear Rock immediately north of Site FN 2X. This site consists of a flat alluvial fan located at the mouth of an erosional gully incised in the steep escarpment of the southeastern exposure of Bear Rock. The site encompasses an area approximately 900 feet by 1500 feet.

The granular material in the alluvial fan consists of small (generally less than 3 inches) angular to sub-angular fragments of limestone cemented in carbonates. The cementation is quite weak, and the material can readily be chipped into small fragments with a hand pick.

A flowing spring was noted at the apex of the fan and ground water was encountered one foot below the ground surface. The general surficial drainage of the site area is southeasterly into the waterbed of a small creek that flows into the Mackenzie River. Very shallow erosional stream channels have been cut into the surface of the fan by surface runoff water. The presence of the spring indicates underground seepage in this area of the Bear Rock escarpment.

There are no known critical wildlife areas in the immediate vicinity of the site.

There is no existing access by land to the site at this time. Any proposed overland access to this site will involve the crossing of Great Bear River and one small unnamed stream. Access to the site by water would entail a land crossing of about $1\frac{1}{2}$ miles from the north shoreline of the Mackenzie River.

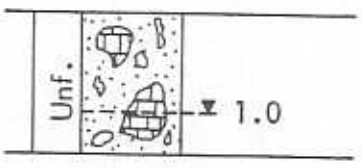
DEVELOPMENT

Site FN 3X is not recommended for development for the following reasons:

- There is no existing access to the site area, and any new one would involve the crossing of Great Bear River and one un-named stream.
- The material available at this site is weakly cemented and would very likely deteriorate if exposed to atmospheric conditions.
- Ground water table lies near to the ground surface.

DETAILED TEST PIT LOG

FN 3X/TP 1



0.0

1.5

Small limestone angular and subangular fragments secondary cemented by carbonates. The cementation is weak, the material can be readily chipped into small (1-2 inch) fragments by a pick.

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 3X/TP 1

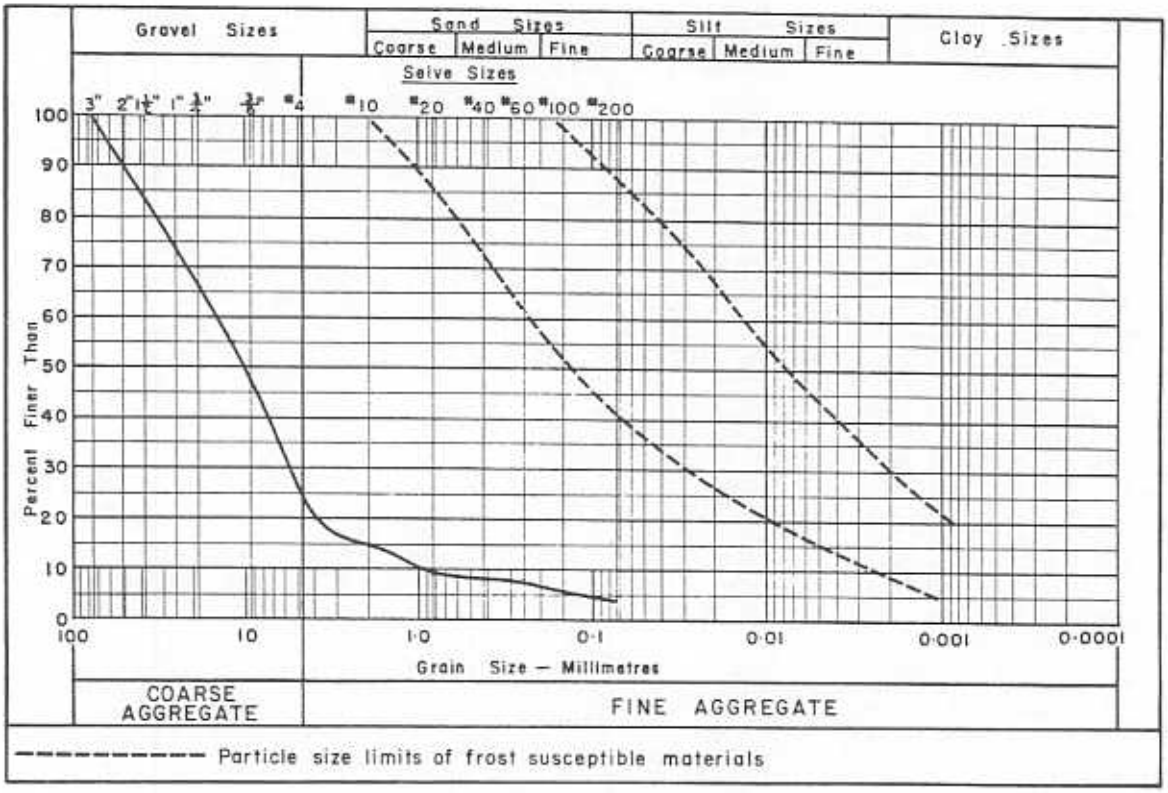
Sample Depth (Feet): 0.7

Moisture Content (%): 4.6

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone (sound)	8.8 %
Limestone (massive, porous)	91.1 %

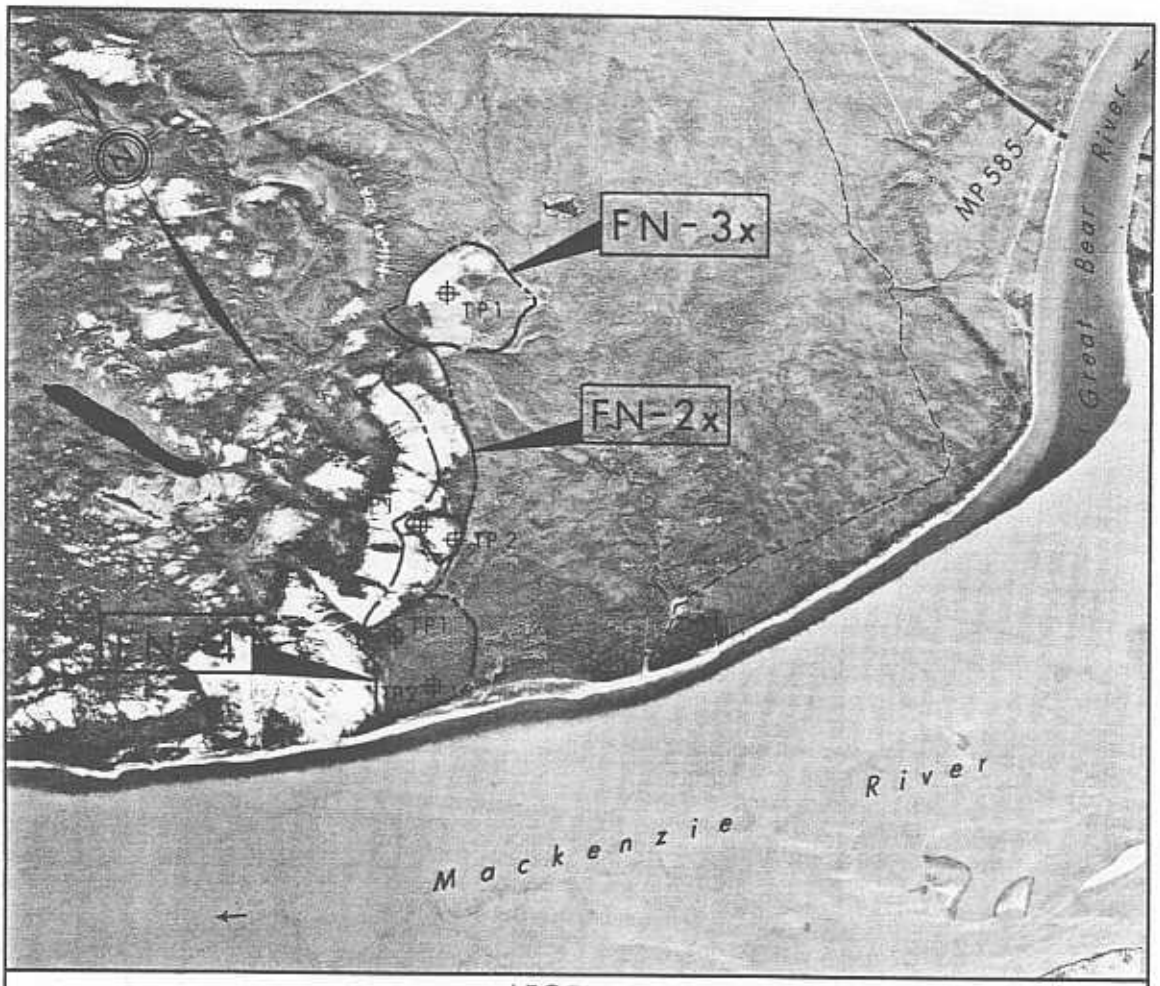
SITE NO. FN 4

Located approximately $2\frac{1}{2}$ miles west of Fort Norman, Site FN 4 consists of a flat alluvial fan situated at the mouth of an erosional gully which is deeply incised into the southeastern escarpment of Bear Rock.

Type of Material: Limestone fragments, angular to sub-angular

Estimated Volume: 1,000,000 cubic yards

Assessment: Fair quality granular materials suitable only for general fill. Development of this site is not currently recommended in view of difficult access.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/146

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 4 is located approximately $2\frac{1}{2}$ miles west of Fort Norman at the mouth of an erosional gully that is deeply incised into the southeastern escarpment of Bear Rock. The site consists of a gently sloping alluvial fan approximately 1500 feet in breadth and length. The southern periphery of the alluvial fan forms the northern shoreline of the Mackenzie River in this vicinity.

The outwash fan consists of rock debris discharged from the erosional gulley and is generally comprised of angular to sub-angular, medium to coarse grained limestone fragments with a silty sand matrix. Occasional rock fragments to 8 inches in size were noted. The sand portion of the recoverable granular material is approximately 35 per cent.

The surficial drainage of the site area is in a southeasterly direction into the Mackenzie River channel.

The entire surface area of the alluvial fan is covered with a shallow layer of organic topsoil, 6 inches in depth, which supports a relatively dense growth of spruce, birch and occasionally poplar. The understory consists of moderately dense growths of small plants and shrubs.

There are no known critical wildlife areas in the immediate vicinity of the site; however, the site is within the broad flyway that is utilized by waterfowl for staging and migration during the spring and fall.

The Mackenzie River channel provides direct access by water to the southern edge of the site area. Relative to overland access, a crossing of the Great Bear River and one stream channel is required. An existing seismic cutline, or trail, paralleling the north bank of the Mackenzie River, approaches within 1 mile of the eastern perimeter of Site FN 4 from the west bank of Great Bear River.

DEVELOPMENT

Site FN 4 is not recommended for immediate development for the following reasons:

- The access to the site is quite difficult if approached overland and would restrict the development of the site to the winter months.
- The quality of the recoverable granular material is fair, suitable only for general fill.
- Although frozen material was not encountered to depths investigated, local experience indicates that these deposits are frozen and are not easily ripped during the winter season.

If future requirements of granular materials in the Fort Norman area dictates the exploitation of this site, then the following development guidelines should be considered:

- Harvesting of the material (horizontal stripping) in the summer and transportation of the aggregate by barge haul is recommended if the material is to be utilized in the community of Fort Norman.

- A buffer strip (approximately 300 feet wide) should be left between the working area and the Mackenzie River bank. Vegetation growing in this strip should not be disturbed.

- The organic topsoil snould be carefully stripped and stockpiled along the eastern perimeter of the fan to prevent drainage of waste material into the active stream channel or river. Dikes and ditches will be constructed if necessary to control surficial drainage patterns.

- The access road from the shoreline to the site should be graded to ensure smooth, stable and gentle slopes, which will minimize excess erosion. Fill must not be placed on the river bank below the high water mark.

- Pit faces should be graded to smooth, clean and stable slopes. The pit floor should be recontoured to provide proper surficial drainage before the pit operations are suspended for any given season.

- The source should be operated to produce a final excavation which blends as far as possible with the natural contours of the immediate area.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site FN 4 is developed as a borrow pit:

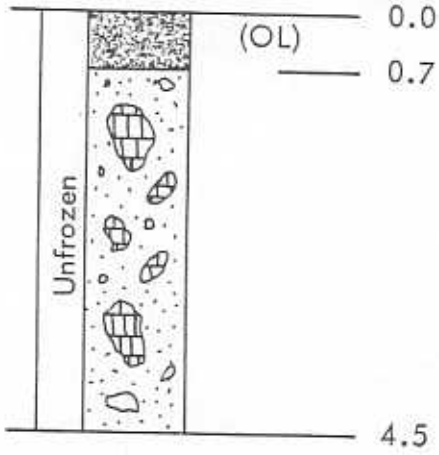
- Recontouring of borrow pit area to maintain good drainage to the adjacent terrain.

- Replacement and spreading of organic topsoil from pre-production stockpiles on the recontoured exposed borrow pit areas.

- Restoration of vegetation.

DETAILED TEST PIT LOG

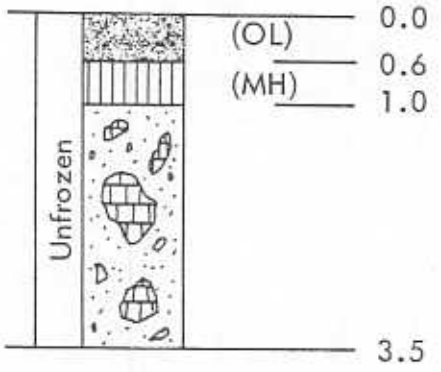
FN 4/TP 1



Topsoil; organic, black, roots

Limestone fragments, angular, occasionally subangular, some dolomitic fragments, predominantly 1 - 3 inch, occasionally to 8 inch in silty and sandy matrix.

FN 4/TP 2



Topsoil; organic, black, roots

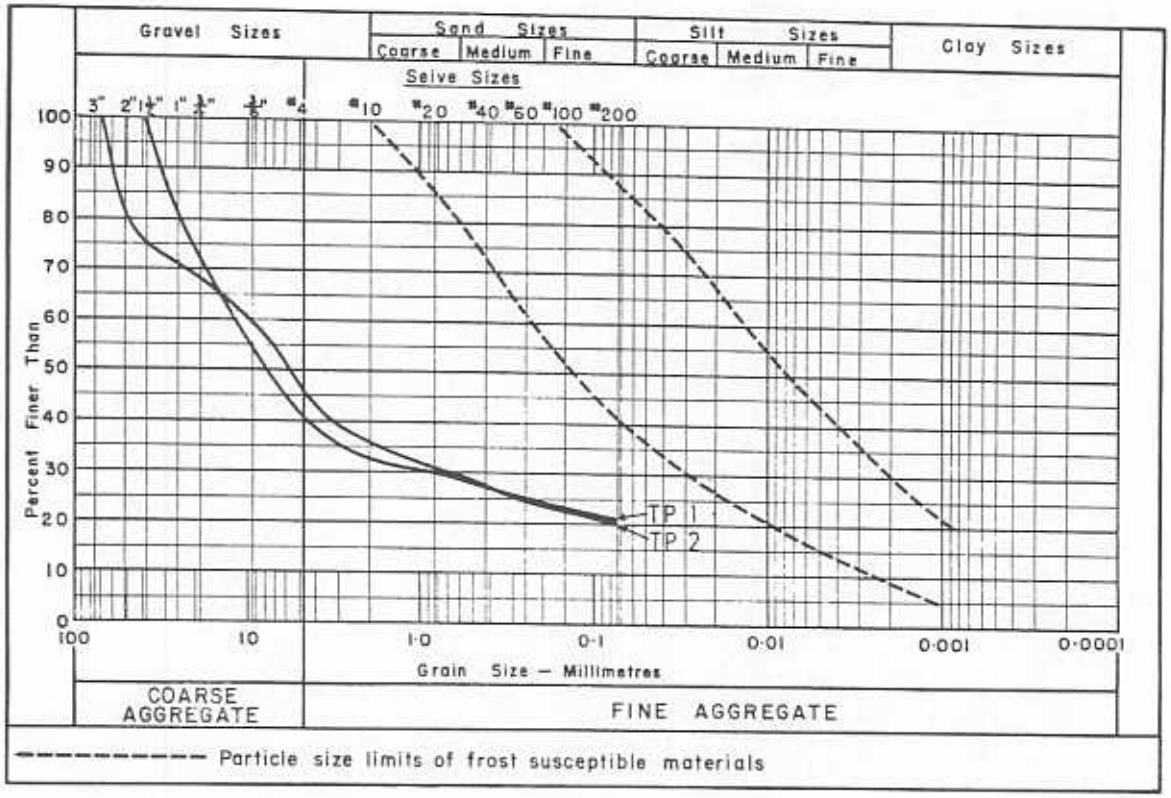
Silt; some clay, plastic

Limestone fragments, angular, occasionally subangular, some dolomitic fragments, predominantly 1 - 3 inch, occasionally to 8 inch in silty and sandy matrix.

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 4/TP 1	FN 4/TP 2
Sample Depth (Feet):	3.0	2.5
Moisture Content (%):	-	8.0
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone and dolomite	95.6 %
Chert	0.01 %

Deleterious limestone and dolomite (porous)	3.1 %
Deleterious siltstone, shale and mudstone	1.3 %

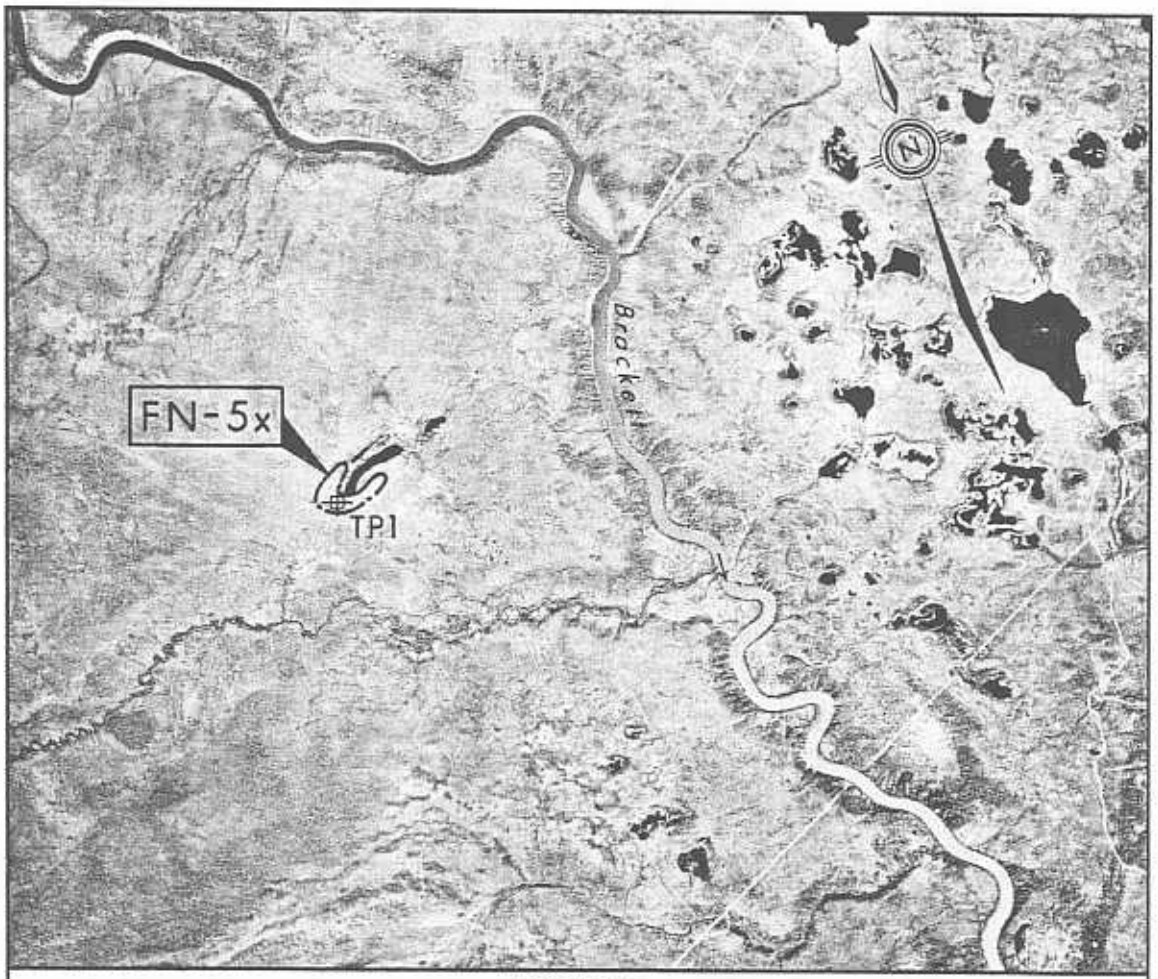
SITE NO. FN 5X

Located approximately 10 miles north of Fort Norman, Site FN 5X consists of a very small eolian sand dune on the southern shoreline of a small lake.

Type of Material: Sand; very fine, some silt.

Estimated Volume: 10,000 cubic yards.

Assessment: This site is not recommended for development because of its remote location, poor quality and very limited quantity of recoverable material.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/80

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 5X is located approximately 10 miles north of Fort Norman adjacent to a small lake on a flat, poorly drained, glaciated plateau. The site consists of a small crescent shaped sand dune, approximately 500 feet in length and 100 feet in width, rising 10 to 20 feet above the adjacent lake level.

The dune contains very fine eolian sand with some silt size particles.

The dune slopes are covered with a very thin veneer of topsoil, 4 to 6 inches in depth, which supports a sparse growth of birch and spruce. The adjacent terrain is predominantly very wet muskeg that supports sparse growths of dwarfed spruce and tamarack.

The general drainage of the adjacent terrain is easterly to the Brackett River which is located about a mile east of this site.

There are no known critical wildlife areas in the immediate vicinity of the site.

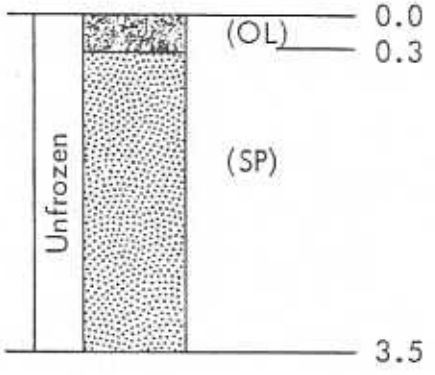
There is no existing access to this site by land or water. The nearest seismic cutline is located 2 miles southeast of the site and entails the crossing of two tributary streams which flow into the Brackett River.

DEVELOPMENT

Site FN 5X is not recommended for development because of its isolated location, no access, very poor quality and very small volume of recoverable granular materials.

DETAILED TEST PIT LOG

FN 5X/TP 1



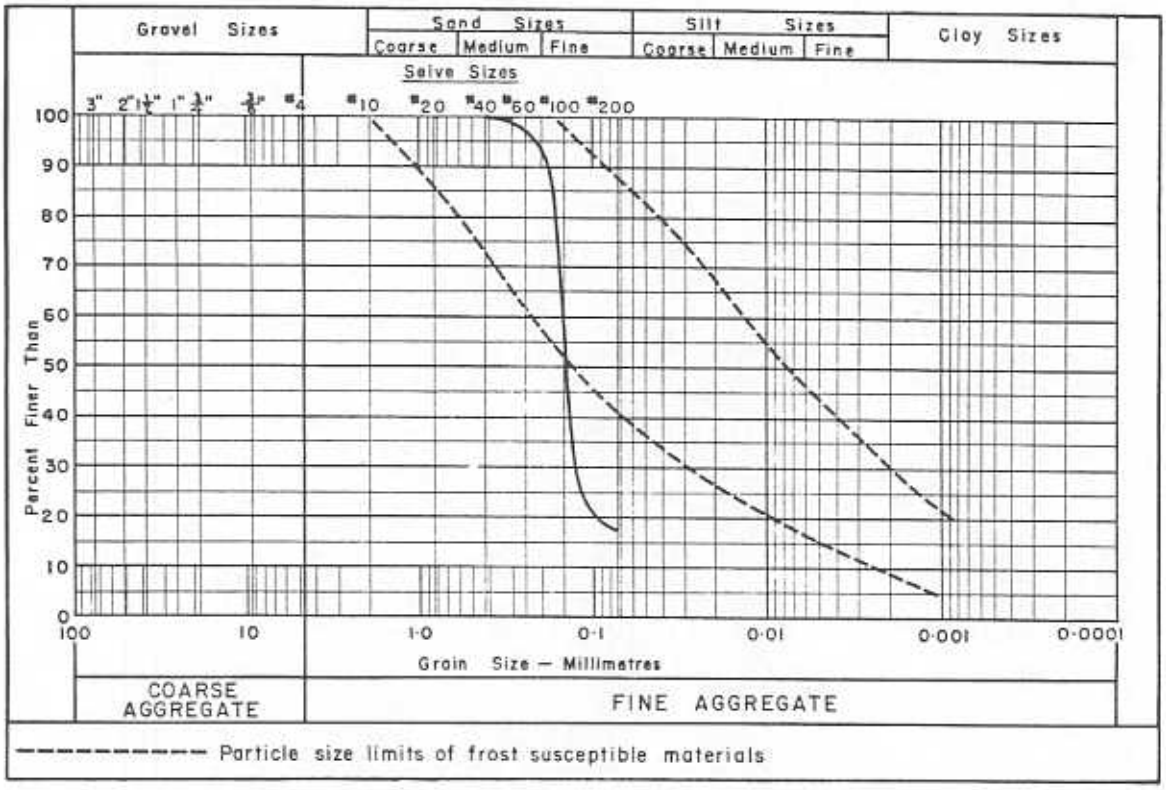
Topsoil; some sand, dark brown

Sand; fine grained, medium dense, slightly wet, light brown

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 5X/TP 1
Sample Depth (Feet):	2.0
Moisture Content (%):	7.4
Ice Content (%):	-
Organic Content (%):	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

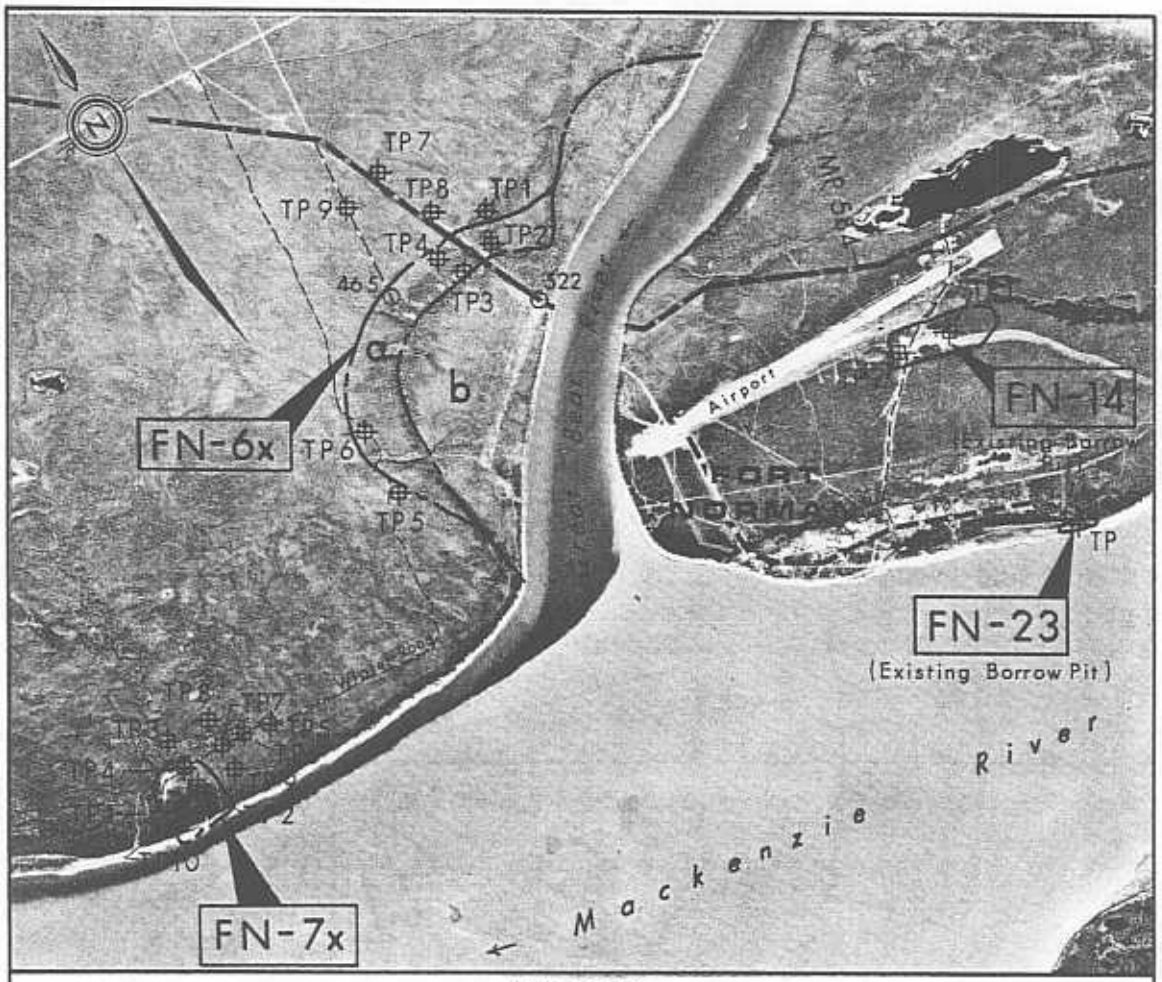
SITE NO. FN 6X

Located approximately $\frac{1}{2}$ mile west of Fort Norman, Site FN 6X consists of a river terrace and the crescent shaped edge of a reworked glaciated plain.

Type of Material: Very fine silty sands with small pockets of gravel

Estimated Volume: Not established

Assessment: This site is not recommended for development because of the scattered and minimal size of the pockets of gravel. Extensive terrain disturbance would result from the harvesting of these scattered pockets of gravel.



Airphoto No. A22889/146 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 6X is located approximately $\frac{1}{2}$ mile west of Fort Norman on the west bank of the Great Bear River immediately north of the confluence of the Great Bear and Mackenzie Rivers. The site encompasses an area approximately 2 miles in length paralleling the Great Bear River and varying in width from 1000 to 3000 feet. The site area has been separated into two parts:

Part "a" consists of the reworked crescent shaped edge of a glaciated plain. The better quality granular materials at this source are contained in the upper edge of the glaciated plain; however, only small pockets of fine grained gravels in a predominantly silty sand deposit were encountered.

Part "b" consists of floodplain deposits which form a terrace immediately adjacent to the current stream channel of Great Bear River. Test hole 522, drilled by the consultant for The Federal Department of Public Works, confirmed that the upper portion of the terrace consists of stratified silts, sands and clays. Gravel was encountered 20 feet below the terrace surface which corresponds to water elevation in the river.

The general surficial drainage is primarily in an easterly direction into the Great Bear River. Erosional gullies are incised periodically along the edge of the glaciated plain.

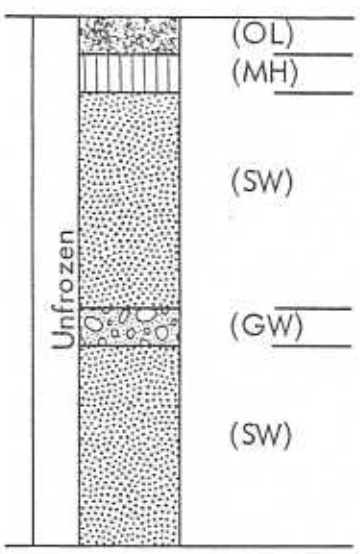
The edge of the glaciated plain (part "a") is well drained while the flat and slightly depressional surface of the river terrace is poorly drained, resulting in localized swamps.

DEVELOPMENT

Site FN 6X is not recommended for development because the availability of usable granular materials is restricted to small, isolated pockets. Harvesting of these scattered pockets of material would result in extensive terrain disturbance. Exploitation of the gravel bed in the river terrace is not practical.

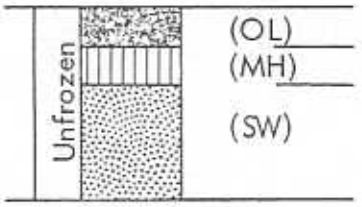
DETAILED TEST PIT LOG

FN 6X/TP 1



0.0	(OL)	Topsoil; organic, black, roots
0.4	(MH)	Silt; some clay, light brown, damp
0.8	(SW)	Sand; little silt, fine grained, dry
3.0	(GW)	Gravel and Sand; trace silt
3.4	(SW)	Sand; little silt, fine to medium grained
5.5		

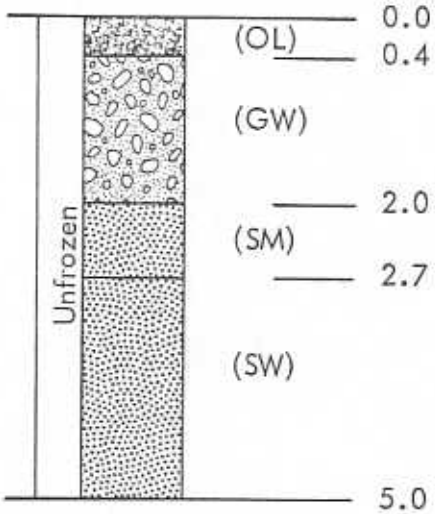
FN 6X/TP 2



0.0	(OL)	Topsoil; organic, black
0.5	(MH)	Silt; some clay, brown
1.0	(SW)	Sand; little silt, fine grained dry
2.0		

DETAILED TEST PIT LOG

FN 6X/TP 3



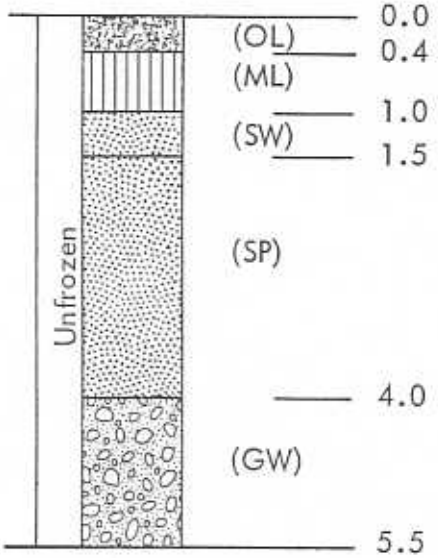
Topsoil; organic, black, roots

Gravel; some sand, trace silt, brown, rootlets

Sand; little silt, trace clay, damp, rootlets

Sand; little silt, fine to coarse grained, damp

FN 6X/TP 4



Topsoil; organic, black, roots

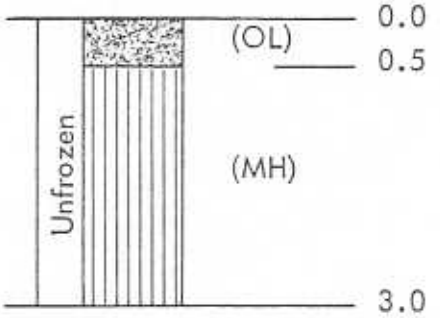
Silt; some sand, trace clay, light brown, damp

Sand and Gravel; greyish

Sand; trace silt, fine to medium grained, grey, dry.

Gravel and Sand; brown

FN 6X/TP 5

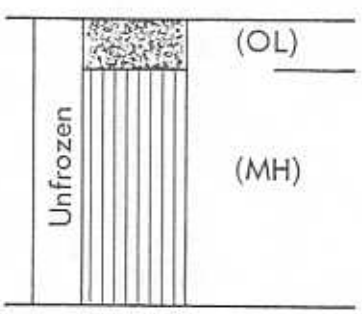


Topsoil; organic, black, wet

Silt; some clay, plastic, soft, wet

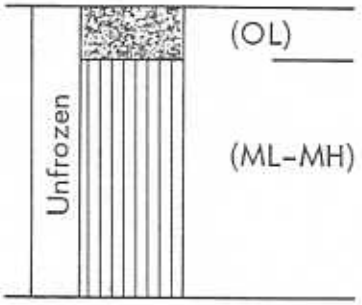
DETAILED TEST PIT LOG

FN 6X/TP 6



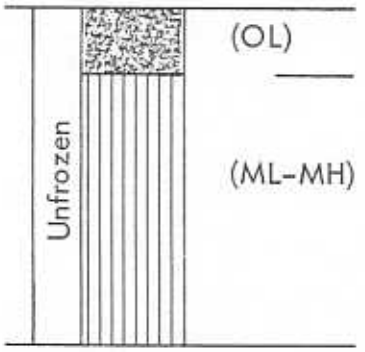
0.0	(OL)	Topsoil; organic, black, wet
0.5		
	(MH)	Silt; some clay, plastic, soft, wet
3.0		

FN 6X/TP 7



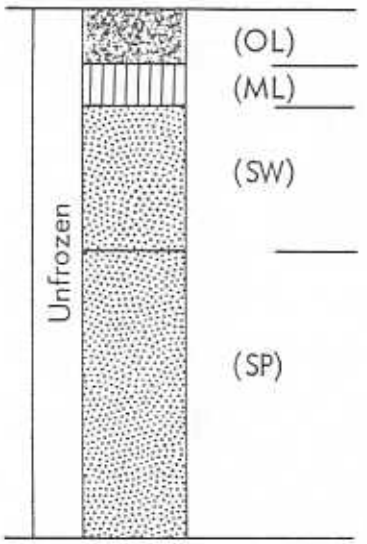
0.0	(OL)	Topsoil; organic, black, roots
0.5		
	(ML-MH)	Silt; some clay and sand, wet to saturated, brown
3.0		

FN 6X/TP 8



0.0	(OL)	Topsoil; organic, black, roots
0.7		
	(ML-MH)	Silt; some clay and sand, light brown, wet to saturated
3.5		

FN 6X/TP 9



0.0	(OL)	Topsoil; organic, black, roots
0.6	(ML)	Silt; some sand, trace clay, brown
1.0	(SW)	Sand; some gravel, trace silt, 1 - 2 inch thick gravel lenses.
2.5	(SP)	Sand; little silt, fine grained
5.5		

DETAILED DRILL HOLE LOG

SITE NO. FN 6X HOLE NO. 465

DATE: FEB. 5, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic		Nbn			0
1.0								
2		ML	SILT (TILL): slightly clayey, low plastic, brown					2
4								4
5.0								
6		SP	SAND (TILL): fine grained, slightly silty, low to non plastic, grey					6
8								8
10								10
12							MC GS	12
14								14
14.0								
16		ML	SILT (TILL): sandy, pebbles to $\frac{1}{4}$", low plastic, grey					16
18								18
18.0								
20		SP	SAND (TILL): fine grained, slightly silty, non plastic, grey				MC GS	20
20.0			END OF HOLE 20.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 6X HOLE NO. S 522N

DATE: FEB. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: category #6		Vx	M		0
1.5								
4		CH	CLAY: sandy, high plastic, dark brown		Vr	L		4
					Nbn			
8			8.0 - slightly silty					8
12								12
16								16
19.5								
20		GP	GRAVEL: sandy, non plastic, brown		Nf		MC GS	20
24								24
27.5								
28		CI	CLAY (SHALE): silty, sandy, rust specks, pebbles, medium plastic, grey		Nbn			28
32			32.0 - no pebbles					32
36			Remark: Drill hole continued to 104'					36
			END OF HOLE					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

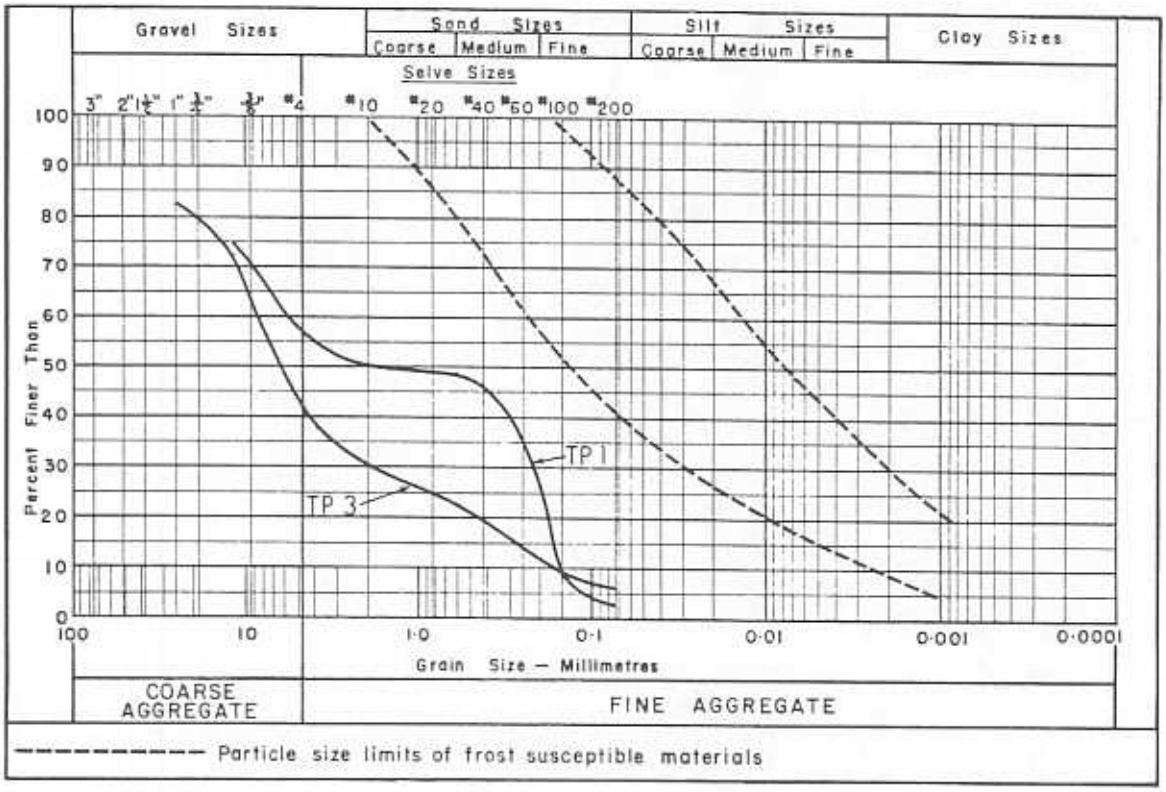
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 6X/TP 1	FN 6X/TP 3
Sample Depth (Feet):	3.2	1.5
Moisture Content (%):	3.8	6.8
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:

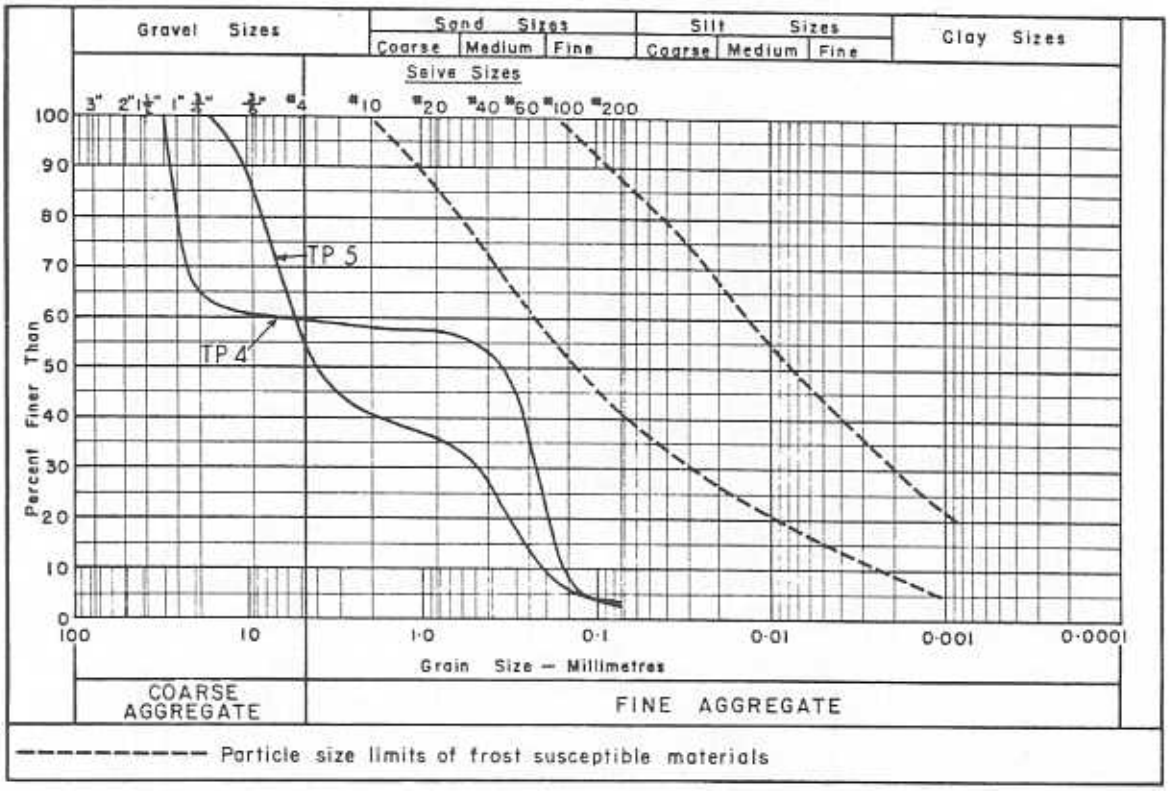


PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 6X/TP 4	FN 6X/TP 5
Sample Depth (Feet):	1.0	4.0
Moisture Content (%):	3.8	4.6
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

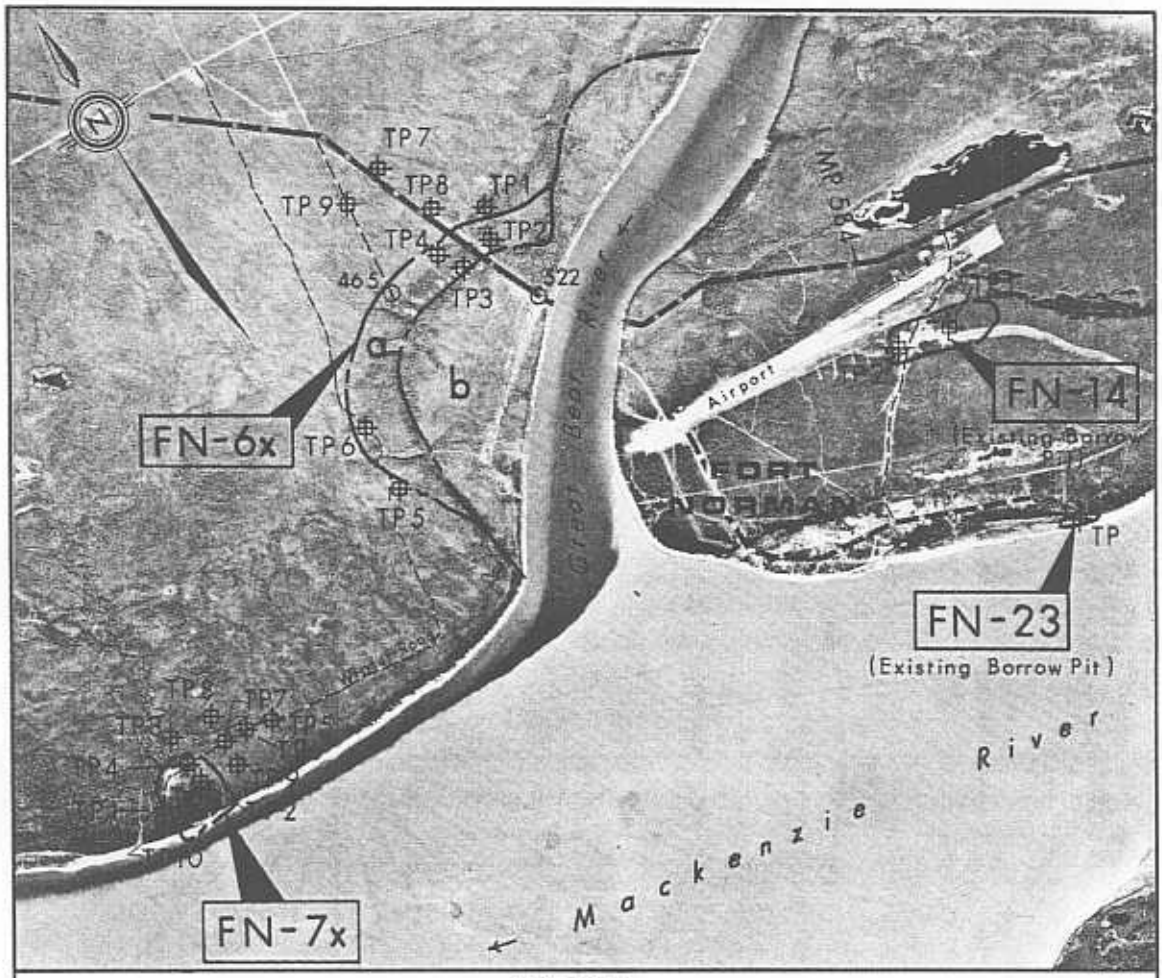
SITE NO. FN 7X

Located approximately 1¼ miles west of Fort Norman, Site FN 7X consists of an alluvial cone remnant located at the mouth of a stream which discharges into the Mackenzie River along the north bank.

Type of Material: Gravel; medium grained, very sandy and silty

Estimated Volume: 25,000 cubic yards

Assessment: This site is not recommended for development because of the presence of the active stream channel, deep overburden, limited quantities and the difficult access to the site.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/146 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 7X is located approximately $1\frac{1}{4}$ miles west of Fort Norman at the mouth of a small stream channel which discharges into the Mackenzie River on its north bank. The site consists of an alluvial cone remnant and is approximately 400 by 1000 feet in size.

The alluvial cone is comprised of medium grained gravel, some sand and a trace of silt. The sand content increases in a upstream direction. Ground water was encountered at a depth of $3\frac{1}{2}$ feet at the northern portion of the site area. An active stream channel flows through the middle of the site area.

The organic topsoil layer, underlain by a stratum of silty sand, overlies the entire site area and varies in depth from $1\frac{1}{2}$ to 3 feet. This surficial organic stratum supports growths of birch, spruce and occasional poplar. The understory growth consists of thick moss and small plants. The adjacent terrain is a relatively flat glaciated plain and is well drained. The general drainage of the site area is southerly into the Mackenzie River.

There are no known critical wildlife areas in the immediate vicinity of the site.

The existing access to the site consists of a seismic cutline by land and by the Mackenzie River by water if barge haul is considered.

DEVELOPMENT

Site FN 7X is not considered suitable for development for the following reasons:

- An active stream channel flows through the middle of the site area; therefore, development of this site may have detrimental environmental effects on the stream regime since excavations near the stream would be necessary in order to harvest a large part of the limited volume of material.

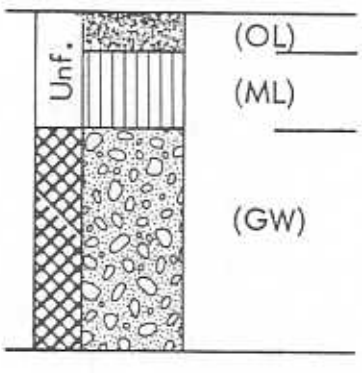
- The thickness of the topsoil and silty sand overburden is substantial, especially when considered in relation to the minimal volumes of granular materials that are available for excavation.

- The quality of the available granular material is fair and it is suitable for general fill requirements.

- Access to the site by land will entail the crossing of the Great Bear River, which restricts the exploitation of the site to the winter season.

DETAILED TEST PIT LOG

FN 7X/TP 1

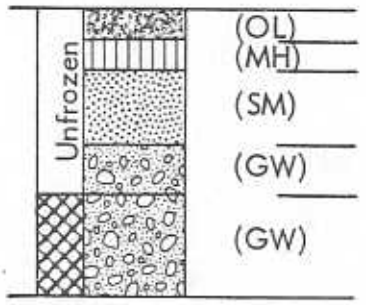


Topsoil; organic, black, roots

Silt; little sand, trace clay

Gravel and Sand; trace silt

FN 7X/TP 2



Topsoil; organic, black, roots

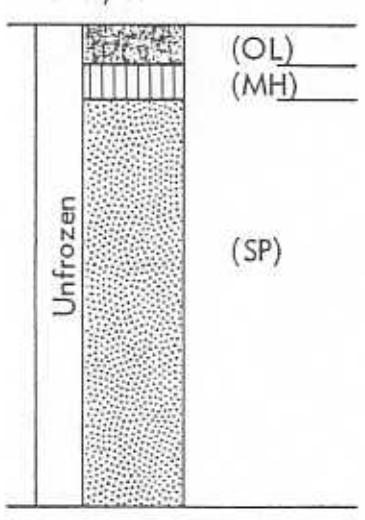
Silt; some clay and sand

Sand; some silt

Gravel and Sand; trace silt, damp

Gravel and Sand; trace silt, damp
Frozen

FN 7X/TP 3



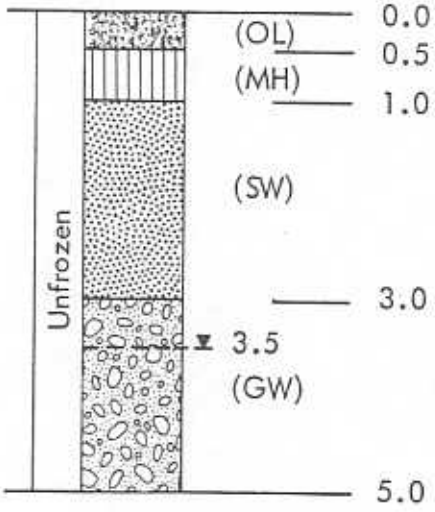
Topsoil; organic, black, roots

Silt; some clay, light brown

Sand; poor graded, damp

DETAILED TEST PIT LOG

FN 7X/TP 4



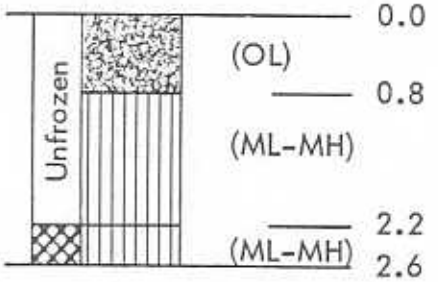
Topsoil; organic, black, roots

Silt; some clay, light brown

Sand and Gravel; well graded, brown

Gravel and Sand; some clay and silt lenses

FN 7X/TP 5

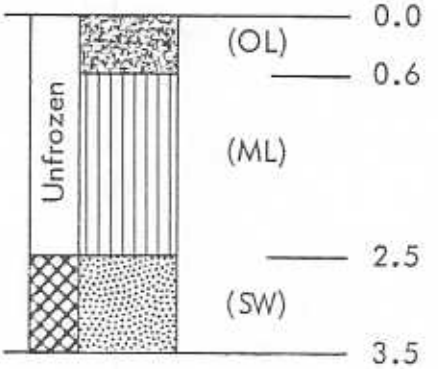


Topsoil; organic, black, roots

Silt; some sand and clay, very soft, wet, brown

Silt; some sand and clay, frozen

FN 7X/TP 6



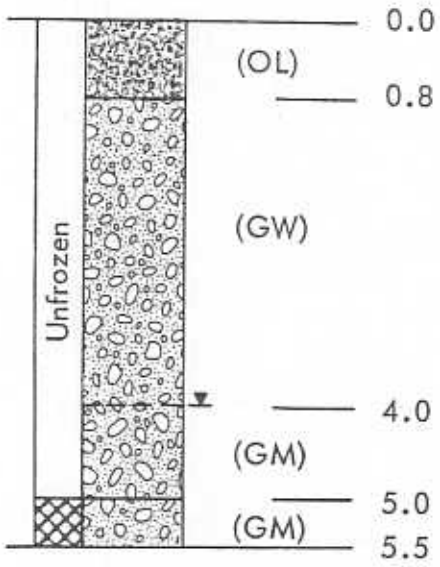
Topsoil; black organic, roots

Silt; some sand and clay, wet

Sand; some gravel, frozen, trace of silt and clay

DETAILED TEST PIT LOG

FN 7X/TP 7



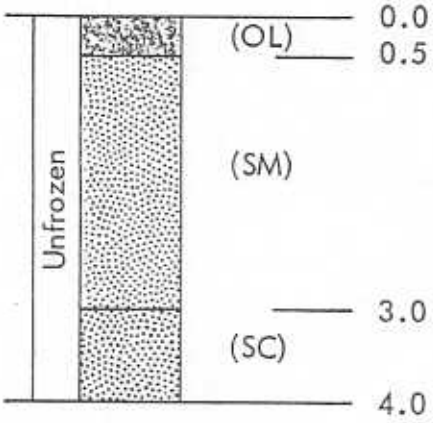
Topsoil; organic, black, roots

Gravel and Sand; some silt and clay lenses, wet

Gravel and Sand; some silt and clay, wet

Gravel and Sand; some silt and clay, frozen

FN 7X/TP 8



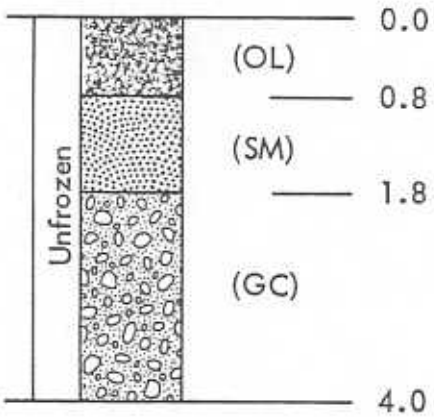
Topsoil; organic, black, roots

Silt; some sand, little gravel, damp, dense, light-medium brown, infrequently boulders

Silt; some clay and sand, little gravel

DETAILED TEST PIT LOG

FN 7X/TP 9

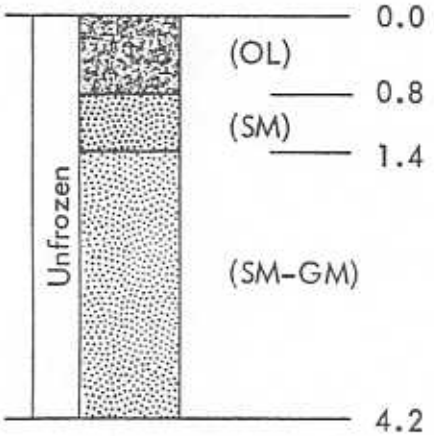


Topsoil; organic, black, roots

Silt; some coarse sand, with gravel lenses, wet

Gravel; some sand, trace of silt and clay, wet

FN 7X/TP 10



Topsoil; organic, black, roots

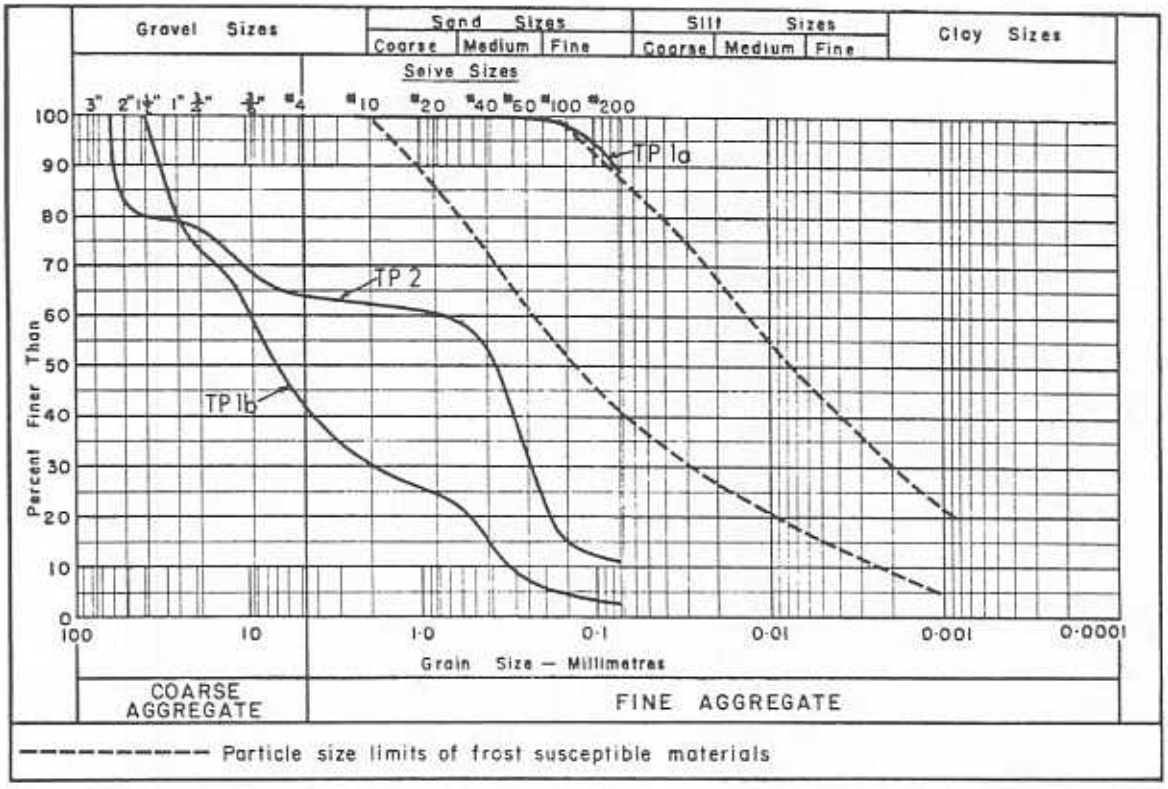
Sand; some silt, light brown, damp

Sand; some silt, thin gravel layers and lenses

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 7X/TP 1a	FN 7X/TP 1b	FN 7X/TP 2
Sample Depth (Feet):	1.0	2.5	
Moisture Content (%):	22.0	2.9	9.9
Ice Content (%):	-	-	
Organic Content (%):	-	-	

GRAIN SIZE DISTRIBUTION:

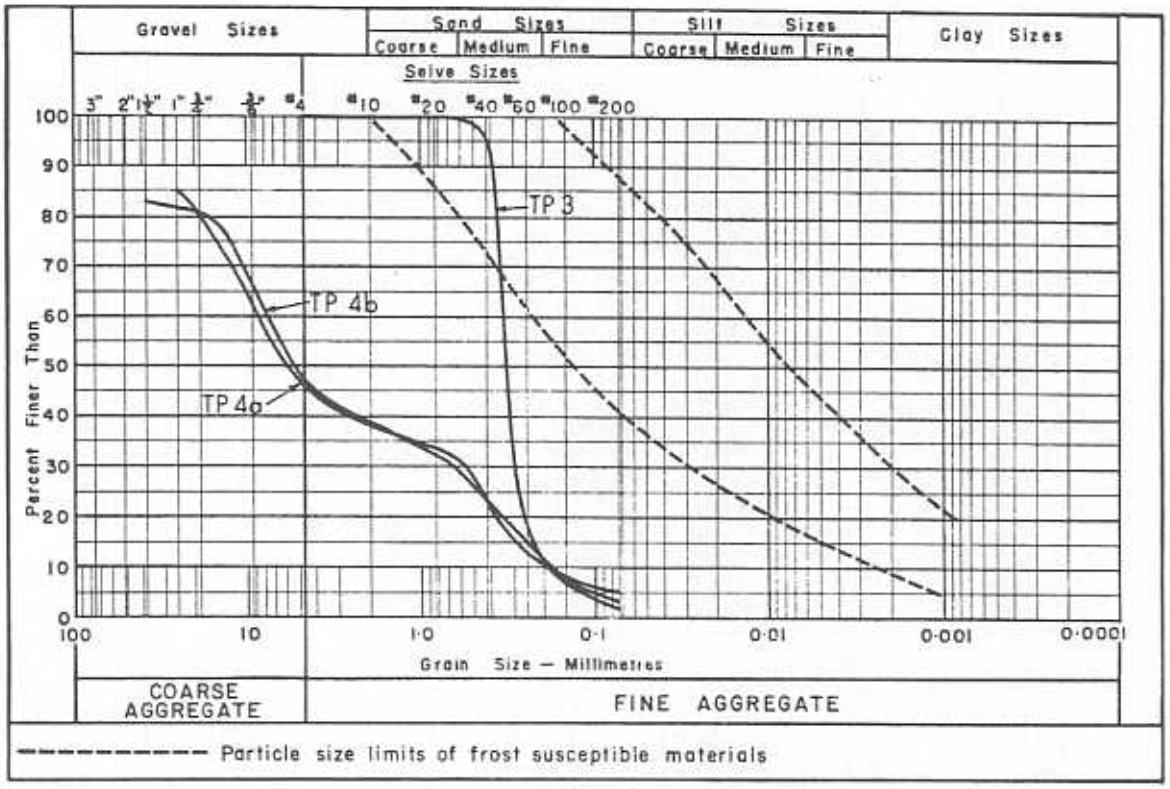


PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 7X/TP 3	FN 7X/TP 4a	FN 7X/TP 4b
Sample Depth (Feet):	2.0	3.0	4.5
Moisture Content (%):	1.2	7.8	-
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS: (From FN 7X/TP 4 a & b)

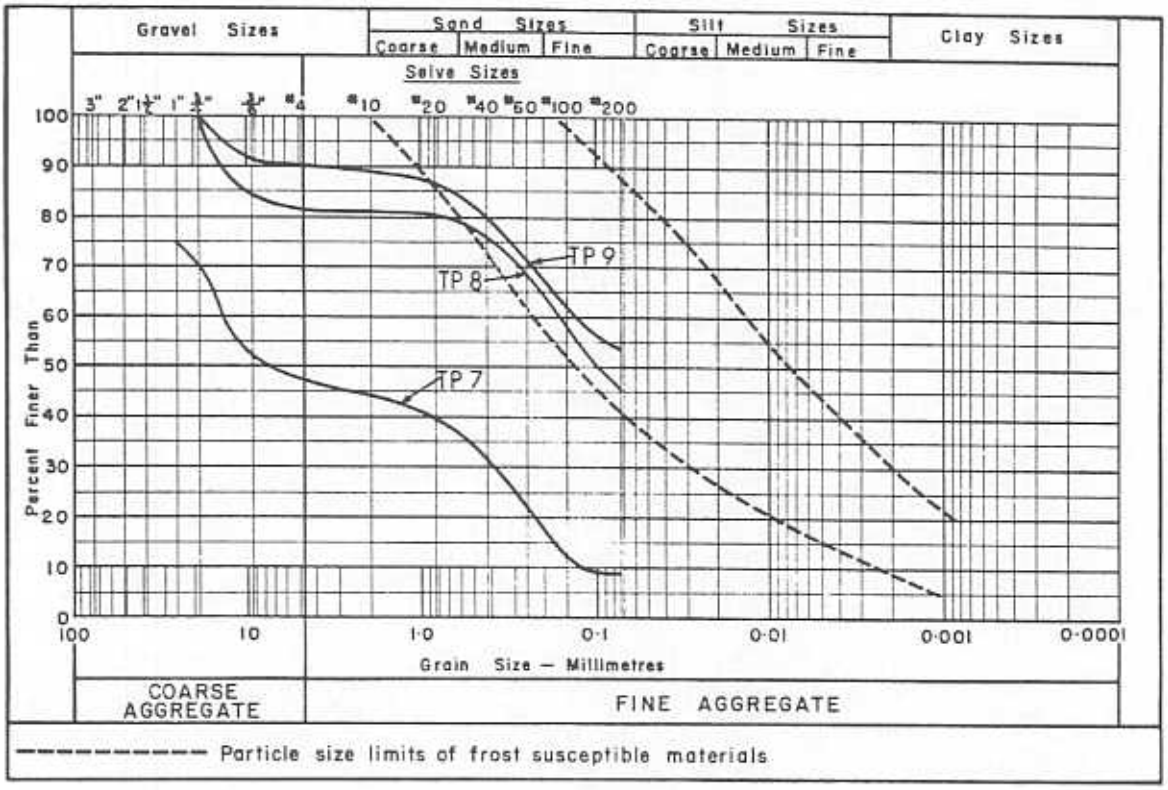
Cherts	39.2 %	Limestone & dolomite	15.2 %
Quartzites	20.1 %	Metamorphic material	2.2 %
Igneous material	20.0 %		

Deleterious siltstone, sandstone and shale	2.9 %
Deleterious ferruginous material	0.2 %

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 7X/ TP 7	FN 7X/TP 8	FN 7X/TP 9
Sample Depth (Feet):	3.5	2.5	1.5
Moisture Content (%):	-	7.1	15.2
Ice Content (%):	-		
Organic Content (%):	-		

GRAIN SIZE DISTRIBUTION:

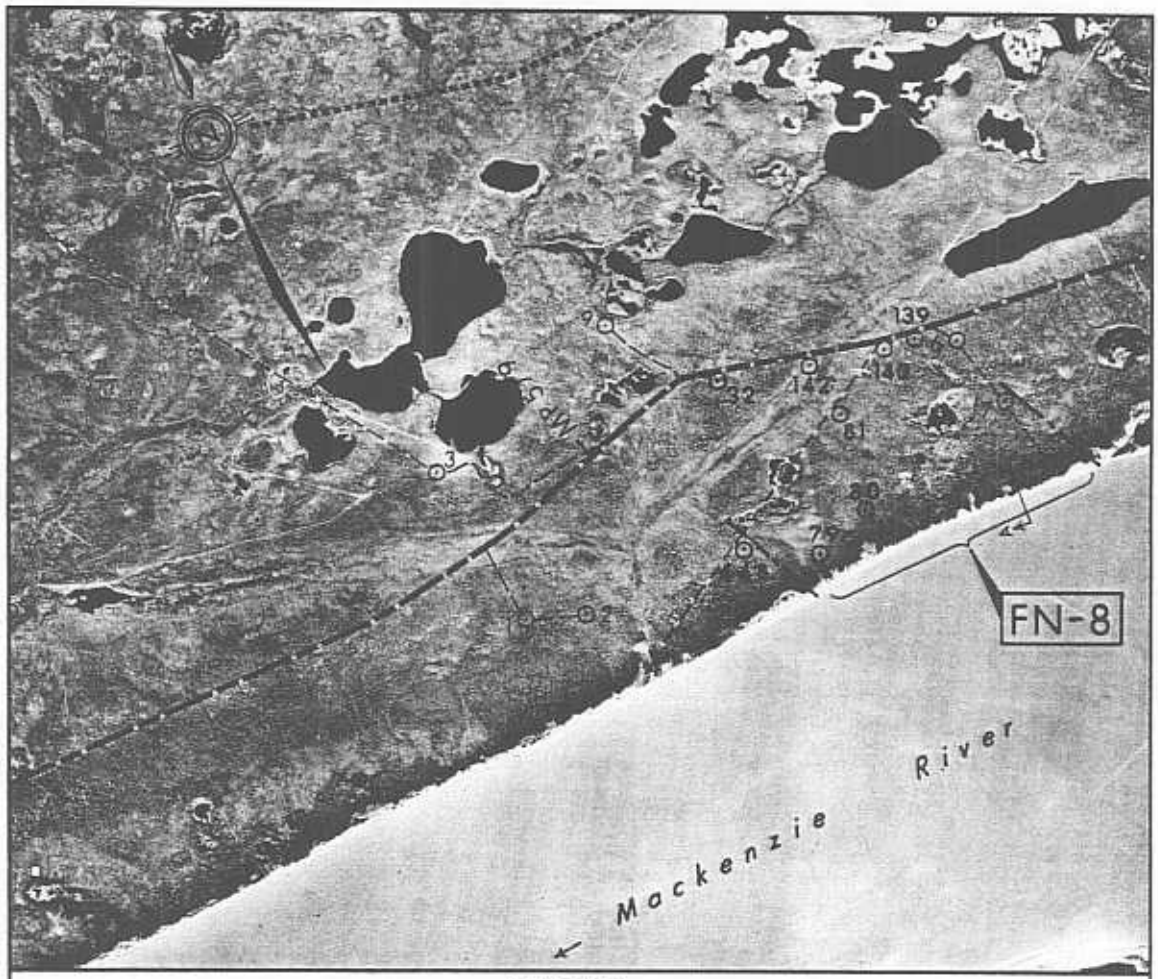


PETROGRAPHIC ANALYSIS:

SITE NO. FN 8

Located approximately 4 miles east of Fort Norman along the north bank of the Mackenzie River, Site FN 8 consists of Tertiary sands and gravels overlain by deep glaciolacustrine deposits.

Type of Material:	Sands and Gravels; medium to coarse grained, cemented.
Estimated Volume:	Not established
Assessment:	The excessive depth of overburden prohibits development of Site FN 8 as a potential source for granular materials.



LEGEND

All weather road	Required access
Existing trails and cutlines	Site limit
Proposed Gas Pipeline	Proposed Mackenzie Highway
⊙ DH Drill Hole	⊕ TP Test Pit

Airphoto No. A22934/162 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 8 is located approximately 4 miles east of Fort Norman and consists of glacio-lacustrine deposits overlying tertiary sands and gravels. The exposures examined during the initial field reconnaissance consisted of the steep northern bank of the Mackenzie River which rises 100 to 150 feet above the water level of the river. The gravel is exposed along the steep bank for approximately 1 mile; however, the width of the tertiary gravels could not be established at this time because of the extensive depth of the overburden.

The exposed tertiary deposit is approximately 50 to 60 feet thick and consists of stratified, cemented, medium to coarse sands and gravels with occasional cobbles and boulders. Since only the exposed cliff faces were examined, details relative to ground ice content and ground water in the tertiary gravels could not be evaluated.

The adjacent terrain away from the river bank is relatively flat, has numerous small lakes and supports moderately dense growths of spruce in excess of 30 feet in height.

The existing access to this site consists of the winter road which parallels the north bank of the Mackenzie River at a distance of approximately 1 mile in the vicinity of Site FN 8. The proposed route of the new Mackenzie Highway is coincident with the existing winter road in this area.

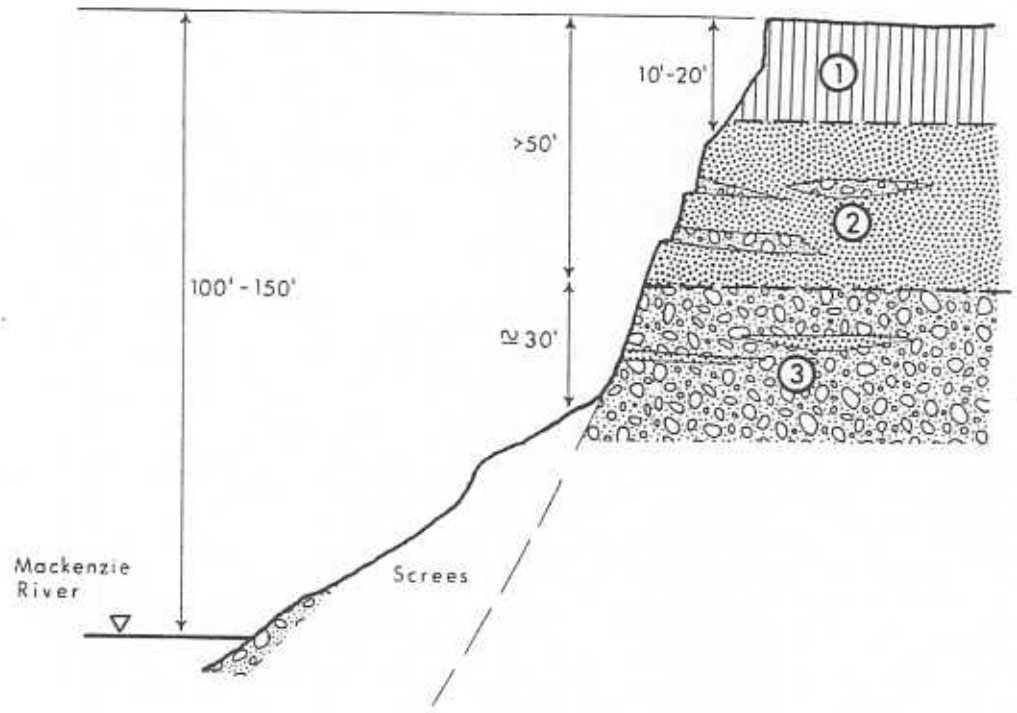
DEVELOPMENT

In view of the promising exposure of Tertiary sands and gravels noted in the steep north Mackenzie River bank during the preliminary field reconnaissance (ref. location: airphoto Site Description map, page 8-1), an extensive drilling program was conducted in February 1973 to evaluate the depth of overburden and to map the areal extent of the Tertiary deposit. The drill holes, located as noted on the airphoto, which were advanced to maximum depths in excess of 40 feet, did not penetrate to the top of the Tertiary gravel stratum. The overburden, consisting of silts with some sand and clay at various intervals of depth, exhibits moderately high ground ice content.

Therefore, on the basis of excessive overburden depths, Site FN 8 is not recommended for development as a potentially exploitable source of granular materials.

SECTION A-A'

NOT TO SCALE



Description of the Exposure

① Silts and silty sands

② Sand medium to coarse grained, cemented horizontally and cross stratified, greyish; occasional layers and lenses of cemented gravel

③ Gravel and sand, slightly cemented, grey. Pebbles predominantly to $1\frac{1}{2}$ inch. Infrequent cobbles and boulders.

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-1

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, dark brown					0
1.0								
3					Vx	M		3
6		ML	SILT: trace sand, greyish brown					6
9				UF				9
11.0								
12								12
15		CL	SILT: some clay, medium to high plastic, grey		Vx	M		15
18								18
21								21
21.0								
24		CH	CLAY: some silt, high plastic, dark grey					24
27								27
27.0			TOTAL DEPTH 27.0'					
30								30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

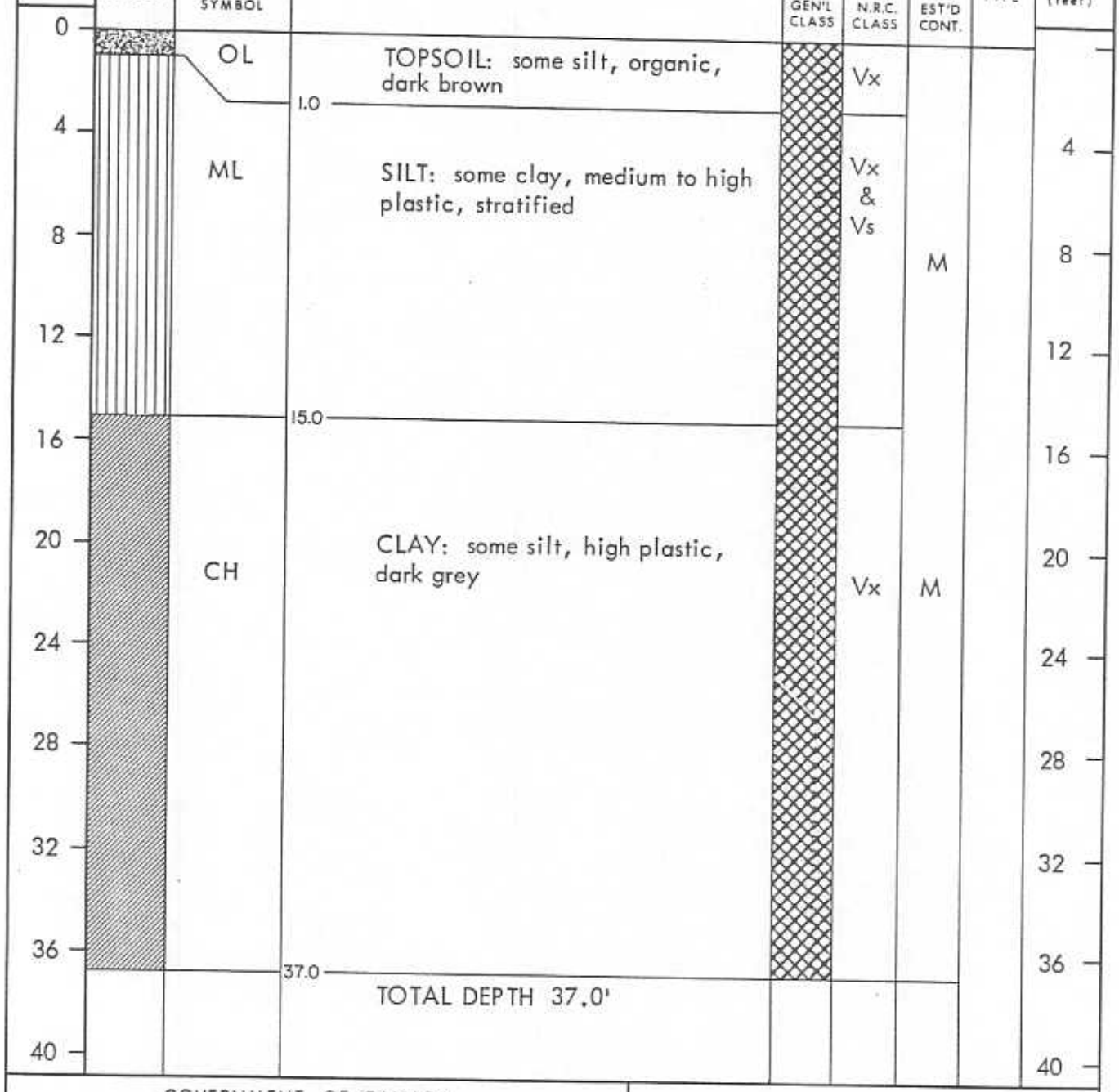
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-2

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

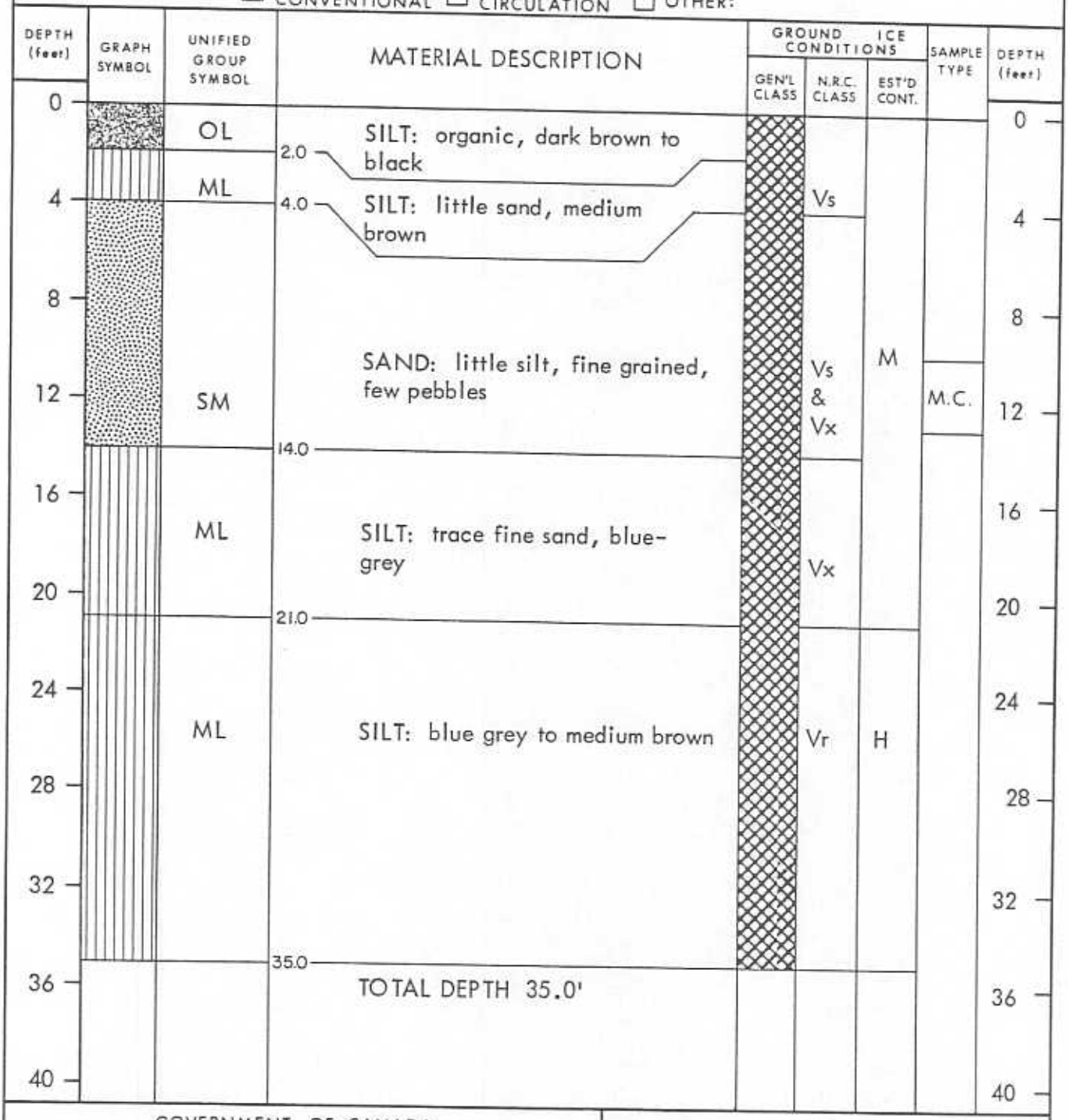
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH 3

DATE: FEB. 1, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-4

DATE: FEB. 1, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: fibrous, muskeg		Vx			0
1.0		SM	SAND: some silt, trace organics, dark brown					
3.0								
5								5
10							M C	10
15		SM-SP	SAND: little silt, very fine grained, dark brown		Vs	M		15
20								20
25								25
30							M C.	30
31.0								
35		SP-SW	SAND: trace silt, medium brown		Vr	H		35
40							M.C.	40
42.0			TOTAL DEPTH 42.0'					
45								45

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

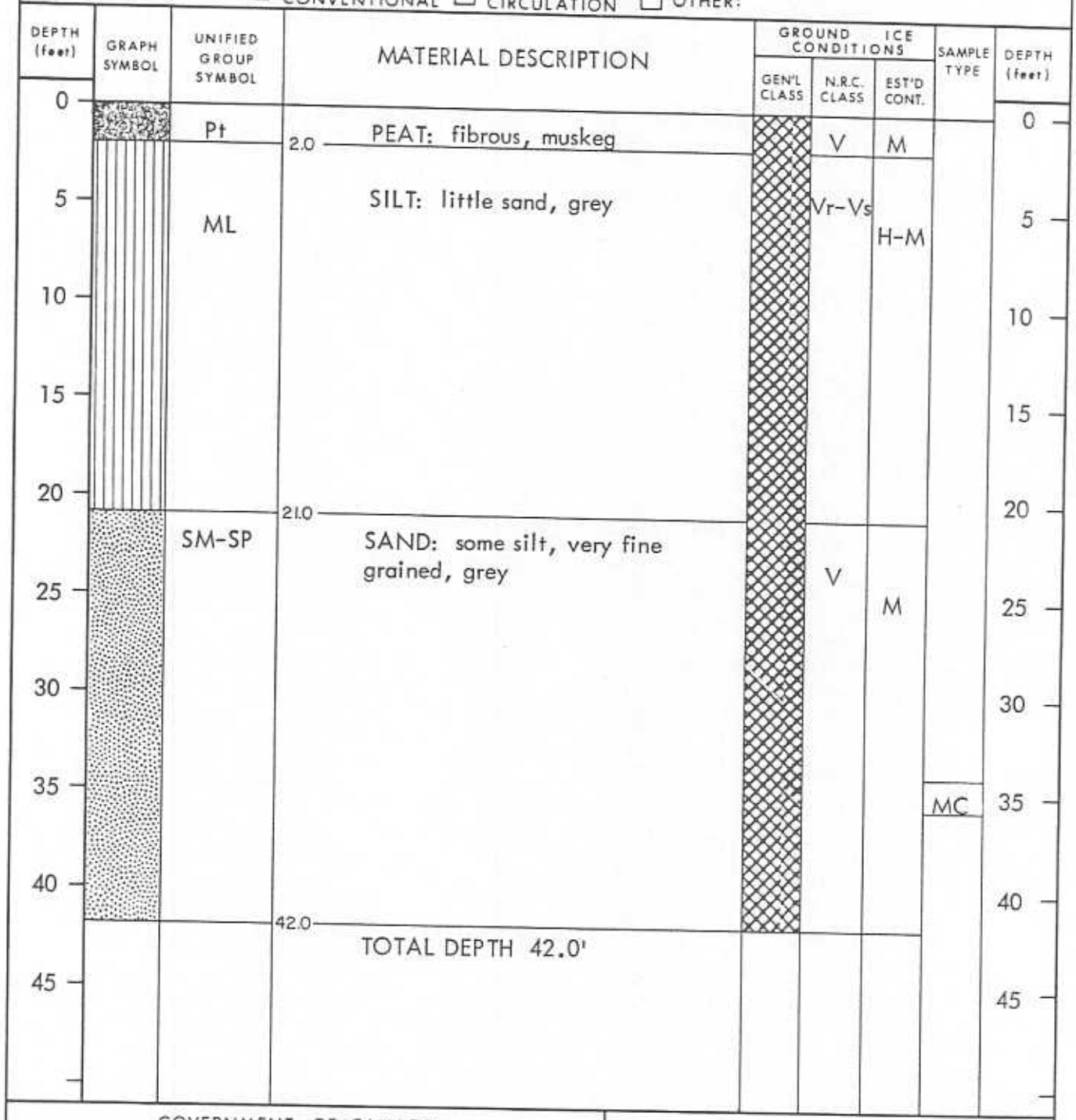
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-5

DATE: FEB. 1, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-6

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: fibrous, muskeg		V	M		0
1.0								
3		ML	SILT: little sand, medium brown		Vs	H		3
5.0								
6			- sand layer 5'-6', fine grained, medium brown					6
9								9
12		ML-CL	SILT: some clay, light grey		Vr-Vs			12
15								15
18								18
18.0		ML	SILT: little sand, light grey		Vs	M		
21								21
23.0								
24		ML-CL	SILT: some clay, medium grey		Vx			24
27								27
30								30
30.0			TOTAL DEPTH 30.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-7

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0								0
4		ML	SILT: trace sand, light brown			M		4
8			- becoming blue-grey in color at 7' - 9'					8
			9.0			H		
12			SILT: some clay, blue-grey		Vs			12
16		ML-CL						16
20								20
24								24
28								28
32			32.0					32
			TOTAL DEPTH 32.0'					
36								36

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-8

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		ML	SILT: light brown		V	L-M		0
4			4.0					4
8								8
12			SILT: some clay, medium brown					12
16		ML-CL			Vs	M		16
20			- occasional sand pockets, medium grained, grey					20
24								24
28								28
32			32.0 TOTAL DEPTH 32.0'					32
36								36

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. DH-9

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, dark brown		V			0
1.0								
4		SM-SP	SAND: little silt, medium brown			M		4
6.0								
		ML	SILT: trace sand, blue grey					
8			8.0					8
12								12
16			SILT: some clay, blue-grey, occasional sand pockets					16
20						H		20
24		ML-CL						24
28								28
32								32
36								36
39.0								
40			TOTAL DEPTH 39.0'					40

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. C 32

DATE: LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		PT	PEAT		Nbn			0
0.5								
2		SM	SAND: SILT - fine sand - very silty - low plastic - brown					2
2.0								
4								4
6			- clayey					6
7.0								
8		CI	CLAY: brown - grey medium plastic					8
10			- grey - high plastic - less silt - less sand					10
12								12
14								14
16								16
16.0			END OF HOLE 16.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. C 139

DATE: DEC. 15, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT		Vx			0
2			2.0					2
		SP	SAND:		Nf			
			- fine	UF				
4			- silty		Vx	L		4
			- non plastic					
			- brown					
			5.5					
6		CI	CLAY:					6
			- silty					
8			- medium plastic					8
					Vx	M		
10					Vx	M		10
			11.5					
12		CH	- high plastic		Vx	M		12
			- grey					
14					Vr-Vx	M		14
			14.5					
			END OF HOLE 14.5'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

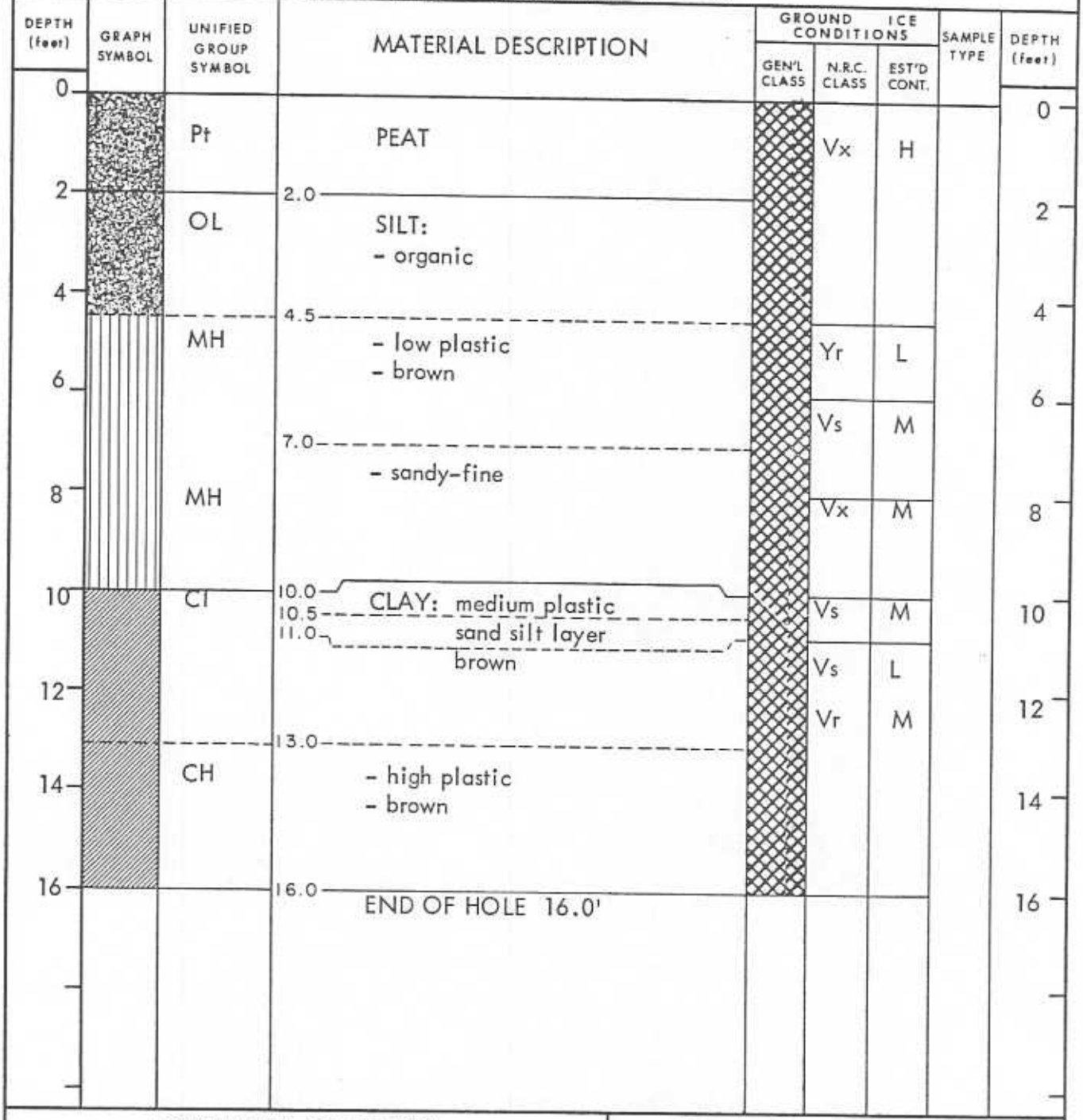
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. C 140

DATE: DEC. 14, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. C 142

DATE: DEC. 15, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0			SILT:		Nbn			0
2			- fine sandy - trace of clay - low plastic - brown					2
4					Vx	M		4
6			6.0					6
8		CI	CLAY: - silty - medium plastic - brown		Vx	M		8
10					Vx	M		10
12			12.0					12
14			- high plastic - grey		Vx	M		14
15			15.0					
16			END OF HOLE 15.0'					16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. B10 79

DATE: DEC. 10, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT		Nbn			0
0.5			CLAY: silty, medium plastic brown		Vx	M		
3								3
					Vx	M		
6			6.0					6
			less silty, medium to high plastic, grey brown		Vx	M		
9								9
					Vx	M		
12								12
			13.0					
			trace of silt medium to high plastic grey		Vx	M		
15								15
18			18.0					18
			no silt high plastic grey		Vs	M		
21								21
24			24.0 END OF HOLE 24.0'					24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. B10 80

DATE: DEC. 10, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT		Nbn			0
		OL	0.8 SILT: organic, brown		Vx	H		
3		MH	non organic, trace of find sand trace of clay, low plastic brown		Vx	M		3
6			more sandy		Vx	L		6
		CI	6.5 CLAY: silty, medium plastic, brown					
9								9
12		CH	less silt, medium to high plastic grey brown trace of silt		Vx	L		12
15		CI	silty, medium plastic		Nbn			15
18					Vx	M		18
21		CH	less silt medium to high plastic		Vx	M		21
24								24
27			26.0 END OF HOLE 26.0'					27

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. B10 81

DATE: DEC. 10, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT					0
			0.3					
		OH	SILT: organic		Nbn			
			2.0					
3		ML	- sandy, low plastic - brown		Vx	L		3
6			7.0					6
		CI	CLAY: - silty - medium plastic		Vx	L		
9								9
12								12
			13.0					
		CH	- less silt - medium high plastic - grey brown		Vx	L		
15								15
18					Vx	M		18
21								21
					Vx	M		
24								24
27								27
			28.0 END OF HOLE 28.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 8 HOLE NO. B10 448

DATE: MAR. 2, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0			SILT: - slightly clayey - non plastic - dark brown		Nbn			0
3		MH						3
6								6
9			9.0					9
12		CI	CLAY: - silty - medium to high plastic - dark grey brown			M		12
15								15
18								18
21								21
24								24
27		CI CH				M		27
30			30.0 END OF HOLE 30.0'					30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

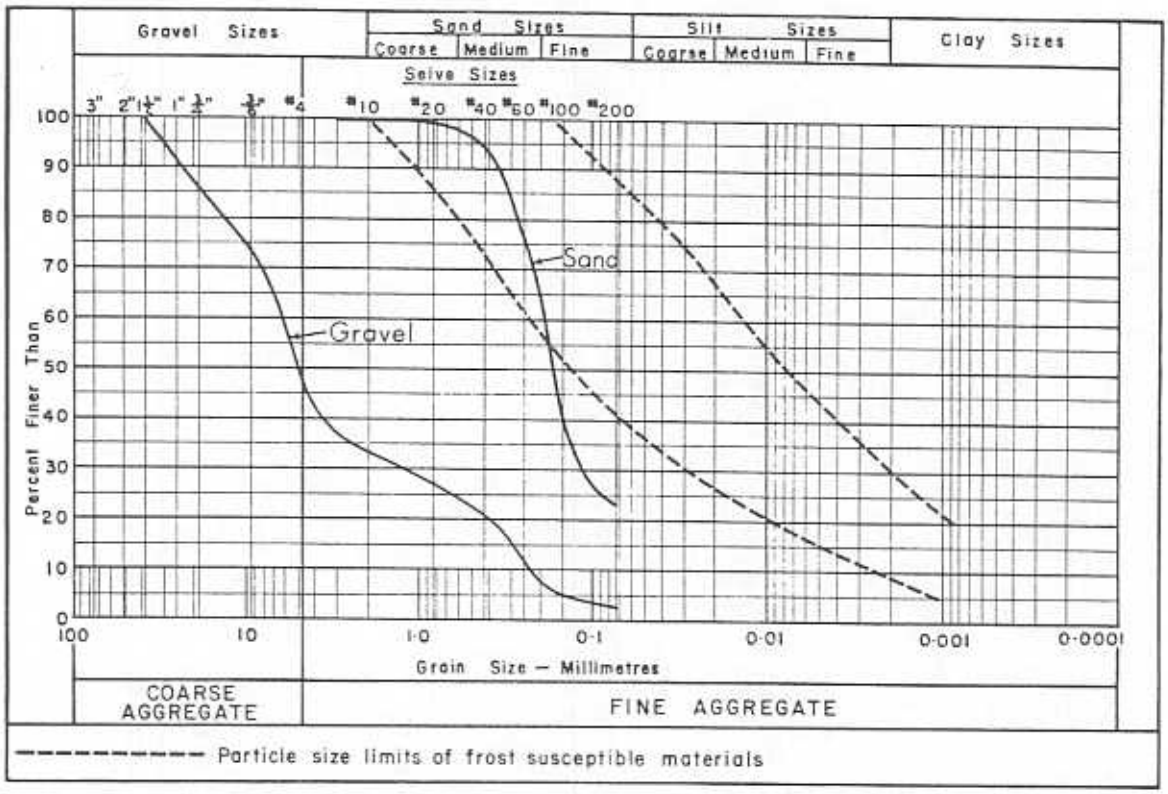
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 8 (Sand)	FN 8 (Gravel)
Sample Depth (Feet):	50	70
Moisture Content (%):	-	-
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Chert	49.4 %
Quartzites	49.3 %
Deleterious material	1.3 %

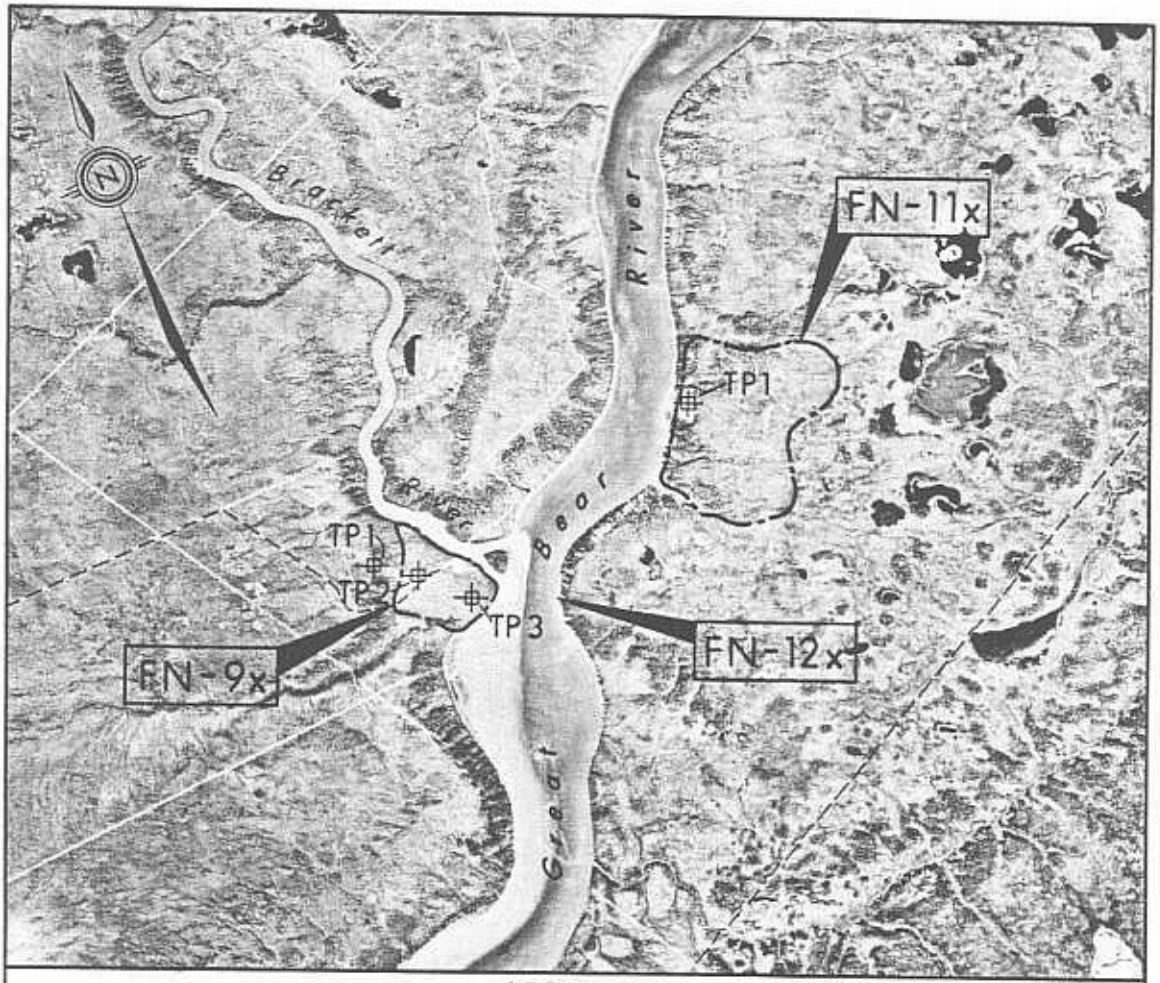
SUMMARY OF MOISTURE CONTENT DETERMINATIONS

Sample Location	Sample Depth (Ft.)	Moisture Content (%)
FN 8/ DH 3	10.0-13.0	20.5
FN 8/ DH 4	11.0-13.0	34.5
FN 8/ DH 4	30.0-32.0	26.8
FN 8/ DH 4	39.0-41.0	28.8
FN 8/ DH 5	29.0-31.0	30.1

SITE NO. FN 9X

Located approximately 6 miles north of Fort Norman at the confluence of the Brackett and Great Bear River, Site FN 9X consists of an alluvial floodplain.

Type of Material:	Silt; some sand, traces of clay
Estimated Volume:	Not applicable
Assessment:	This site does not contain any appreciable quantities of granular type material; therefore, the site should not be considered for development.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/79

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 9X is located approximately 6 miles north of Fort Norman at the confluence of the Brackett and Great Bear Rivers. The site consists of an alluvial floodplain adjacent to the west bank of the Great Bear River, and is approximately 1000 feet by 1000 feet in area.

The alluvial floodplain consists primarily of a sandy silt with traces of clay. Gravel layers and pockets can be expected only at greater depths below ground surface. Ground ice was encountered at a depth of about $2\frac{1}{2}$ feet below existing ground surface.

An organic topsoil stratum, 6 inches in depth, overlies the site area. This organic layer supports a moderately dense growth of spruce, with some birch and poplar.

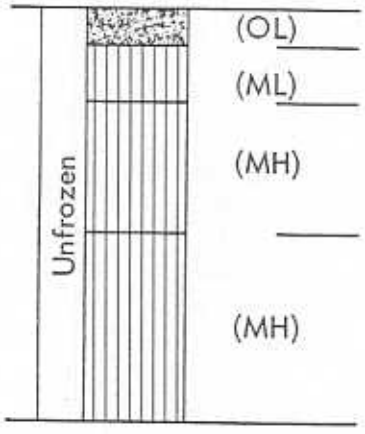
There are no known critical wildlife areas in the immediate vicinity of the site; however, the upstream area along the Brackett River is reported to contain spawning beds that are utilized by grayling.

DEVELOPMENT

Site FN 9X is not recommended for development because the in situ material encountered to depths investigated do not constitute a granular type material.

DETAILED TEST PIT LOG

FN 9X/TP 1



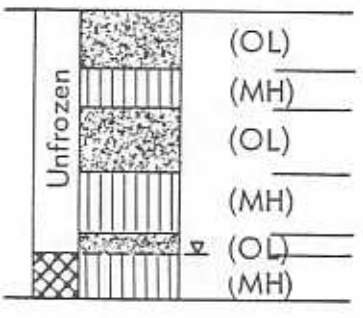
Topsoil; organic, black, roots

Silt; some sand and clay, brown

Silt; some sand and clay, brown wet

Silt; some sand and clay, medium grey

FN 9X/TP 2



Topsoil; organic, black, roots

Silt; some clay, little sand, light brown

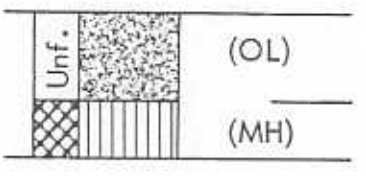
Organic soil, black

Silt; some clay, little sand, brown, wet

Silt; organic, wet

Silt; some clay, little sand, frozen

FN 9X/TP 3



Topsoil; organic, black, roots

Silt; some clay, little sand, brown, frozen

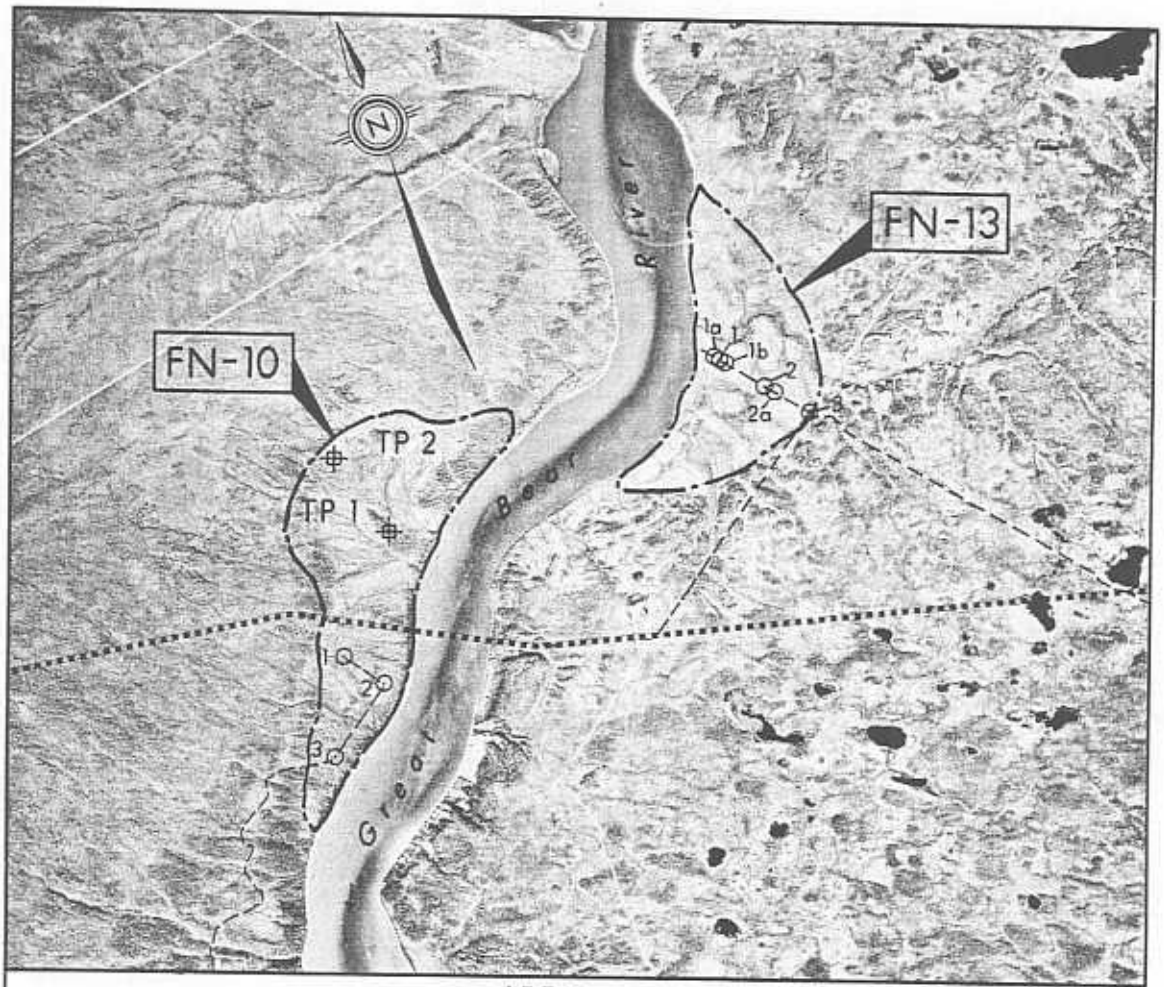
SITE NO. FN 10

Located approximately 4½ miles north of Fort Norman, Site FN 10 consists of an erosional river terrace on the west bank of the Great Bear River.

Type of Material: Sands and Silts; fine grained, small pockets of gravel.

Estimated Volume: 400,000 cubic yards.

Assessment: Very poor quality material suitable only for marginal general fill requirements. This site is not currently recommended for development because of the difficult access and poor quality of material.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/160

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 10 is located approximately $4\frac{1}{2}$ miles north of Fort Norman on a glaciofluvial plateau that slopes downward to the erosional river terrace on the west bank of the Great Bear River. The site area is 700 feet to 2000 feet wide and parallel to the river for a distance of one mile.

The erosional river terrace consists of fine sands and silts of fluvial origin, locally reworked by wind action. Periodic small pockets of gravel are evident in the fluvial deposits in the southwestern portion of the site. The mantle of organic topsoil is approximately 6 inches in depth and supports sparse growths of spruce and birch trees, 15 to 20 feet in height. The understory growth consists of moss, small bushes and clusters of Labrador Tea.

There are no known critical wildlife areas in the immediate vicinity of the site.

The adjacent terrain above the site area is relatively flat and consists of a glaciated plain. The general surficial drainage of the site area is southeasterly into the Great Bear River.

There is no existing road access to the site and the nearest seismic cutline is approximately 1 mile to the northwest.

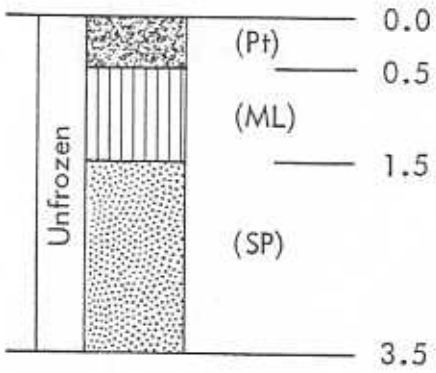
DEVELOPMENT

Site FN 10 is not currently recommended for development because of the poor quality of recoverable material and difficult access to the site. It is considered that the fine eolian sand can only be utilized for marginal general fill requirements. Random development of isolated gravel pockets may be considered, but considerable description to the existing terrain resulting in environmental damage may result.

If this source is considered for development at a future date then a detailed assessment of physical and biotic conditions inherent at Site FN 10 at that time should be undertaken and specific development guidelines for the site in accordance with current Land Use Regulations should be outlined.

DETAILED TEST PIT LOG

FN 10/TP 1

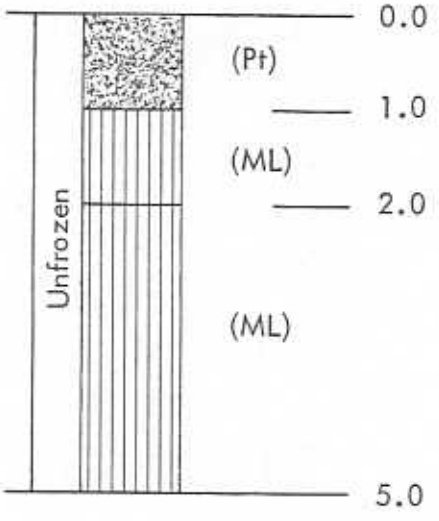


Topsoil; organic, black, some peat

Silt; powdery, some fine grained sand, brown, roots

Sand; little silt, poorly graded, brown.

FN 10/TP 2



Topsoil; organic, some peat

Silt; powdery, little fine grained sand, roots, brown

Silt; some sand, light brown, thin layers of very fine grained sand.

DETAILED DRILL HOLE LOG

SITE NO. FN 10 HOLE NO. DH-1

DATE: JAN. 30, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0		Pt	PEAT: fibrous, muskeg		V	M		0
1.0								
2		ML	SILT: low plastic, medium brown		Vs	H		2
4								4
6								6
6.0								
8		ML	SILT: some clay, low to medium plastic, medium to dark brown		Vs Vx	M		8
10								10
11.0			TOTAL DEPTH 11.0'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 10 HOLE NO. DH-2

DATE: LOGGED BY: ☐ PEMCAN ☐

DRILLING METHOD: ☐ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, medium to dark brown		Vs			0
2			2.0					2
		ML	SILT: little sand, occasional pebbles to $\frac{1}{2}$", medium brown					
4			4.0			M		4
6		ML-CL	SILT: some clay, medium plastic, grey		V			6
8								8
10								10
			11.0					
12			TOTAL DEPTH 11.0'					12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 10 HOLE NO. DH-3

DATE: JAN. 30, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, dark brown		V	M		0
1.5								
2		ML	SILT: little sand, low plastic, medium brown to grey		Vs	H		2
4								4
6								6
7.0			some sand, light brown from 7.0'					
8								8
10		GM-GP	GRAVEL: some sand, little silt, medium brown		V	M		10
12								12
13.0								
14		ML	SILT: little sand, blue grey		Vs			14
16			TOTAL DEPTH 16.0'					16
16.0								
18								18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

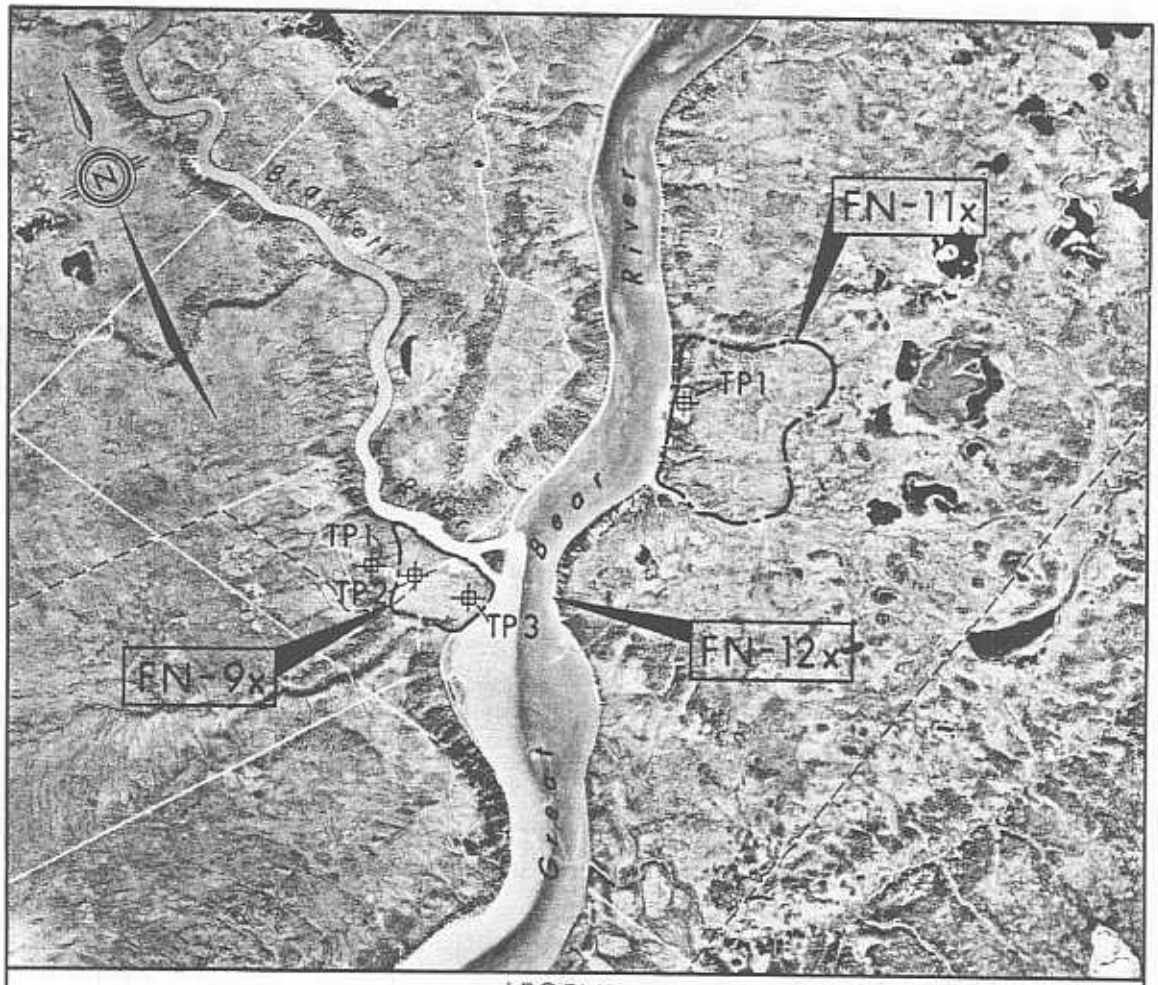
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SITE NO. FN 11X

Located approximately 7 miles north of Fort Norman, Site FN 11X consists of the steep east bank of the Great Bear River and is comprised of proglacial lake sediments.

Type of Material:	Sand; fine grained, some silt
Estimated Volume:	Not established
Assessment:	Very poor quality material, suitable only for marginal, low priority general fill. This site is not recommended for development.



LEGEND

All weather road	Required access
Existing trails and cutlines	Site limit
Proposed Gas Pipeline	Proposed Mackenzie Highway
⊙ DH Drill Hole	⊕ TP Test Pit

Airphoto No. A22934/79

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 11X is located on the east bank of the Great Bear River approximately 7 miles north of Fort Norman. The area investigated consists, primarily, of the steep river bank and encompasses an area 3000 feet in length by 2000 feet in width, although similar type material appears to extend extensively over adjacent terrain. The site area is situated in an ancient proglacial lake basin and material generally consists of fine lacustrine silty sands. The surficial layer of the terrain appears to have been reworked by wind action.

The adjacent terrain is relatively flat and generally wet muskeg with numerous small lakes. The crown of the Great Bear River bank is incised with numerous erosional gullies and the river bank slopes are characterized by minor slumps and one major slide. The presence of these minor land movements, generally, indicates active ground water seepage in the proglacial lake sand deposits.

The site area is covered with a shallow layer of topsoil, approximately 6 inches in depth, and supports growths of spruce trees ranging in height to 30 feet.

There are no known critical wildlife areas in the immediate vicinity of the site.

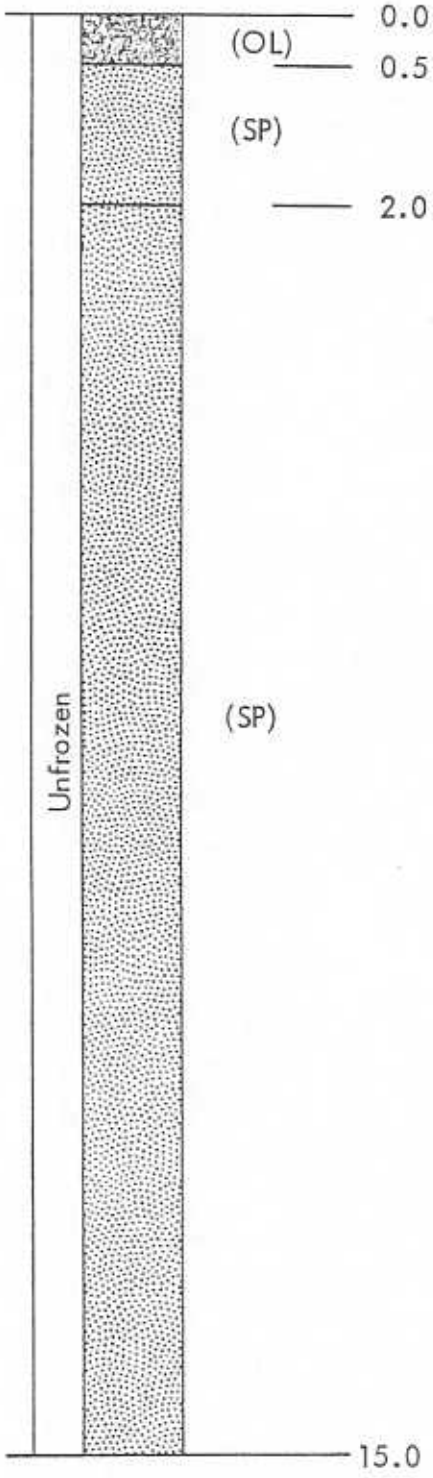
There is no existing land access to this site area. The nearest seismic cutline is located approximately 1 mile south of Site FN 11X.

DEVELOPMENT

Site FN 11X is not recommended for development because the fine sand available at this site is only suitable for very marginal general fill requirements. Moreover, sources of similar quality exist at the northeastern outskirt of the townsite. In addition, the lack of existing access roads and the surrounding muskeg terrain has isolated this site from the Fort Norman community.

DETAILED TEST PIT LOG

FN 11X/TP 1



0.0 – 0.5 (OL): Topsoil; some sand, organic, brown

0.5 – 2.0 (SP): Sand; little silt, fine to medium grained, light brown, roots

2.0 – 15.0 (SP): Sand; trace of silt, fine to medium grained, light grey, horizontally layered.

Unfrozen

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 11X/TP 1

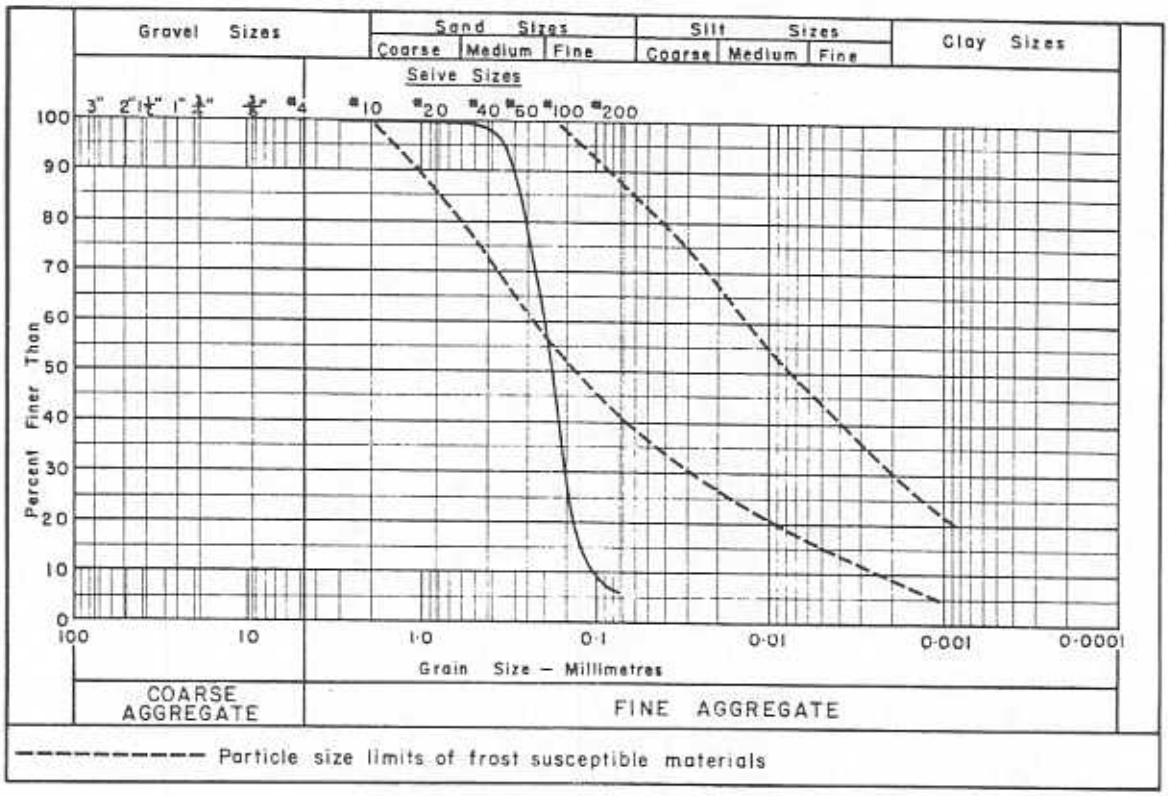
Sample Depth (Feet): 10.0

Moisture Content (%): 1.3

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

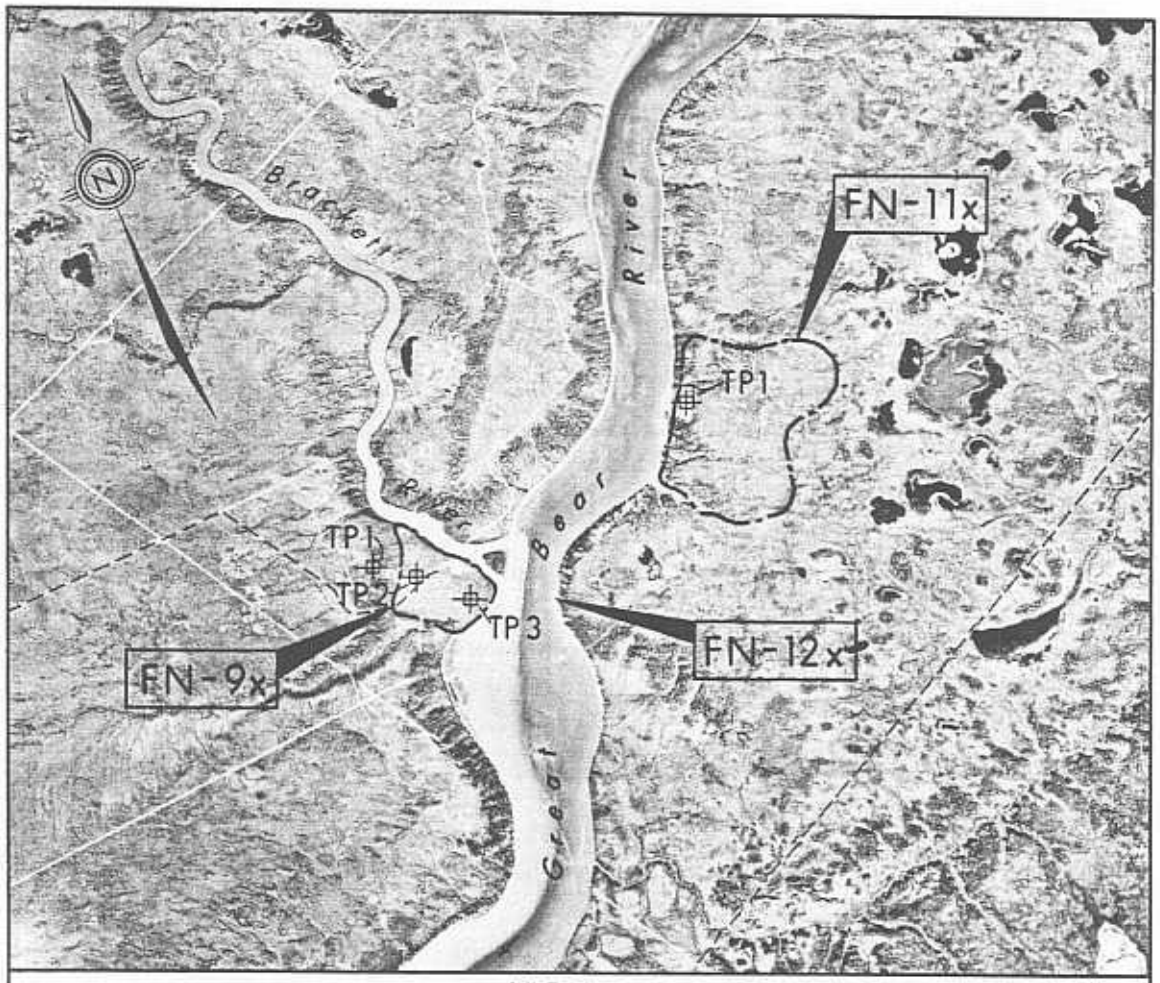
SITE NO. FN 12X

Located approximately 6 miles north of Fort Norman on the east bank of Great Bear River opposite the confluence of Brackett River, Site FN 12X consists of Tertiary sands and gravels overlain by layers of glaciolacustrine sand and silt.

Type of Material: Sands and Gravels; medium to coarse grained.

Estimated Volume: Not established.

Assessment: This site is not recommended for development because of excessive depths of overburden and very difficult access.



Airphoto No. A22934/79 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 12X is located on the east bank of the Great Bear River opposite the mouth of the Brackett River, approximately 6 miles north of Fort Norman. The geological setting of this site consists of glaciolacustrine deposits overlying possible major deposits of Tertiary sands and gravels. The exposure examined during the initial field reconnaissance consisted of the steep eastern bank of the Great Bear River. Visual observations indicate that a layer of silty sand overburden in excess of 40 feet overlies a 50 to 60 foot thick stratum of stratified Tertiary sands and gravels.

It is considered that this exposure of Tertiary materials may be the northern extension of similar type granular material encountered at Site FN 8, east of Fort Norman.

The adjacent terrain on top of the high river bank is relatively flat and supports relatively dense growths of spruce and birch trees. The presence of birch and the absence of small ponds in the immediate vicinity of the site may indicate a well drained terrain.

There are no known critical wildlife areas in the immediate vicinity of the site.

The exposure examined at Site FN 12X is very remotely situated. The nearest access consists of a seismic cutline located approximately 1 mile south of the riverbank exposure.

DEVELOPMENT

Site FN 12X is not recommended for development because of the excessive depths of overburden overlying the Tertiary sands and gravels and the very difficult access to the site area. On the basis of drill hole information from Site FN 8, it is considered that the silty sand overburden depth maybe in excess of 40 feet.

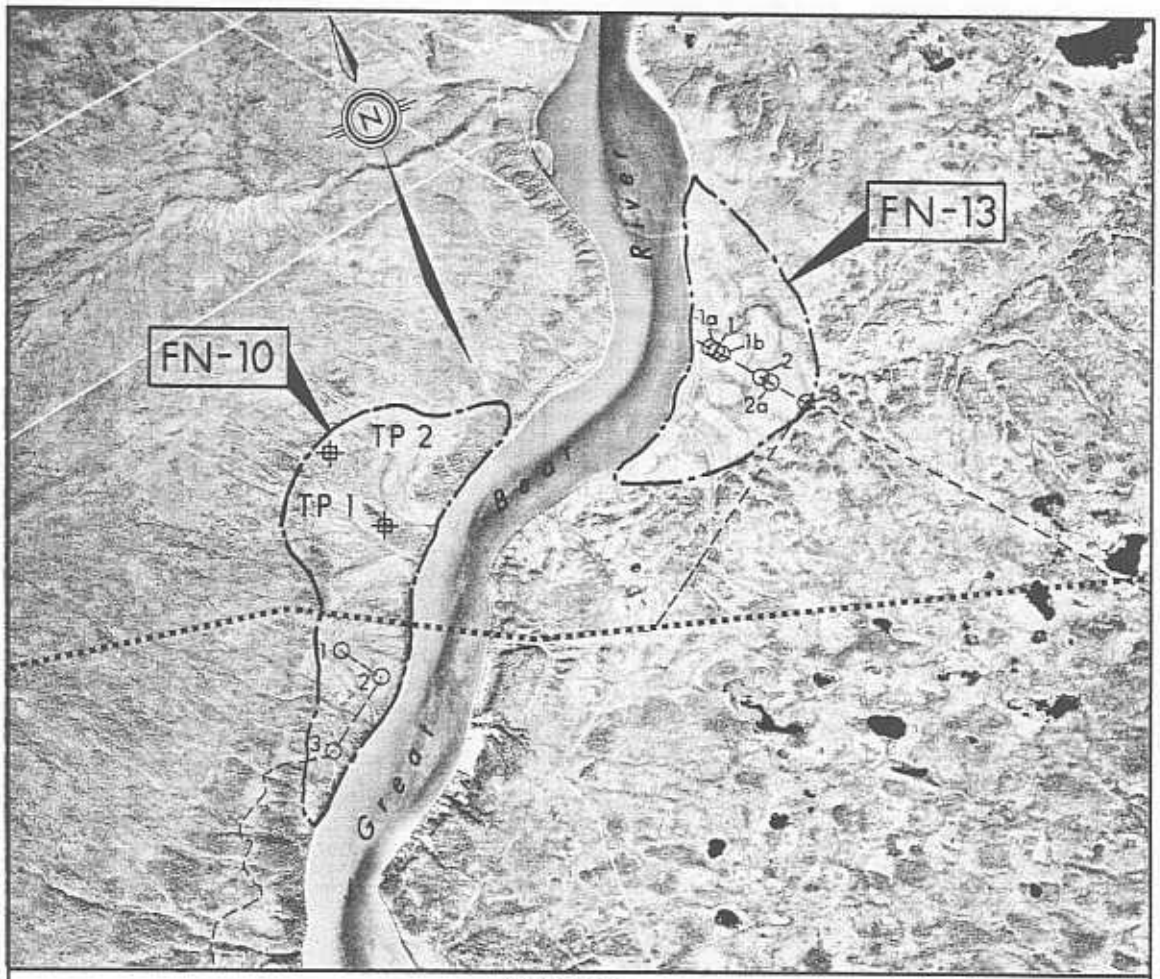
SITE NO. FN 13

Located approximately 5 miles northeast of Fort Norman on the southeast bank of Great Bear River, Site FN 13 consists of a crescent shaped river terrace at the mouth of a major erosional gully.

Type of Material: Sand; very silty with pockets of gravel.

Estimated Volume: 1,000,000 cubic yards.

Assessment: This site is not currently recommended for development because of the low quality of granular materials and the difficult access to the site.



LEGEND

----- All weather road	..... Required access
----- Existing trails and cutlines	·—·—· Site limit
..... Proposed Gas Pipeline	·— — — Proposed Mackenzie Highway
⊙ DH Drill Hole	⊕ TP Test Pit

Airphoto No. A22934/160 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 13 is located approximately 5 miles northeast of Fort Norman on the southeast bank of the Great Bear River. The site consists of a crescent shaped river terrace at the mouth of a major erosional gully. The top of the terrace is approximately 30 feet above the river level. Site FN 13 encompasses an area 5000 feet in length by 1000 to 2000 feet in width.

The material within the terrace consists primarily of silty sand with pockets or layers of gravels at depths. The general configuration of the eastern river bank is indicative that some granular material may be buried beneath the relatively thick surficial layer of alluvial silts and sands.

The general drainage of the site area is in a westerly direction into the Great Bear River. Relatively sparse growths of dwarfed spruce and occasional birch trees were noted on Site FN 13.

There are no known critical wildlife areas in the immediate vicinity of the site. However, the site is opposite and slightly downstream from the mouth of the Brackett River which is reported to contain spawning beds that are utilized by grayling.

An existing seismic cutline from Fort Norman, traversing a distance of 7 miles, provides access to the southern periphery of the site area. The access, however, traverses poorly drained terrain with frequent thermokarst features. Any construction activity and especially the removal of the vegetation cover will disturb the thermal conditions of the subgrade resulting in localized erosional processes. The proposed routes of the gas pipeline and the Mackenzie Highway pass immediately south of Site FN 13.

DEVELOPMENT

The data obtained from the winter drilling program denoted the following sub-surface conditions at Site FN 13.

- The deposition of granular materials occur in relatively isolated and scattered pockets and consist of poorly graded, medium grained gravels.

- These gravel pockets are overlain with considerable depth of overburden, generally, in excess of 10 feet. The overburden consists of very fine grained, poorly graded sands which may be suitable for very marginal general fill requirements. The silt content of the fine sands increase with an increase in distance from the east bank of Great Bear River. The fine grained sands with a varying silt content are considered to be frost susceptible material.

- The overburden soil and gravel pockets exhibit moderate ground ice content and were frozen to depths drilled during the winter field program.

Site FN 13 is not recommended for development for the following reasons:

- The site is generally quite remotely situated relative to Fort Norman and any development of this site will necessitate the upgrading of existing seismic cutlines for access. This, in turn, may adversely affect stability conditions of the thermally sensitive terrain.

- The alluvial overburden is relatively thick in excess of 10 feet, and may negate the economical exploitation of this site for granular materials. The fine grained sand overburden may be utilized for very marginal general fill requirements.

- The recoverable granular material consists of poorly graded gravels which are suitable for general pit run fill requirements. These pockets of gravel are quite isolated and scattered and may result in considerable terrain disturbance during foraging and exploiting operations.

However, in view of the proposed gas pipeline and new Mackenzie Highway routes, this site may be considered for providing granular materials for the construction of embankment fill of such utilities. If the site is developed, then an assessment of development procedures coupled with environmentally acceptable restoration guidelines should be established in conjunction with land use regulations that are in effect at that time.

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-1

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: little silt, organic, fibrous, dark brown		Vs	M		0
1.0								
2		SM-SP	SAND: little silt, trace clay, fine grained, poorly graded, grey		Vx	M		2
4								4
6							M.C. G.S. H.	6
8								8
10			boulders at 10.5'					10
10.5			TOTAL DEPTH 10.5'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-1a

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: little silt, organic, fibrous, dark brown		Vs			0
1			1.0					1
2		SM-SP	SAND: little silt, fine grained, poorly graded, grey		Vx	M		2
3								3
4								4
5								5
6								6
7			7.0					7
			TOTAL DEPTH 7.0'					
8			Note: Refusal on boulders at 7.0'; relocated to DH-1b					8
9								9
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-1b

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: little silt, organic, fibrous, dark brown					0
1.0								
1		SM-SP	SAND: little silt, fine grained, poorly graded, grey		Vx	M		1
2								2
3								3
4								4
5								5
6								6
7.0								
7			TOTAL DEPTH 7.0'					7
8			Note: Refusal on boulders at 7.0'; relocated to DH 1					8
9								9
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-2

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: little silt, fibrous, dark brown		Vx			0
1.0								
2								2
4		SM-SP	SAND: little silt, fine grained, poorly graded, grey					4
6					Vx Vs			6
8								8
10						M		10
11.0								
12		SM-GM	some gravel, little silt					12
13.0								
14		GM-GP	GRAVEL: some sand, trace silt, pebbles from 1" to 1½" (limestone & quartzites), subangular or sub-rounded, poorly graded, occasional cobbles, brown		Vx		M.C. G.S. P.	14
16								16
18								18
18.0			TOTAL DEPTH 18.0'					
20								20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-2a

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	TOPSOIL: trace silt, organic, fibrous, dark grey		Vs			0
1.0								
2		SM-SP	SAND: little silt, fine grained, poorly graded, grey		Vx	M		2
4								4
6								6
8								8
10								10
12								12
14								14
16								16
18								18
19.0			TOTAL DEPTH 19.0'					
20								20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

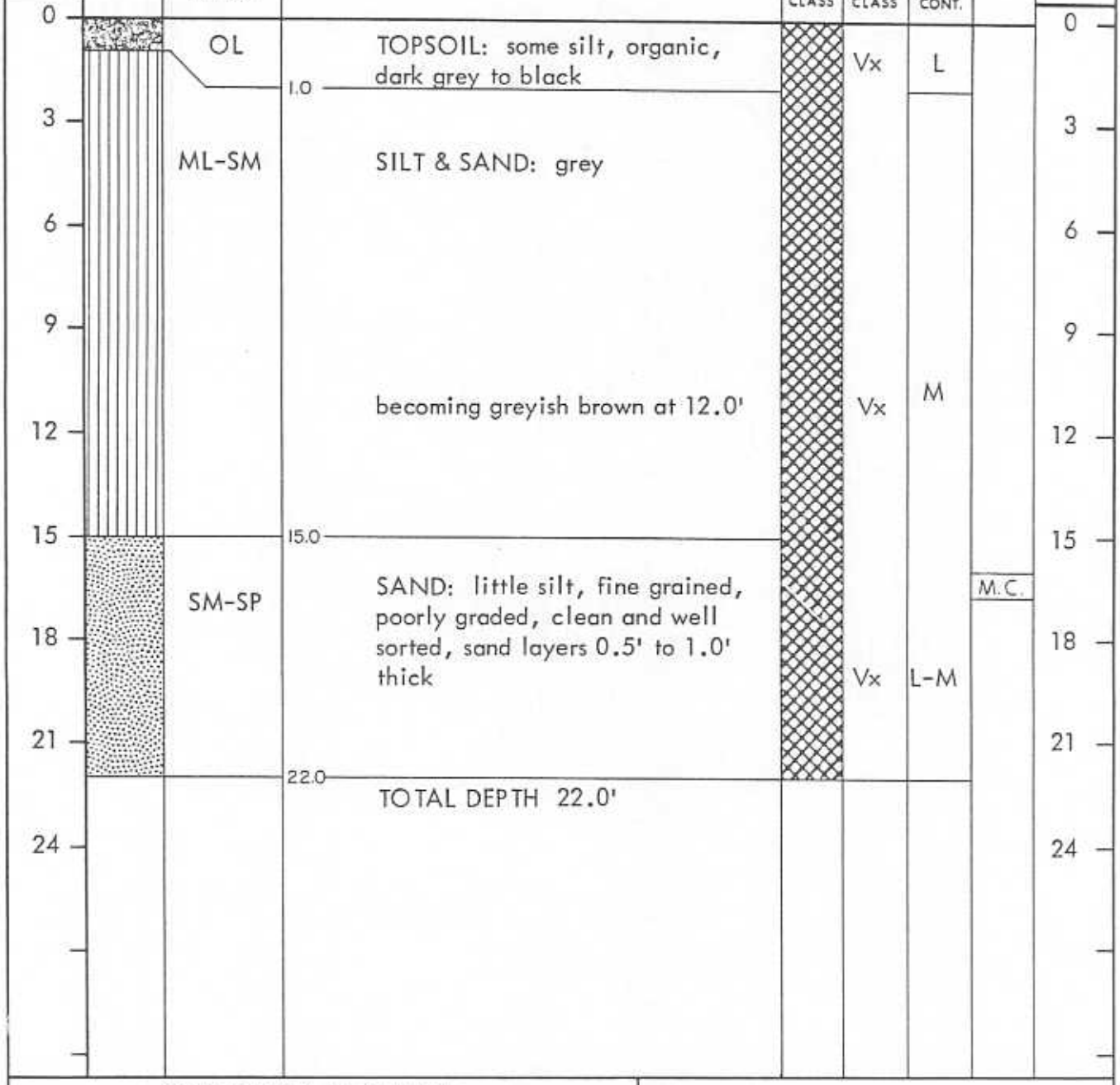
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 13 HOLE NO. DH-3

DATE: FEB. 2, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

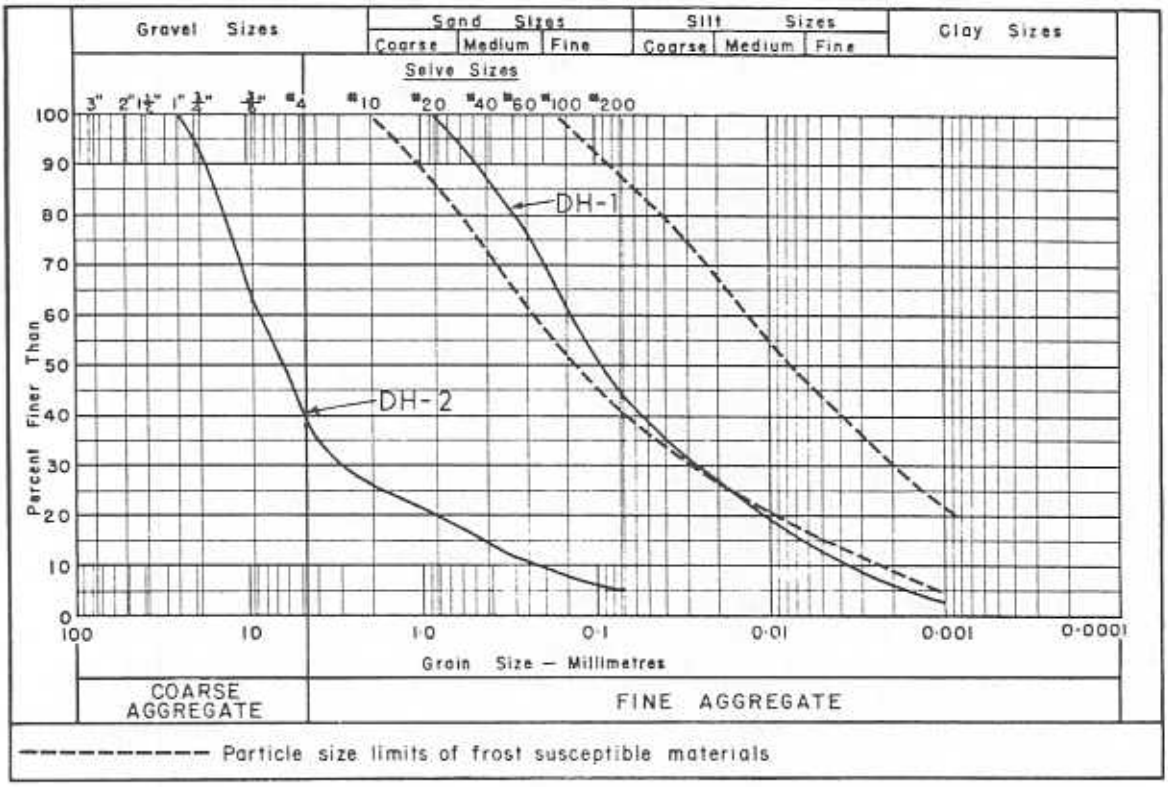
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 13/ DH 1	FN 13/ DH 2
Sample Depth (Feet):	6.0	13.0
Moisture Content (%):	31.8	4.6
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS: (FN 13/ DH 2 at 13.0')

Quartzite	47.4%
Igneous	20.7%
Chert	19.9%
Limestone & dolomite (sound)	6.8%
Deleterious shale, ironstone, porous sandstone	5.3%

SUMMARY OF MOISTURE CONTENT DETERMINATIONS

Sample Location	Sample Depth (Ft.)	Moisture Content (%)
FN 13/ DH 1	7.0	22.5
FN 13/ DH 2	14.0	6.1
FN 13/ DH 3	17.0	24.8

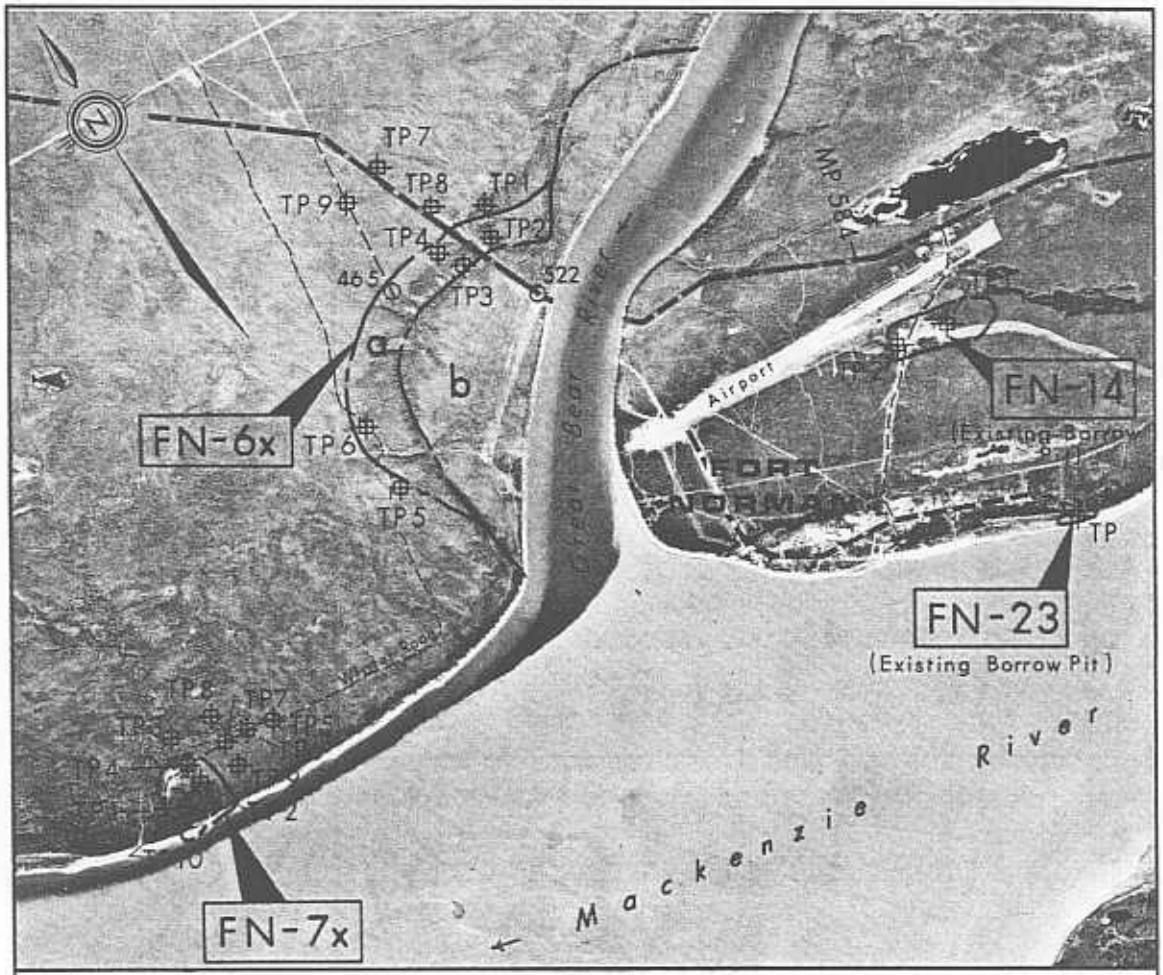
SITE NO. FN 14

Located approximately $\frac{1}{2}$ mile northeast of the Fort Norman townsite immediately adjacent to the southern edge of the airstrip, Site FN 14 consists of an existing borrow pit.

Type of Material: Sand; fine grained, some silt.

Estimated Volume: 300,000 cubic yards

Assessment: The quality of material is poor and only suitable for miscellaneous backfill or marginal general fill requirements. The material removed from this site should be restricted to immediate local needs.



LEGEND

——— All weather road	····· Required access
——— Existing trails and cutlines	·—·—· Site limit
····· Proposed Gas Pipeline	·— — —· Proposed Mackenzie Highway
⊙ DH Drill Hole	⊕ TP Test Pit

Airphoto No. A22889/146 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 14 is located approximately $\frac{1}{2}$ mile northeast of the Fort Norman townsite immediately adjacent to the south side of the Fort Norman airstrip. The site consists of an existing borrow pit, occasionally harvested to supply the domestic requirements of the Fort Norman community. The site is located on a flat, slightly undulating glacial lake basin. The surficial layer consisting of lake bed sediments has been reworked by wind and wave action, resulting in horizontal stratification of material in this stratum.

The granular material at Site FN 14 consists of fine grained sands with a trace of silt. The material is only suitable for low quality general fill requirements.

The organic topsoil and surficial silt layer is relatively shallow, averaging about $\frac{1}{2}$ foot in depth. The area adjacent to the borrow pit supports spruce growth with scattered birch.

There are no known critical wildlife areas in the immediate vicinity of the site. The proximity of the site to both the community of Fort Norman and the airstrip negates any severe implications on wildlife.

An existing all weather road provides good access to the site area from the townsite of Fort Norman.

DEVELOPMENT

Site FN 14, containing the existing borrow pit, can be operated in its current condition to supply the immediate local requirements for marginal material for periodic backfill and general fill. This site is not recommended as a potential source for any major requirements for granular materials for the community area.

The following development guidelines should be considered during the extraction of material from this site:

- The areal extent of the borrow pit should be compatible with current and future regional town planning schemes.
- Recontouring of the borrow pit area should be maintained during the periodic exploitation of materials from the pit to minimize detrimental erosional effects and instability of exposed pit slopes.
- Standard, light excavating equipment such as overhead loaders, dozers or backhoes can be utilized to remove the in situ material.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following:

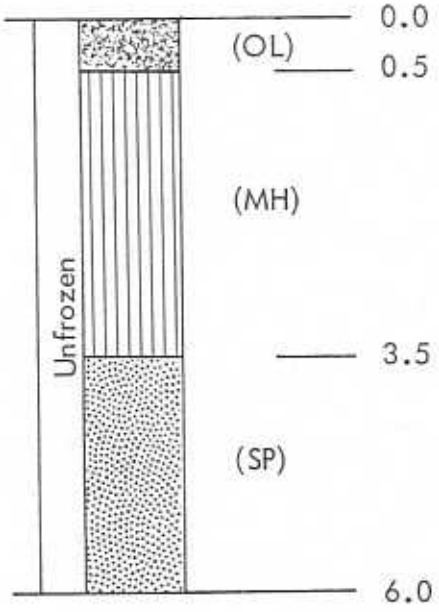
- Final recontouring or backfilling of the pit area.

- Replacement and spreading of imported topsoil or recovered topsoil from pre-production stockpiles on the recontoured borrow pit areas.

- Revegetation of the restored borrow pit area.

DETAILED TEST PIT LOG

FN 14/TP 1

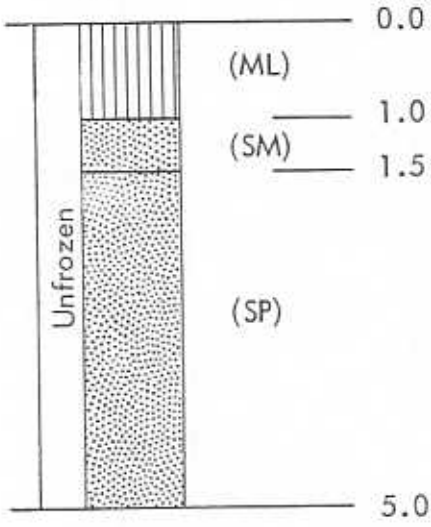


Topsoil; some silt, organic

Silt; some sand, horizontally stratified, infrequent cobbles (erractics)

Sand; trace silt, fine to medium grained, horizontally layered, grey

FN 14/TP 2



Silt; some sand, little organic, grey

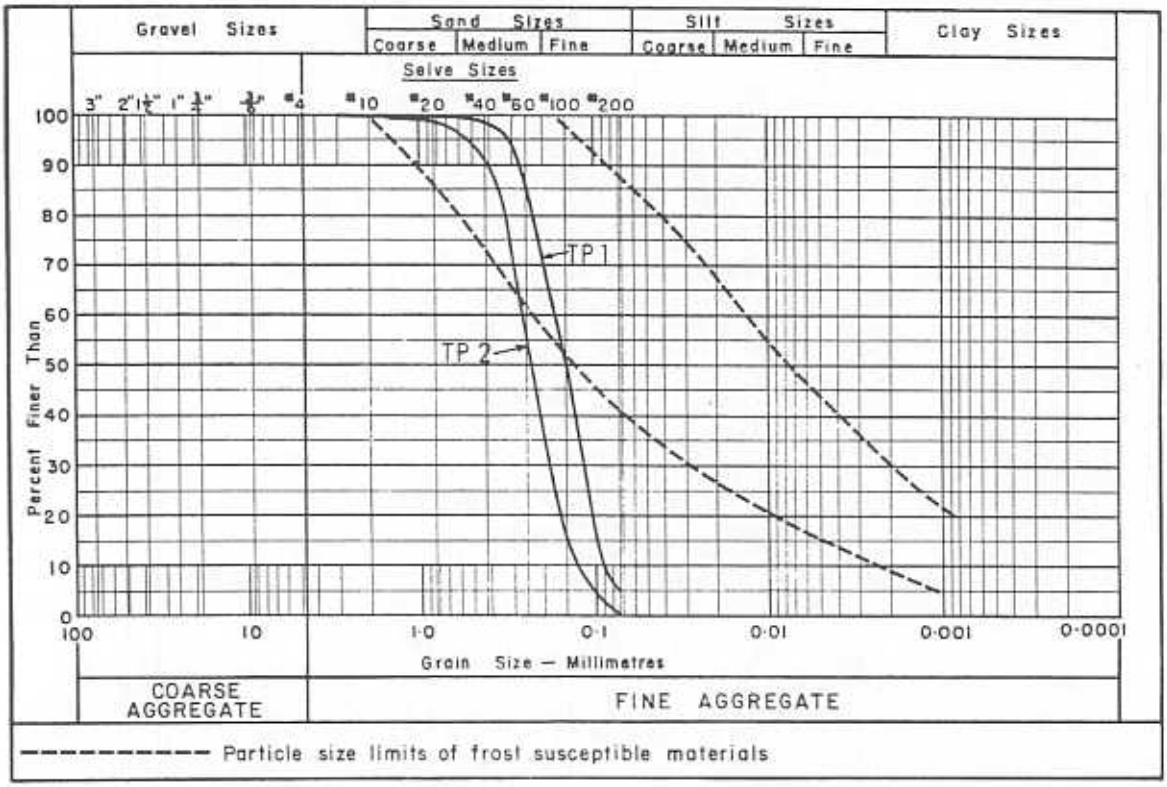
Sand; some silt, fine grained, layered

Sand; fine to medium grained, poorly graded, horizontally layered, grey

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 14/TP 1	FN 14/TP 2
Sample Depth (Feet):	5.0	3.0 - 5.0
Moisture Content (%):	5.1	3.5
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

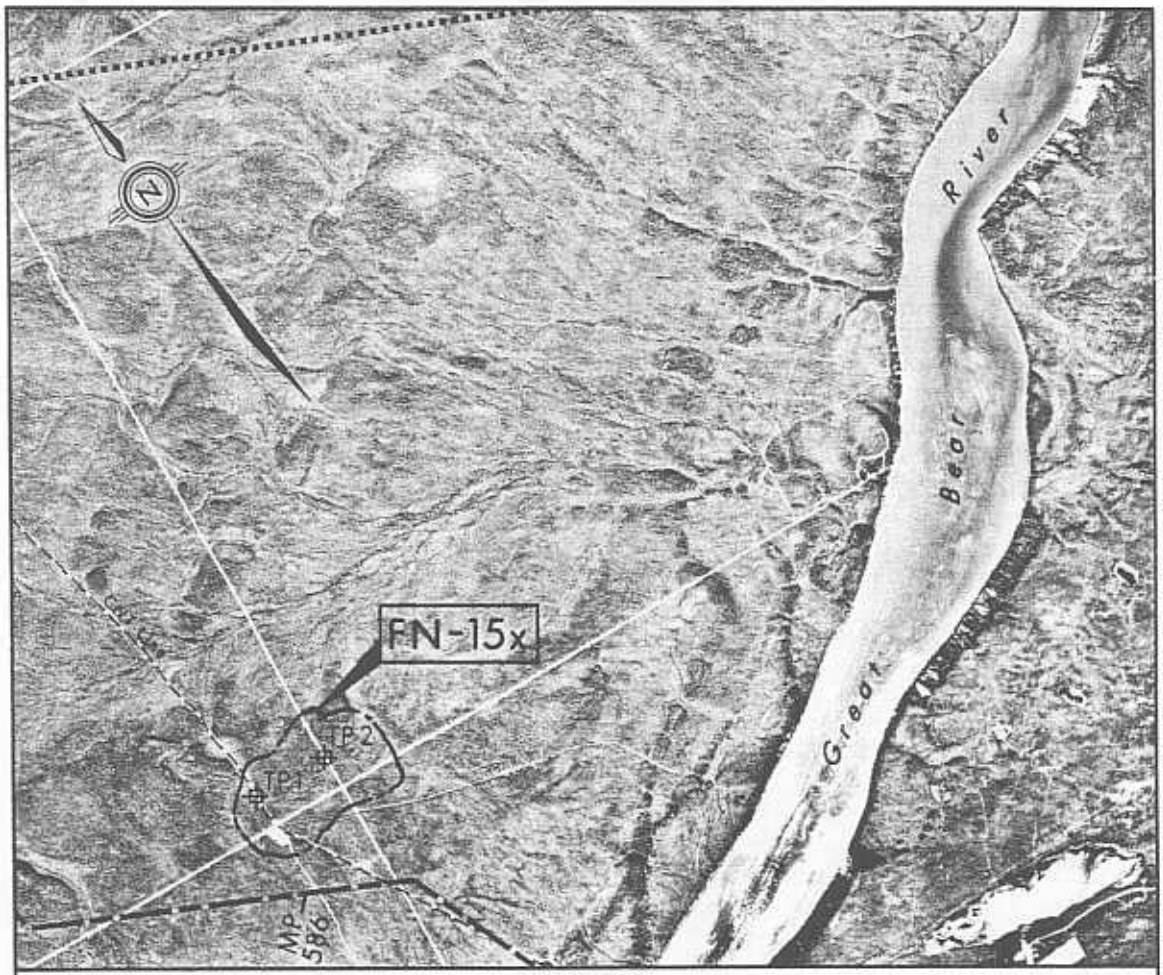
SITE NO. FN 15X

Located approximately $2\frac{1}{4}$ miles northwest of Fort Norman, Site FN 15X consists of a group of partially eroded hummocks.

Type of Material: Silt; some sand, glacial till at depth.

Estimated Volume: Not established.

Assessment: This site does not contain any appreciable amounts of granular material; therefore, the site is not recommended for development.



LEGEND

- ——— All weather road
- ------ Existing trails and cutlines
- ..... Proposed Gas Pipeline
- ⊙ DH Drill Hole
- ..... Required access
- ·—·—· Site limit
- ·— — —· Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/159 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 15X is located approximately 2¼ miles northwest of Fort Norman on the higher elevated flat terrain west of Great Bear River. The site consists of a group of partially eroded hummocks possibly constituting the erosional remnants of an island in a former glacial lake. The site encompasses an area 3000 feet by 1500 feet.

The hummocks are comprised of morainal till which is a heterogeneous mixture of till, sand and clay with scattered pebbles and cobbles topped with relatively wet sandy silt. These silts are of a glaciolacustrine origin and their depth is indicated to be in excess of 5 feet. A shallow layer of topsoil, 5 to 9 inches in depth, supporting growths of spruce with occasional birch, covers the site area

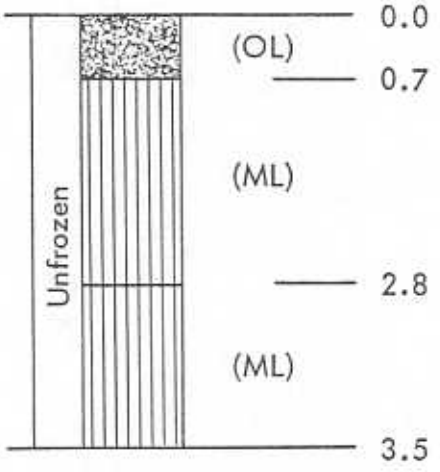
The site is located immediately adjacent to the existing winter road.

DEVELOPMENT

Site FN 15X consisting of sandy clay and morainal till is not recommended for development.

DETAILED TEST PIT LOG

FN 15X/TP 1

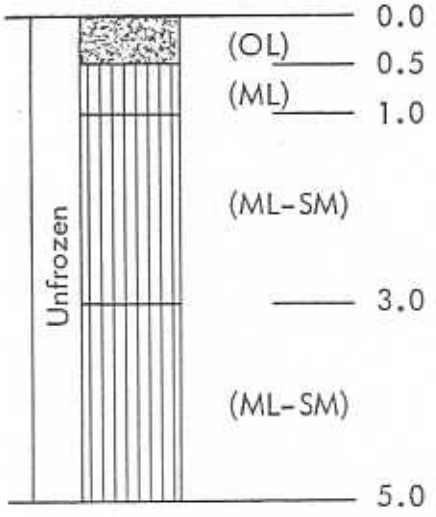


Topsoil; organic, black, roots

Silt; some clay and sand, brown

Silt; some clay and sand, low plastic, damp, grey

FN 15X/TP 2



Topsoil; organic, black, roots

Silt; some clay, trace of sand, brown

Silt; some sand, trace of clay, brown, damp

Silt; some sand, trace of clay, grey, damp

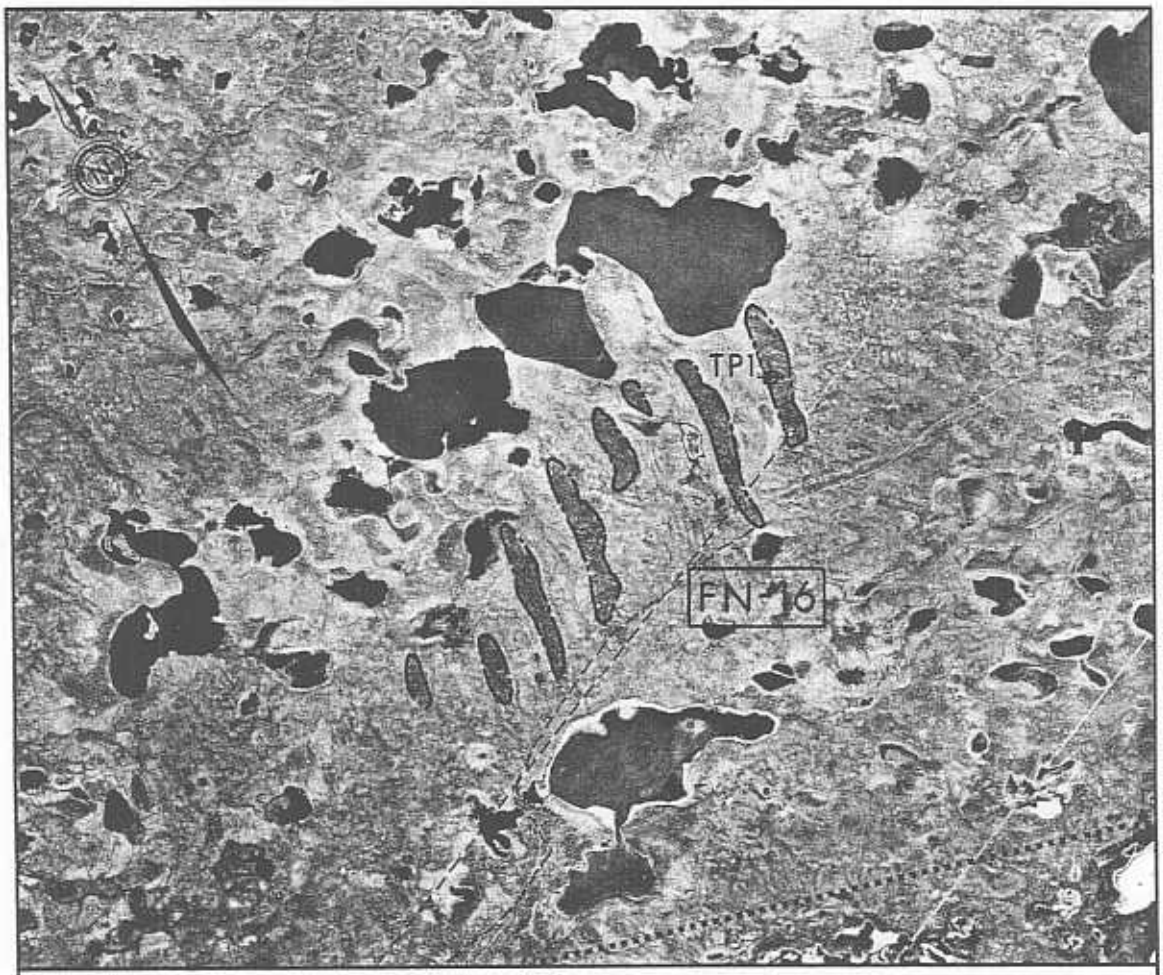
SITE NO. FN 16

Located approximately 8 miles northeast of Fort Norman, Site FN 16 consists of a group of eolian sand dunes.

Type of Material: Sand; fine grained, trace of silt.

Estimated Volume: 1,000,000 cubic yards.

Assessment: Poor quality material suitable only for general fill. Site FN 16 is not recommended for development at this time.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/77

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 16 is located approximately 8 miles northeast of Fort Norman and consists of a group of longitudinal sand dunes. The sand dunes range in length from a few hundred feet to approximately 3000 feet and are generally consistent in width, averaging 200 to 300 feet at the base. In height, they rise 10 to 40 feet above the adjacent flat terrain. The height of the dunes generally increase in a northeasterly direction.

The dunes, unfrozen to depths investigated, contain very fine, eolian sand with a trace of silt.

The dune slopes are covered with a shallow layer of organic topsoil which supports birch growth. The adjacent terrain is relatively flat and consists of a wet muskeg terrain supporting sparse growths of spruce and tamarack. Numerous lakes inundate the adjacent muskeg terrain and the sand dunes represent the only well drained terrain features in the vicinity of Site FN 16.

There are no known critical wildlife areas in the immediate vicinity of the site.

An existing seismic cutline, which traverses thermally sensitive terrain, is located along the southern edge of the group of sand dunes.

DEVELOPMENT

Site FN 16 is not recommended for development at this time as a source of granular materials for Fort Norman because material of similar quality is available in relatively unlimited quantities at sites closer to the community and with better access.

However, if development of this site is anticipated at a future date to supply the requirements in the construction of local utilities, the following development guidelines should be considered:

- Vertical excavation opposed to horizontal excavation should be considered to minimize the erosion of the exposed borrow area by wind and rain action.

- The shallow organic topsoil should be carefully stripped and stockpiled along the lower slopes of the dunes for future utilization in the restoration of the borrow pit areas.

- Vegetation buffer zones should be maintained between work areas to minimize erosion and instability of the dune areas.

- The clearing of existing tree and understory growth on the dune slopes should be carried out in accordance with applicable Land Use guidelines.

- The material should be adequately extracted with the use of standard excavation equipment such as dozers, overhead loaders and backhoes.

- Transportation of the material by truck haul will inevitably entail a winter operation because of the wet muskeg terrain.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site FN 16 is exploited as a source of granular material at a future date:

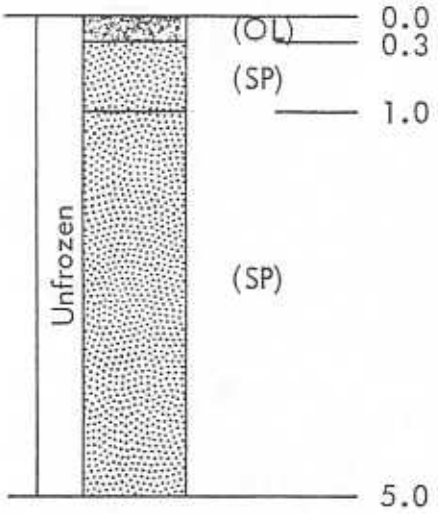
- Recontouring of borrow pit area to maintain good drainage to the adjacent terrain.

- Replacement and spreading of organic topsoil from pre-production stockpiles on to the recontoured pit areas.

- Revegetation of the restored borrow pit areas should be considered, especially in areas where exposed and abandoned pits may be susceptible to rapid gullying by water or blow outs by wind.

DETAILED TEST PIT LOG

FN 16/TP 1



Topsoil; organic, dark brown

Sand; trace of silt, fine grained, brown, roots

Sand; trace of silt, fine grained, brown.

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 16/TP 1

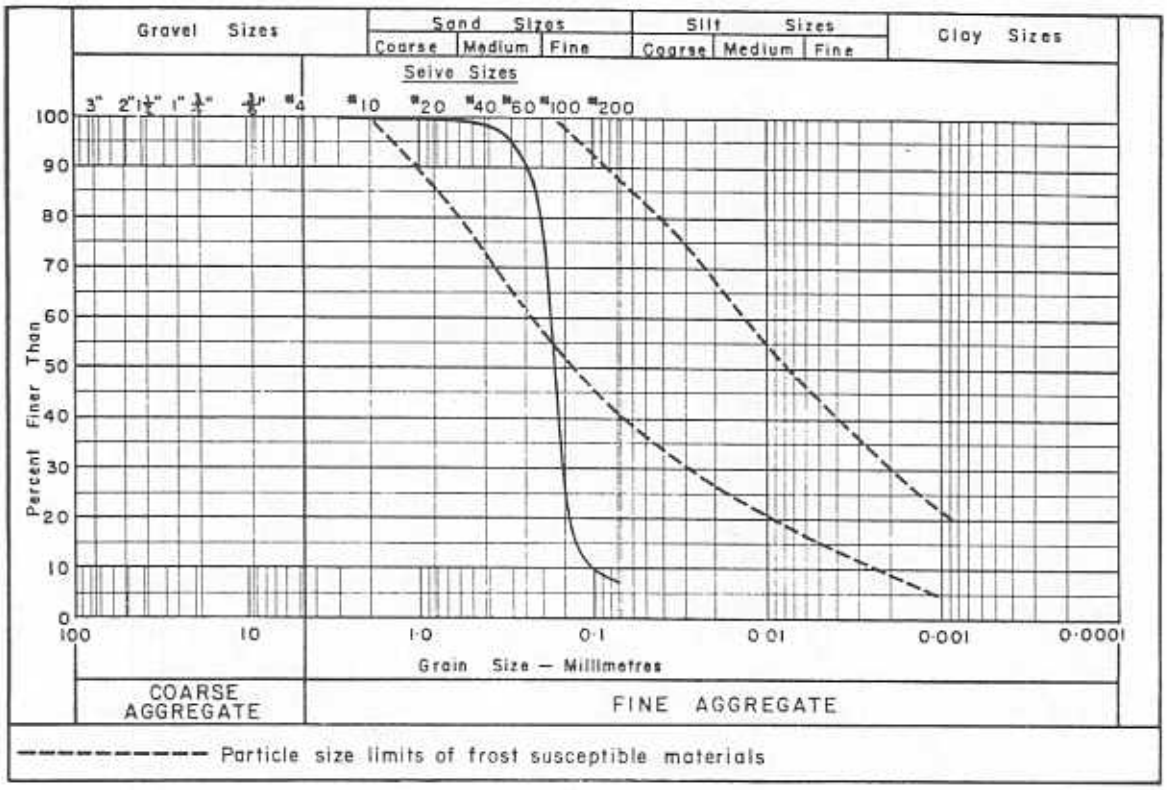
Sample Depth (Feet): 4.0 - 5.0

Moisture Content (%): 5.2

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

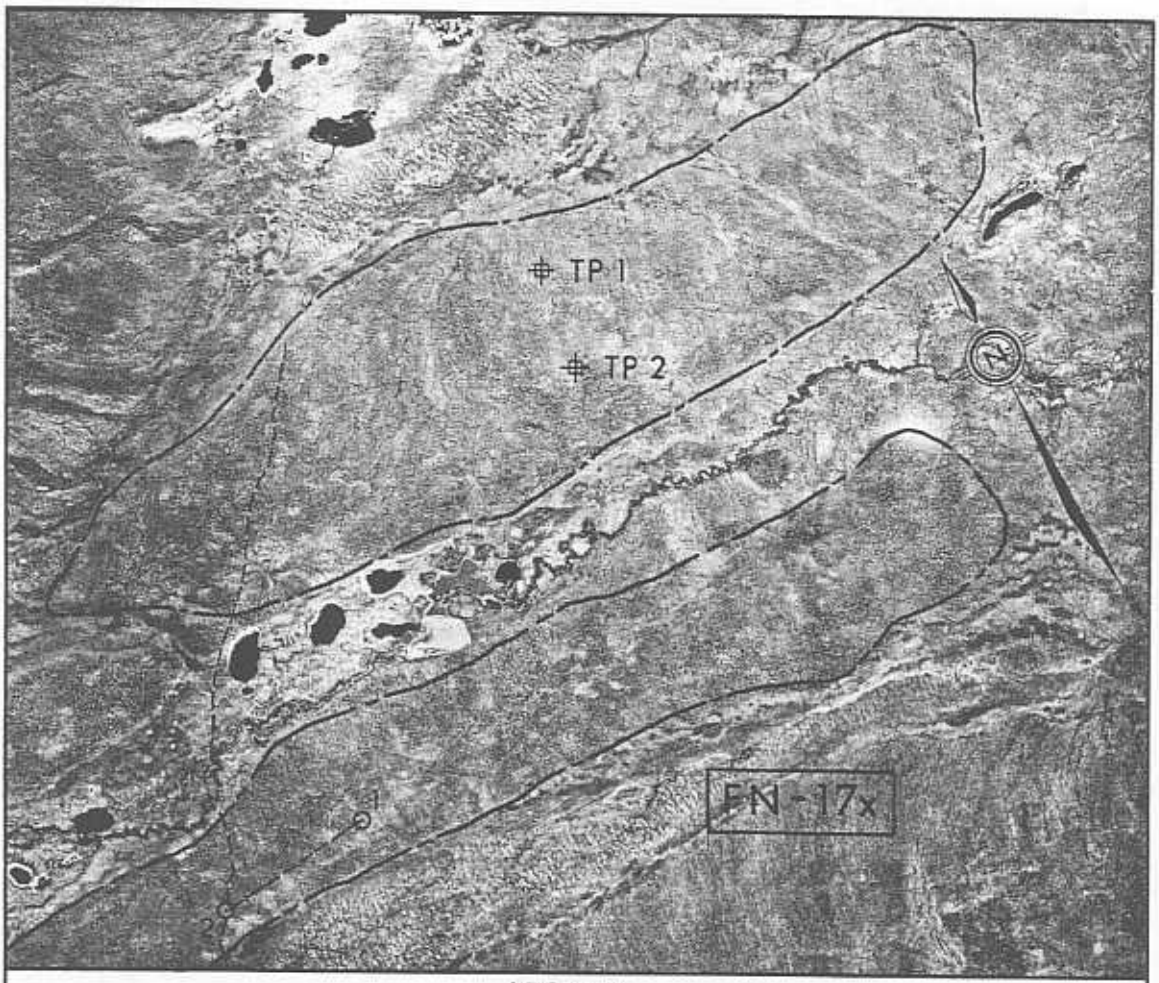
SITE NO. FN 17X

Located approximately 9 miles north of Fort Norman, Site FN 17X consists of an elevated glaciofluvial plain.

Type of Material: Silt; some sand, wet. (Glacial Till at depth)

Estimated Volume: Not applicable.

Assessment: The material encountered at this site is a fine grained soil and does not constitute a possible source for granular materials. Therefore, this site is not recommended for development.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⌖ TP Test Pit

Airphoto No. A22934/81

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 17X is located approximately 9 miles north of Fort Norman on a glaciofluvial plain. The site encompasses an area 4 miles in length by 1 mile in width and is better drained because the site is slightly elevated relative to the adjacent terrain. An unnamed creek which flows eastward into the Brackett River flanks the southern perimeter of the site area.

The in place soil at Site FN 17X consists of soft, sandy silt overlying a glacial till formation. A shallow organic topsoil layer, 8 to 10 inches in depth, overlies the entire site area and supports a growth of spruce and birch. The understory growth consists of moss and brush with occasional willow and alder on the lower portions of the site.

There are no known critical wildlife areas in the immediate vicinity of the site.

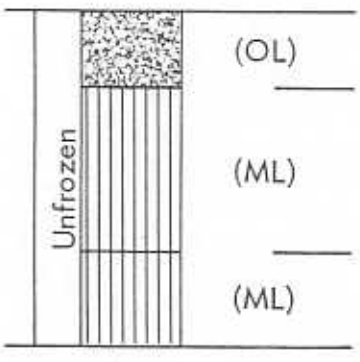
There is no existing access to this site. The nearest seismic cutline is situated approximately $1\frac{1}{2}$ miles south of the site.

DEVELOPMENT

Site FN 17X consists of wet, sandy silts and glacial till which cannot be classified as granular materials. Therefore, Site FN 17X is not recommended for development.

DETAILED TEST PIT LOG

FN 17X/TP 1

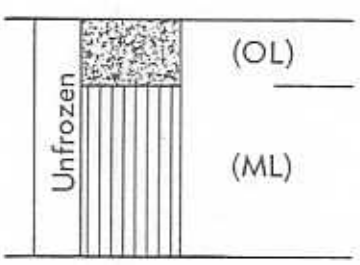


Topsoil; organic, black, roots

Silt; some clay, little sand, light brown, saturated, very soft

Silt; some clay, little sand, grey, saturated, very soft

FN 17X/TP 2



Topsoil; organic, black, roots

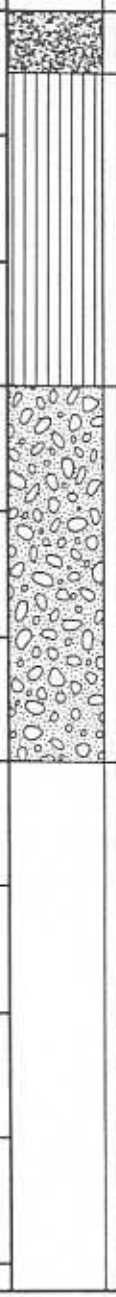
Silt; some clay, little sand, light brown, saturated, very soft

DETAILED DRILL HOLE LOG

SITE NO. FN 17X HOLE NO. DH-1

DATE: JAN. 30, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



DEPTH (feet)	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0							0
	OL	TOPSOIL: silt, organic, dark brown		Vr Vx			
1.0							
2		SILT: little sand, trace clay, occasional pebbles 1" and cobbles, grey					2
4	ML	- boulders to 10" size at 5'					4
6							6
6.0							
	GM-ML	GRAVEL, SAND SILT MIXTURE: trace clay pockets, massive, subangular (occasionally sub-rounded), limestone pebbles to 1", occasionally quartzites, greyish brown (Till)		Vx	M	MC	
8							8
10							10
12							12
12.0		TOTAL DEPTH 12.0'					
14							14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 17 X

HOLE NO. DH-2

DATE: JAN. 30, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: silt, little organic, dark brown		Vx			0
1.0								
2		ML	SILT: little sand, grey					2
3.0								
4		SM-SP	SAND, SILT, CLAY MIXTURE: trace gravel, subangular fragments of limestone (occasional granite) to 1", occasional cobbles, grey (TILL)		Vr	M		4
6								6
8							M.C. G.S. H.	8
10								10
11.0			TOTAL DEPTH 11.0'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

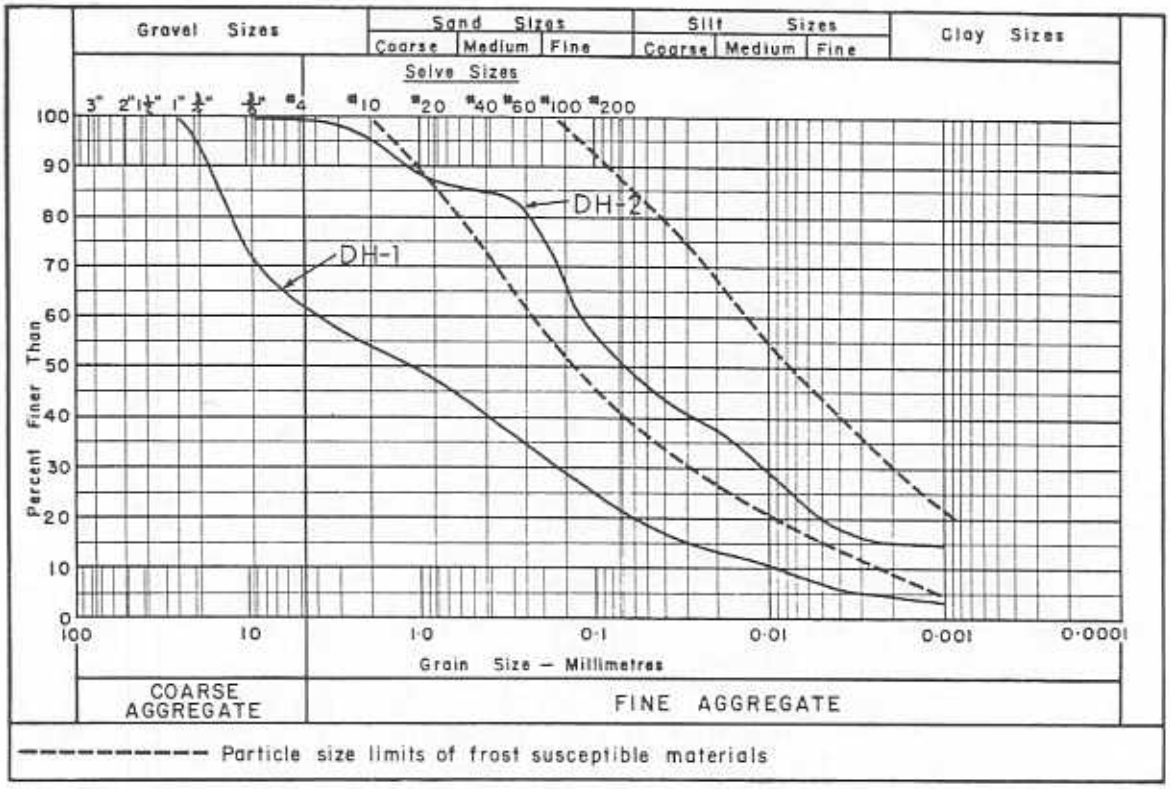
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	F N 17X/ DH 1	FN 17X/ DH 2
Sample Depth (Feet):	7-9	7-9
Moisture Content (%):	14.7	15.8
Ice Content (%):	-	-
Organic Content (%):	4.8	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SUMMARY OF MOISTURE CONTENT DETERMINATIONS

Sample Location	Sample Depth (Ft.)	Moisture Content (%)
FN 17/ DH 1	9.0 - 10.0	12.2
FN 17/ DH 2	9.0 - 10.0	15.0

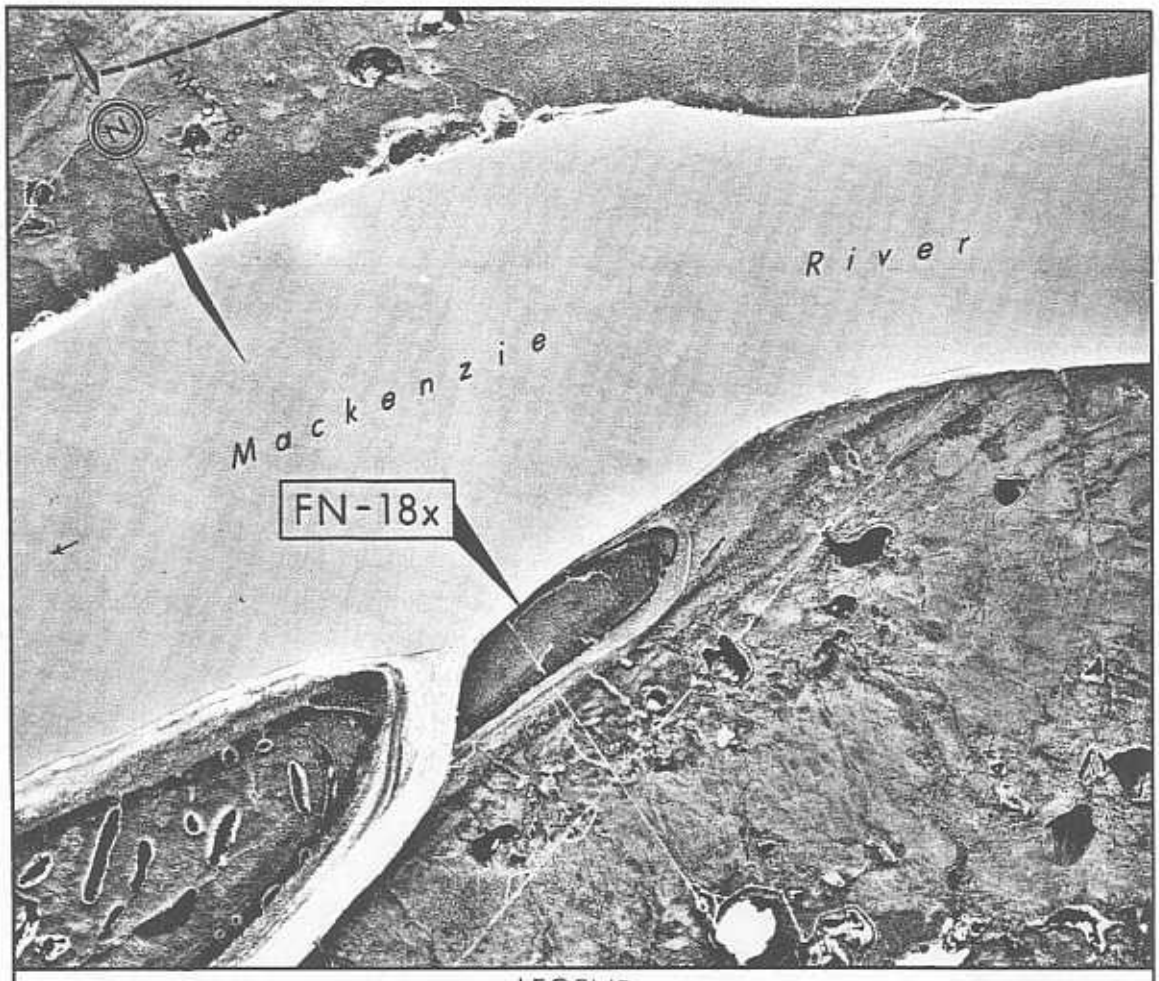
SITE NO. FN 18X

Located approximately 8 miles east of Fort Norman on the south bank of the Mackenzie River, Site FN 18X consists of a river bar.

Type of Material: Silt; sandy with layers and pockets of sand.

Estimated Volume: Not applicable.

Assessment: Very poor quality material not suitable for granular fill requirements; therefore, Site FN 18X is not recommended for development.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22834/163

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 18X is located approximately 8 miles east of Fort Norman on the south bank of the Mackenzie River and consists of a sand and silt bar. The site encompasses an area 5000 feet in length and 1500 feet in breadth.

The river bar consists primarily of sandy silts with layers and pockets of sand. The entire site area is covered with a dense growth of spruce, birch and poplar. It is expected that the island in the Mackenzie River and other similar river bars in the Fort Norman area contain similar material.

The northern perimeter of the site has direct access to the Mackenzie River.

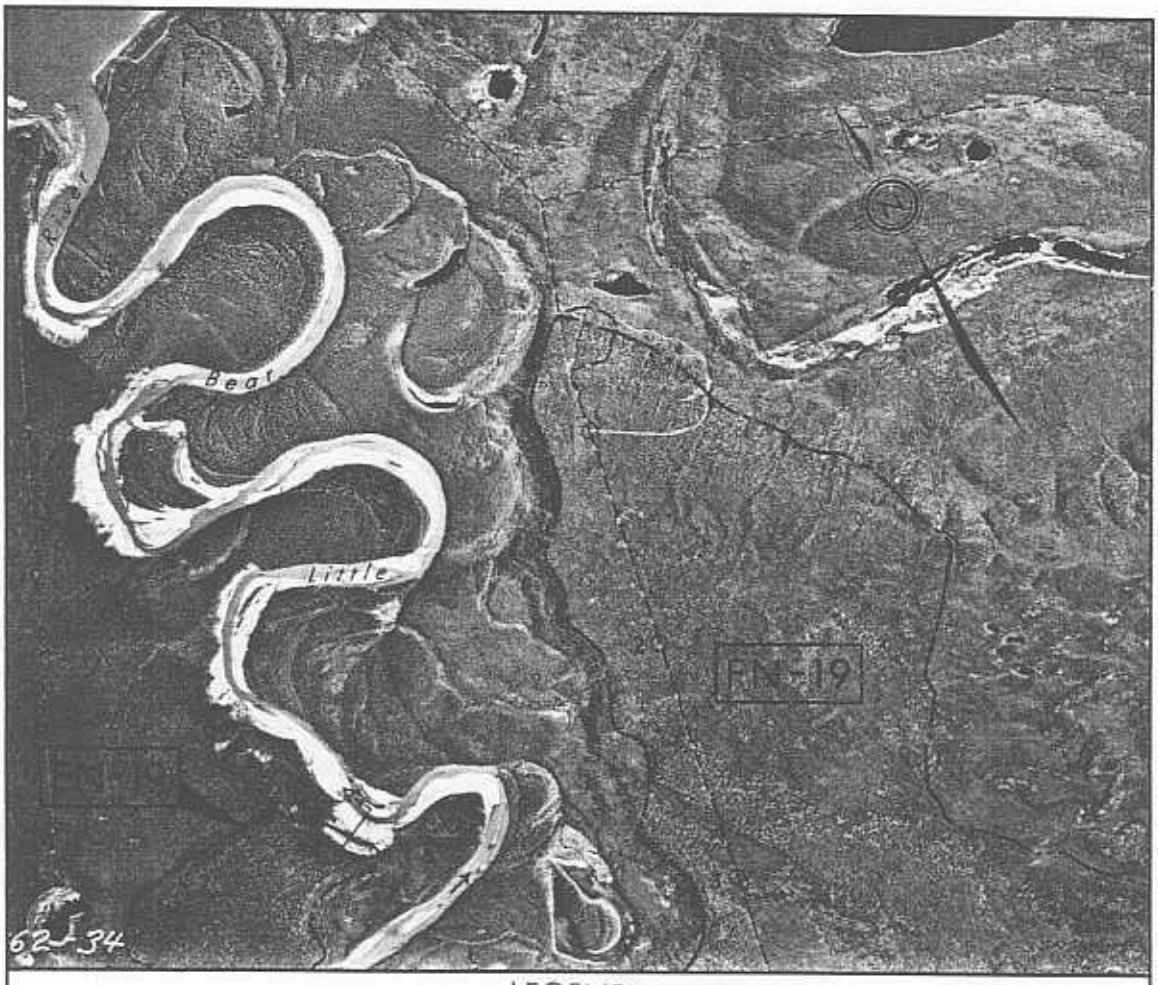
DEVELOPMENT

Site FN 18X is not recommended for development.

SITE NO. FN 19

Located approximately 11 miles southwest of Fort Norman, on the south bank of the Mackenzie River, Site FN 19 consists of a large glacial outwash plain. The Little Bear River has eroded its current active stream channel along the western periphery of this site.

Type of Material:	Gravel; medium to coarse grained, well graded.
Estimated Volume:	Unlimited for the current requirements of Fort Norman.
Assessment:	The granular material is of excellent quality to meet the requirements of all construction aggregates. Site FN 19 should be considered as a major and primary source of granular materials for the community of Fort Norman, and is recommended for development.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22862/34 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 19 is located approximately 11 miles southwest of Fort Norman on the south bank of the Mackenzie River and consists of a large glacial outwash plain, several square miles in area. The major portion of the glacial outwash plain is located immediately east of the Little Bear River channel. The portion of the site which was examined during the field reconnaissance consists of an erosional remnant of the glacial outwash plain located approximately 2 miles upstream of the confluence of the Little Bear and Mackenzie Rivers. The top of the glacial outwash plain is approximately 100 feet above the current water level of Little Bear River.

The glacial outwash plain consists of medium to coarse grained, poor to well graded gravels. The gravel exposure along the west bank of Little Bear River appears to be in excess of 50 feet thick. A thin veneer of organic topsoil, 6 inches in depth, underlain by a shallow stratum of silty sands covers the centre site area. Dense growths of spruce and birch are common and attain heights in excess of 30 to 50 feet.

There are no known critical wildlife areas within the immediate vicinity of the site; however, the site area is within the broad flyway that is utilized for staging and in some cases, molting, by various waterfowl during spring and fall migration (Figure 2).

Substantial quantities of potential spawning gravels are found within the channel of the Little Bear River and it is reported that upstream movements of flathead chub occur in the river in June.

The access to the site consists of the Mackenzie River relative to water transportation and seismic cutlines along the edge of the glacial outwash plain flanking the eastern bank of Little Bear River.

DEVELOPMENT

On the basis of field examination of the erosional remnant of the glacial outwash plain on the west bank of the Little Bear River and careful airphoto studies, three exploratory test holes were drilled on the western edge of the large glacial outwash plain along an existing seismic cutline which parallels the Little Bear River. The information relative to quality and quantity of granular materials available at Site FN 19 are outlined as follows:

- Granular materials of excellent quality consisting of medium grained, clean gravels of varying gradation were encountered.

- These gravels are sound and competent and are considered suitable for utilization in all types of construction requirements including "Pit Run" fill, base and surface course aggregates and concrete aggregates.

- Depths of recoverable gravels are in excess of 20 feet and may be as deep as 50 feet as indicated in the exposure examined on the west bank of the Little Bear River. (ref. Stratigraphy Section A-A', page 19-5).

- The overburden depth consisting of topsoil and silty sand varies from $\frac{1}{2}$ to 3 feet.

- It is considered that gravel quantities in excess of several hundred million cubic yards are potentially available from the extensive glacial outwash plain in Site FN 19.

Therefore, Site FN 19 is considered to be the major source of granular materials for the community of Fort Norman. The following operational guidelines should be considered during the development of this site for granular materials.

- The development of borrow pit areas for the granular materials needs of Fort Norman should be commenced at the extreme northern extremities of the site area in the vicinity of drill hole DH-1.

- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.

- The organic topsoil layer should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.

- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain into the active Little Bear River channel.

- A vegetation buffer zone of adequate height and breadth should be maintained between the outer limits of the borrow pit and the east shoreline of the Little Bear River.

- Stands of natural growth should be retained between pit areas in order to facilitate regrowth through natural regeneration.

- The use of dozers, overhead loaders and conventional ripping equipment should adequately remove the material from this site. However, the extent of ground ice at greater depths in this granular source may dictate the use of heavier equipment or staged pit development. The adverse effects of in situ ground ice is considered to be quite minimal.

- The production of quality surface course and concrete aggregate material is anticipated. The production of higher quality aggregates will dictate the need of screening or crushing plants to ensure aggregate properties for specified construction requirements.

- Additional laboratory tests to evaluate specific physical and chemical properties of the granular materials will be required, if the material is to be considered for the production of concrete aggregates. In addition, a washing operation may be required to reduce the silt content to within acceptable limits for fine concrete aggregates.

- In view of the need of utilizing the Mackenzie River channel as a primary access by water during the summer months or as a frozen access road during the winter months, stockpiling facilities for various grades of aggregates should be considered.

- The construction of an all weather access road from the northern extremities of the site area to the south shoreline of the Mackenzie River should be considered to provide year round access to the borrow pit areas.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include the following:

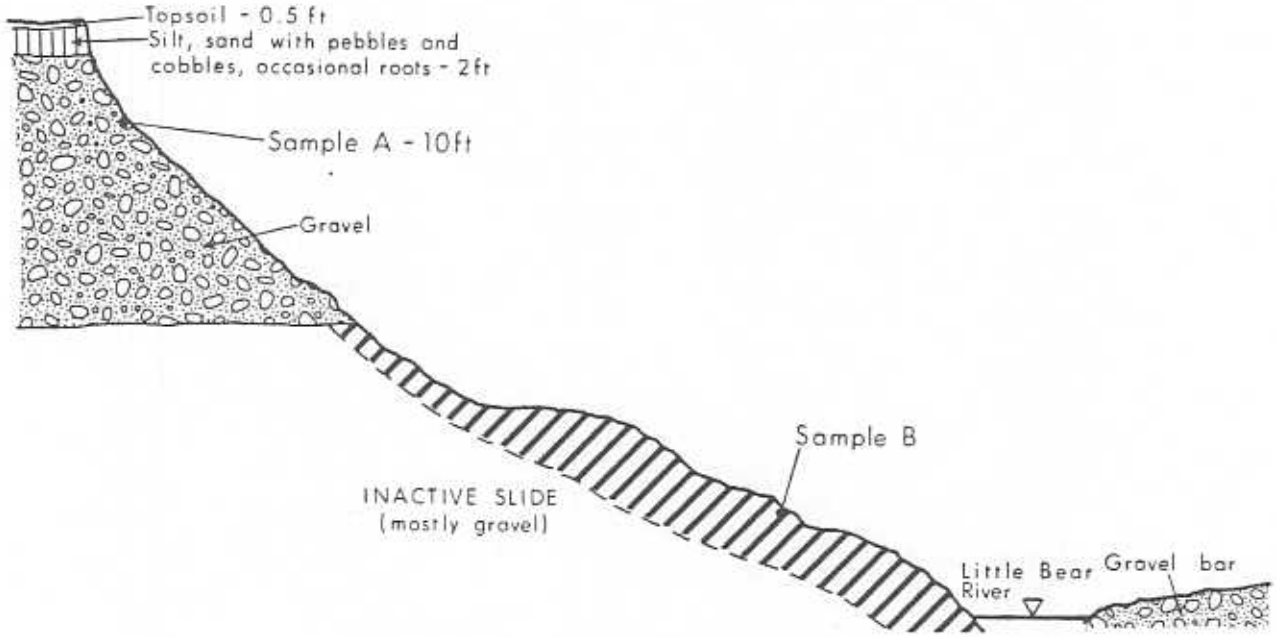
- Recontouring of abandoned pit areas to provide general drainage that is compatible with the natural drainage of the adjacent terrain.

- Replacing stockpiled surficial waste material and organic topsoil on the abandoned and recontoured pit areas.

- Revegetation of the recontoured areas should be considered, especially in potential erosion cases where the artificial reseeding of annuals and perennials will result in a semi-permanent cover growth prior to reestablishment by native species.

SECTION A-A'

NOT TO SCALE



Description of the Exposure

0.0 - 0.5	(OL)	Topsoil; organic
0.5 - 2.0	(ML)-(SM)	Silt; some sand with pebbles and cobbles, occasional roots
2.0 - 30.0	(GW)	Gravel; some sand, pebbles, rounded, predominantly to 3 inches in diameter, infrequent boulders and coal fragments, dry, greyish

DETAILED DRILL HOLE LOG

SITE NO. FN 19 HOLE NO. DH-1

DATE: JAN. 31, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☐ AIR CONVENTIONAL ☒ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, little organic, dark brown		Vs			0
1.0		ML	SILT: trace sand, greyish brown					
2.0		SM-SP	SAND AND SILT: trace clay and gravel, occasional subrounded pebbles and cobbles, fine grained, poorly graded, brown		Vx	M	M.C. G.S. O.	2
4								4
5.0		GP	GRAVEL: trace sand, medium grained, poorly graded, predominantly chert and quartzites, few granite and dark coloured igneous pebbles, maximum 2"		Vx Vc	M-H		6
6								
8								8
10							M.C. G.S.	10
12							M.C. G.S. P.	12
14					Vx Vc	M-H		14
16								16
18								18
20			20.0 TOTAL DEPTH 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 19 HOLE NO. DH-2

DATE: JAN. 31, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☐ AIR CONVENTIONAL ☒ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, organic, roots, dark brown					0
0.5								
2		ML	SILT: little sand, light brown		Vs			2
3.0								
4		GP	GRAVEL: trace sand, medium grained, poorly graded, rounded or subangular pebbles from 1/16" to 3", predominantly chert, quartzites, few igneous and limestone, grey					4
6								6
8						M		8
10					Vx			10
12							M.C. G.S. P.	12
14							G.S.	14
15.0			TOTAL DEPTH 15.0'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

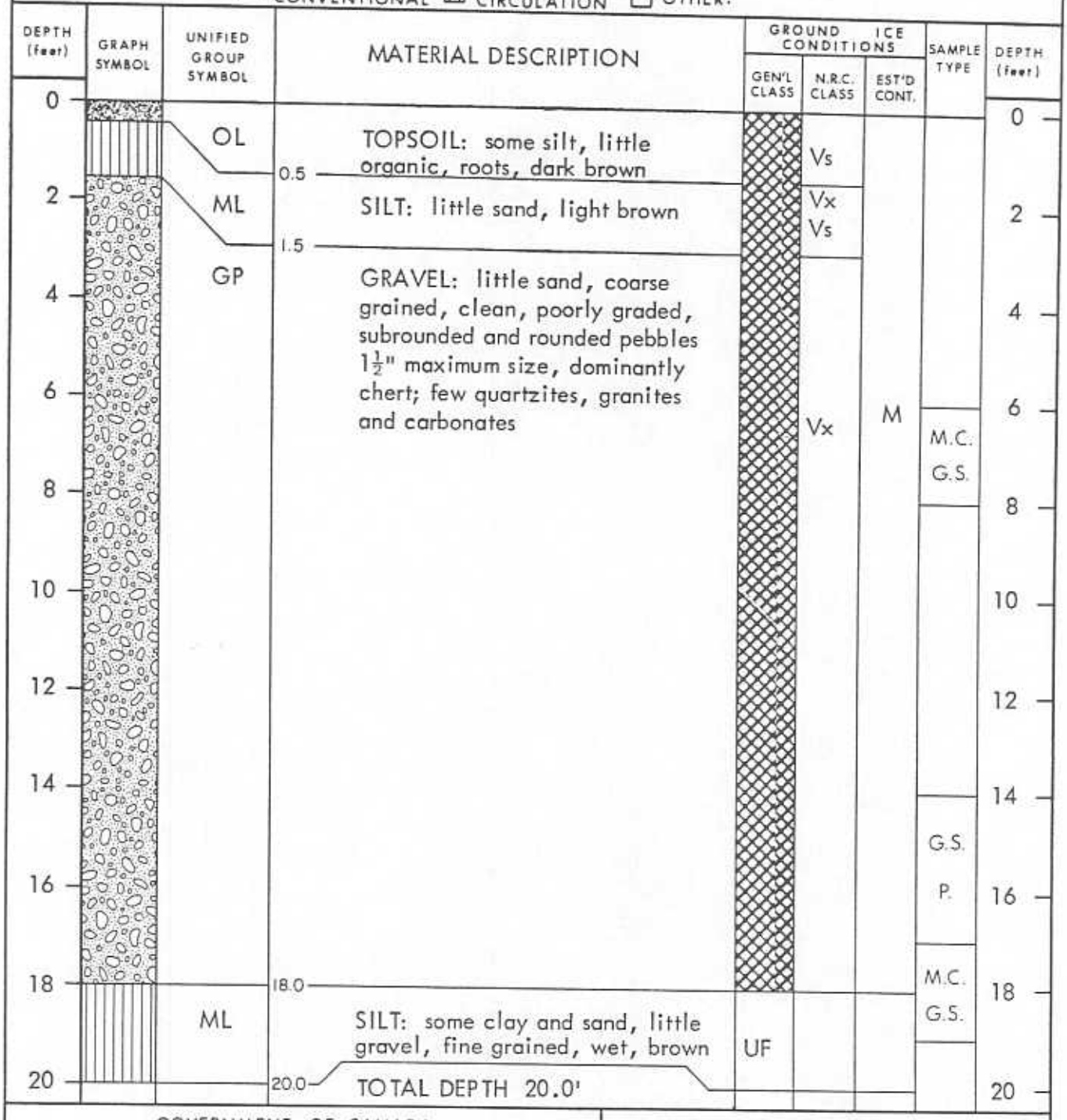
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 19 HOLE NO. DH-3

DATE: JAN 31, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☐ AIR CONVENTIONAL ☒ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

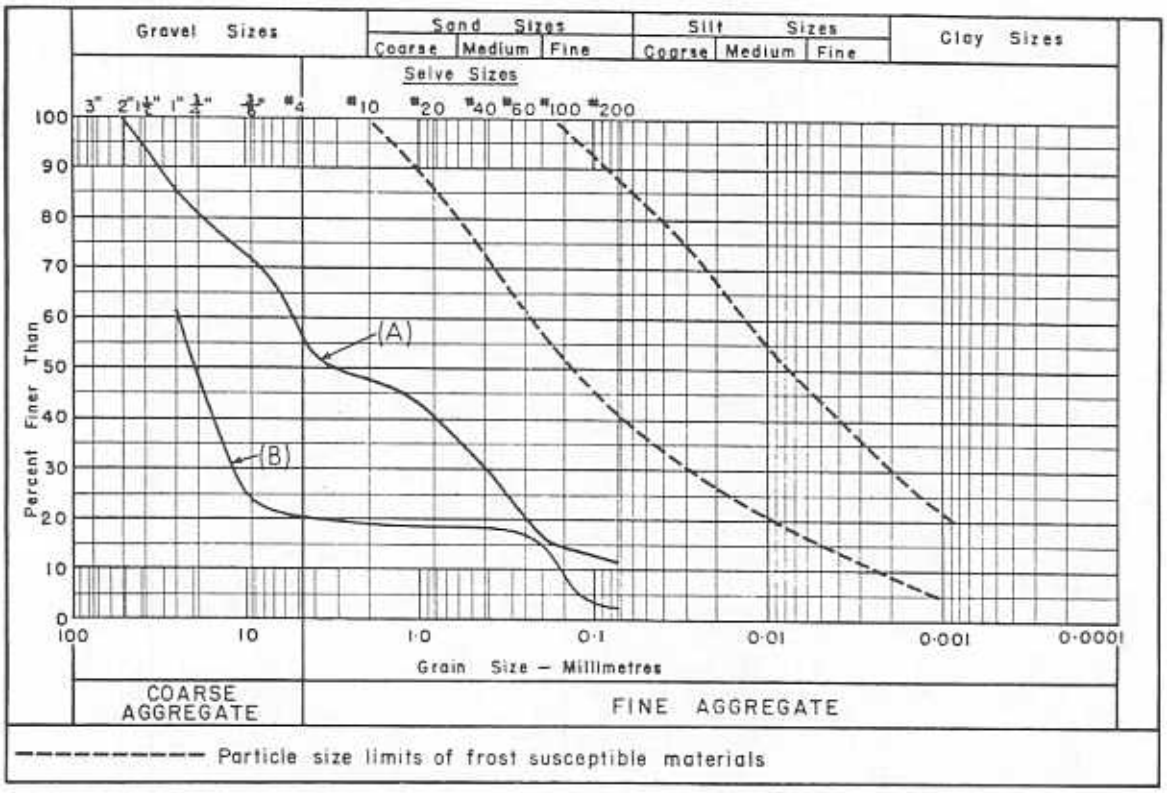
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 19 (A)	FN 19 (B)
Sample Depth (Feet):	10	-
Moisture Content (%):	6.8	-
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



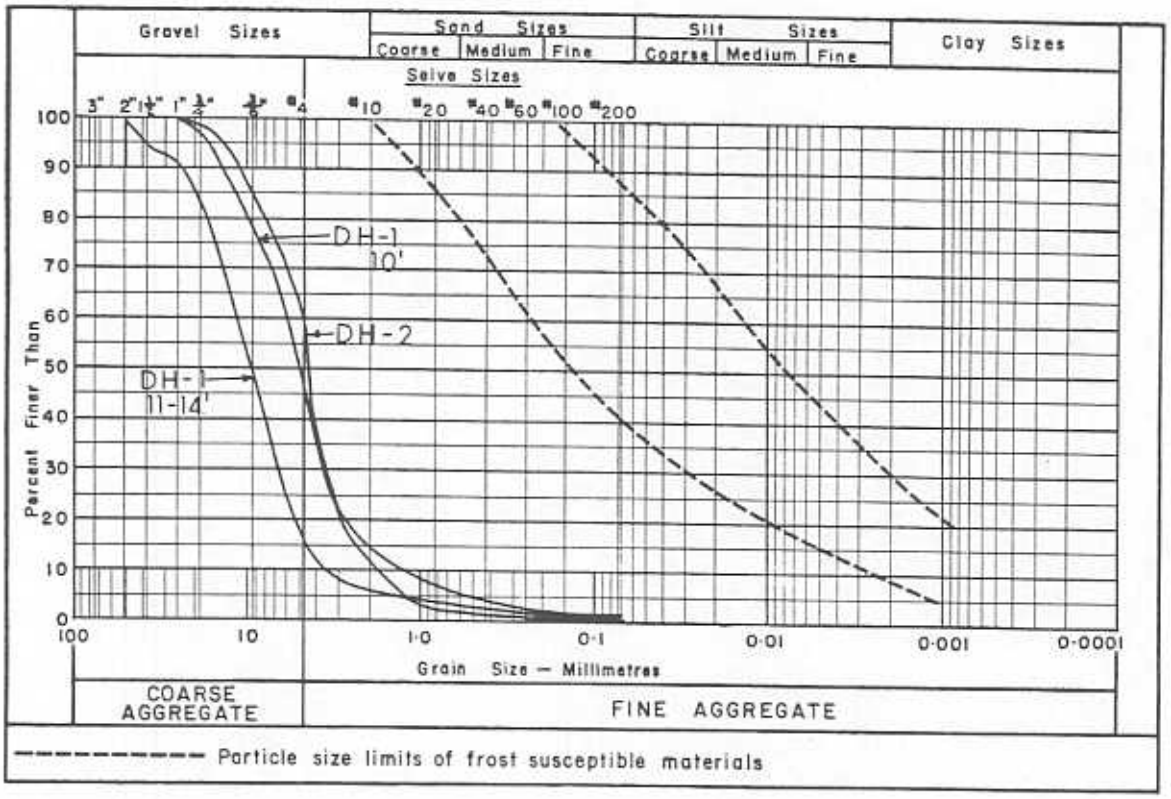
PETROGRAPHIC ANALYSIS:

Quartzites	45.9 %	Igneous material	6.4 %
Cherts	35.2 %	Coal fragments - trace	
Limestone & dolomite	2.5 %		

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 19/ DH 1	FN 19/ DH 1	FN 19/ DH 2
Sample Depth (Feet):	10	11-14	11
Moisture Content (%):	10.9	5.6	1.9
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



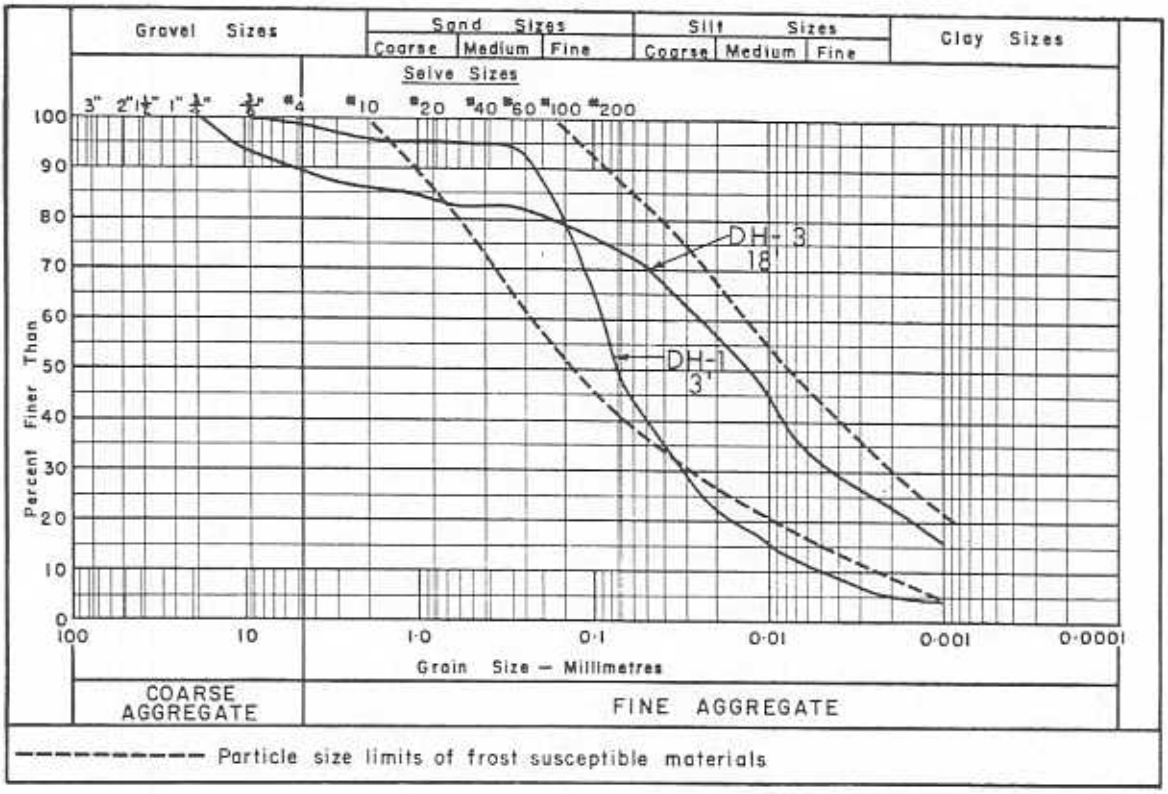
PETROGRAPHIC ANALYSIS: (1) (FN 19/ DH 1 @ 11'-14' (2) FN 19/ DH 2 @ 11.0'

Cherts	58.13%	52.48%
Quartzites	36.95%	47.51%
Igneous	4.92%	

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 19/ DH 1	FN 19/ DH 1	FN 19/ DH 3
Sample Depth (Feet):	3.0	4.0	18.0
Moisture Content (%):	20.8	15.2	22.2
Ice Content (%):	-	-	-
Organic Content (%):	4.5	-	-

GRAIN SIZE DISTRIBUTION:

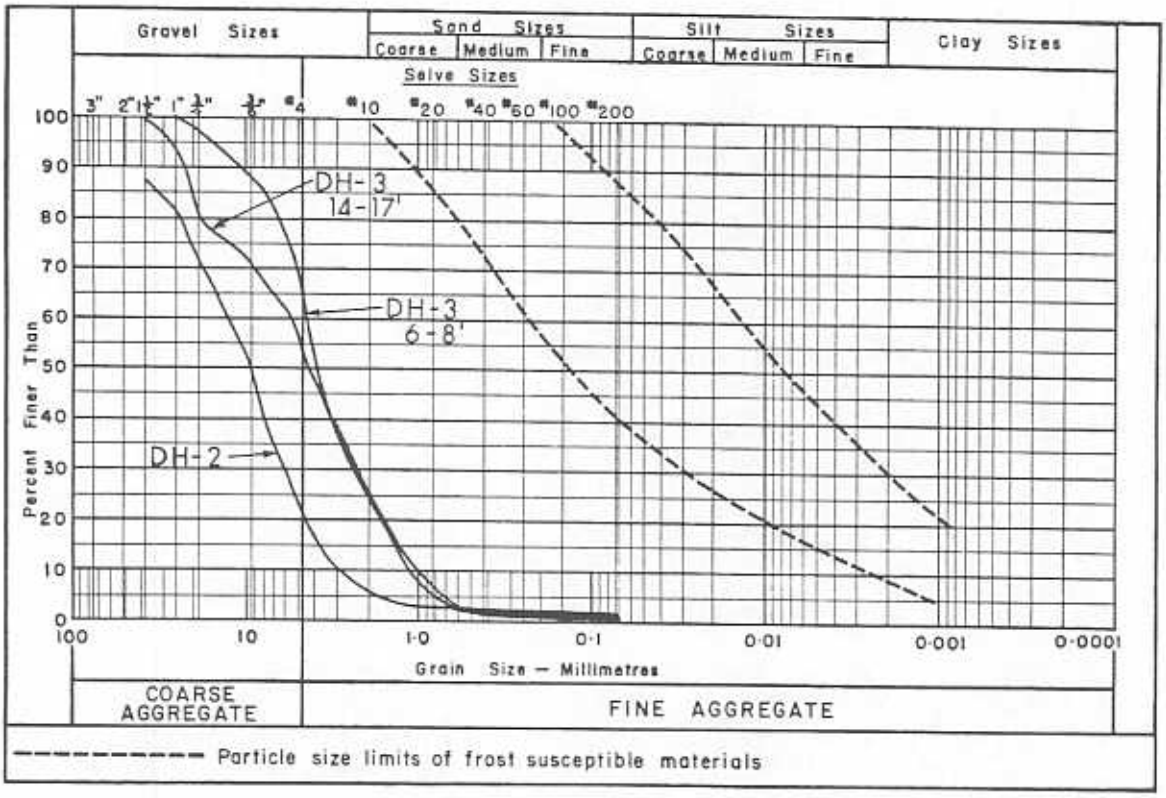


PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 19/DH 2	FN 19/ DH 3	FN 19/ DH 3
Sample Depth (Feet):	14	6-8	14-17
Moisture Content (%):	-	2.0	-
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS: (FN 19/ DH 3 @ 14'-17')

Chert	66.8%
Quartzites	15.3%
Igneous	13.2%
Carbonates	4.0%
Deleterious	0.7%

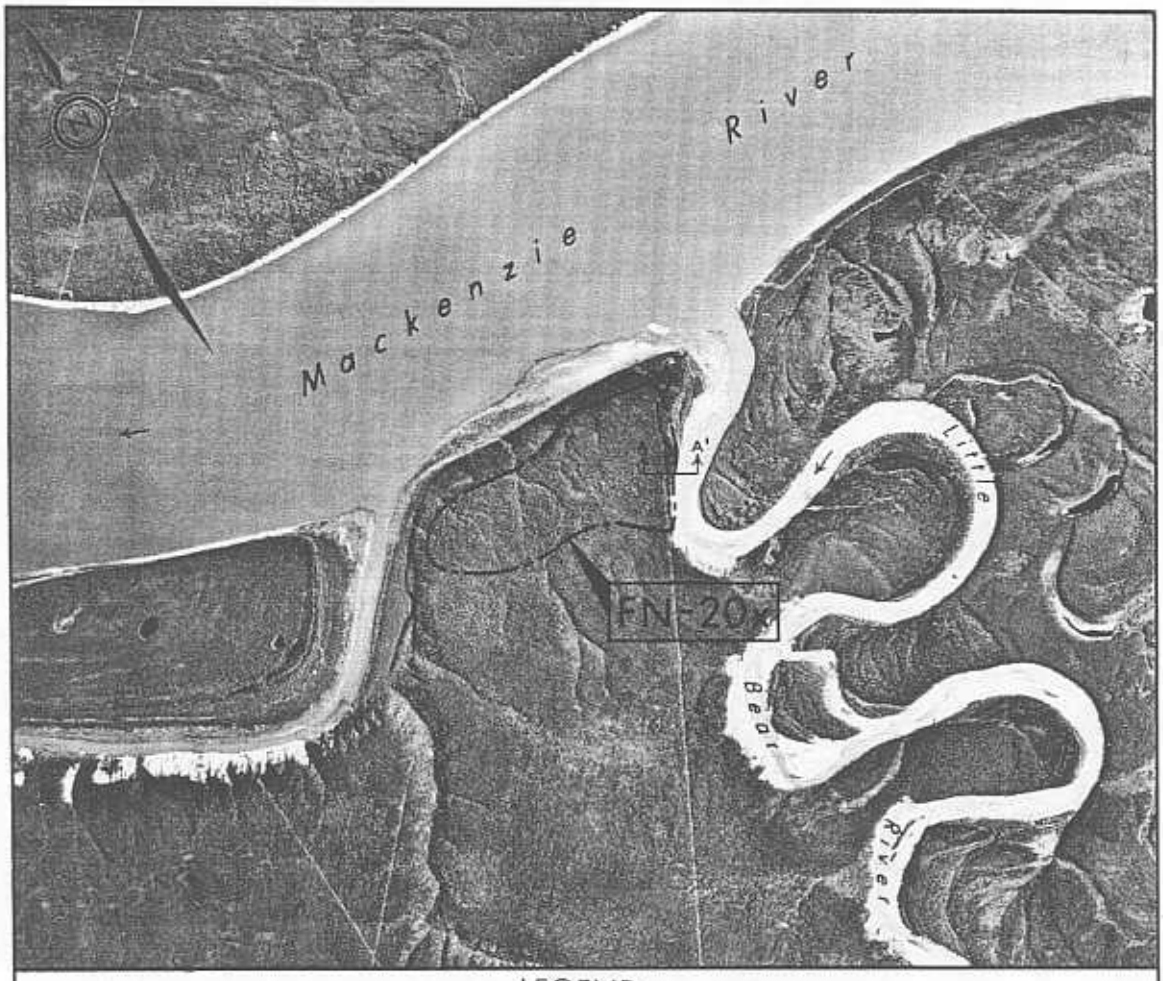
SITE NO. FN 20X

Located approximately 10½ miles west of Fort Norman at the confluence of the Mackenzie and Little Bear Rivers, Site FN 20X consists of an elevated river terrace.

Type of Material: Stratified silts and sands with pockets of gravel

Estimated Volume: Not established

Assessment: This site is not recommended for development because of its difficult and excessive distance from the community, low quality of recoverable material and better material availability at other sites.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22862/33

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 20X is located approximately $10\frac{1}{2}$ miles west of Fort Norman at the confluence of the Little Bear and Mackenzie Rivers, on the west bank of Little Bear River. The site consists of an elevated river terrace and encompasses an area approximately one mile in length by $\frac{1}{2}$ mile in width.

The terrace deposits consist of horizontally stratified silts and sands with isolated pockets and seams of gravel. The general surficial drainage of the site area is north into the Mackenzie River. The shallow organic topsoil stratum supports sparse growths of spruce and birch.

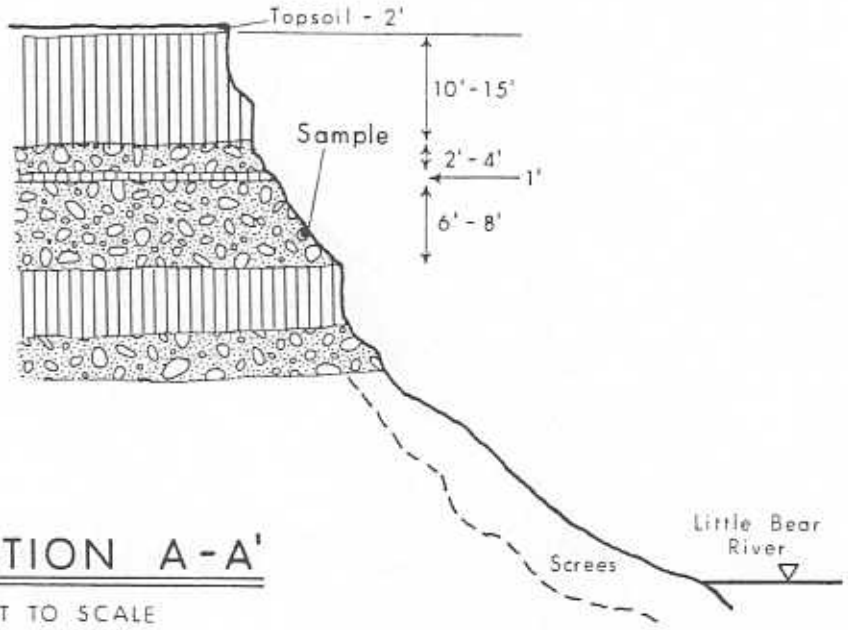
The site is within the broad flyway that is utilized by waterfowl during spring and fall migrations.

The primary access to this site is by water along the Mackenzie River. An existing seismic cutline flanks the eastern extremity of the site area which parallels the western bank of Little Bear River.

DEVELOPMENT

Site FN 20X is not recommended for development for the following reasons:

- The river terrace is located at the confluence of the Mackenzie and Little Bear Rivers and would be more sensitive to environmental disturbance by borrow pit operations than similar deposits located further upstream on the Little Bear River.
- The long haul distance from Fort Norman and the relatively poor quality of recoverable material does not justify the exploitation of this site.
- Granular materials of better quality for construction materials is available in relatively unlimited quantities in the glacial outwash plain deposits at Site FN 19.



SECTION A-A'

NOT TO SCALE

Description of the Exposure

0.0 - 2.0	(OL)	Topsoil; organic, silty
2.0 - 12.0	(ML)-(SM)	Silt; some sand, stratified with silty sand layers and lenses
12.0 - 15.0	(GW)	Gravel; some sand, well graded, scattered cobbles, grey
15.0 - 22.0	(GW)	Gravel; some sand, well graded, medium to coarse grained, scattered cobbles and boulders, grey

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 20X (Exposure)

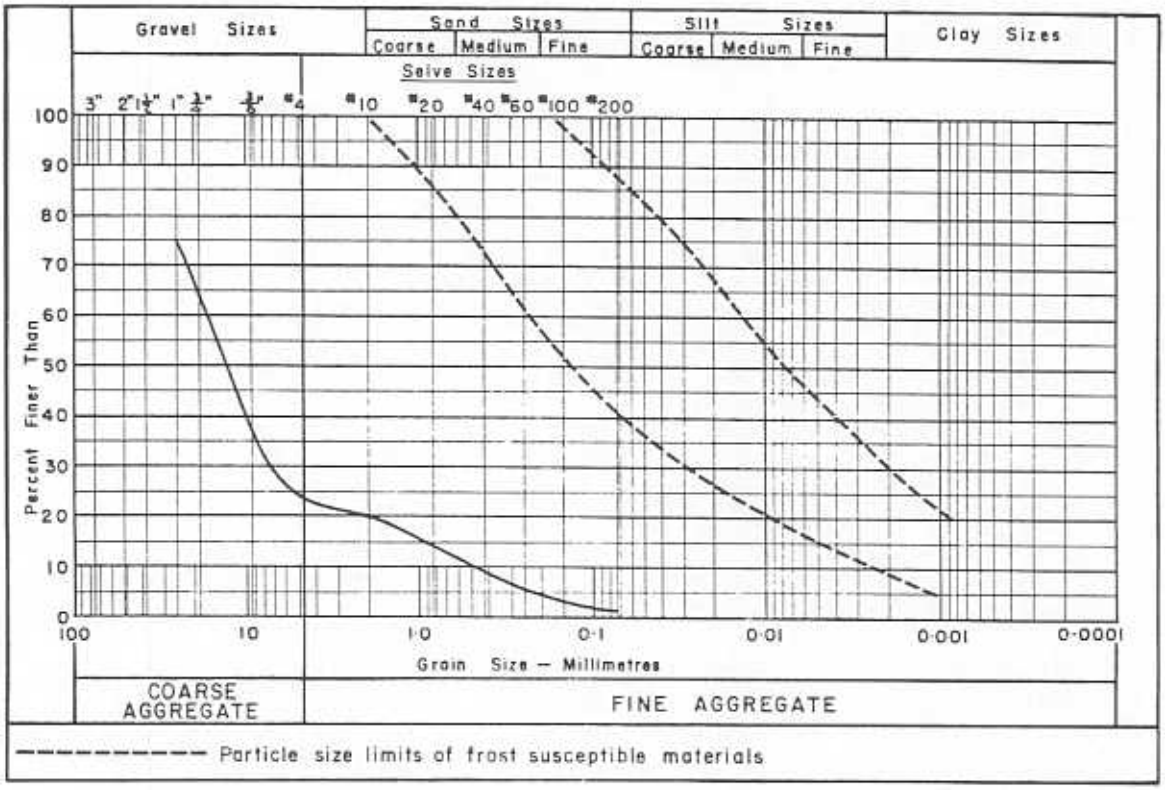
Sample Depth (Feet): 6 - 8

Moisture Content (%): 1.2

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



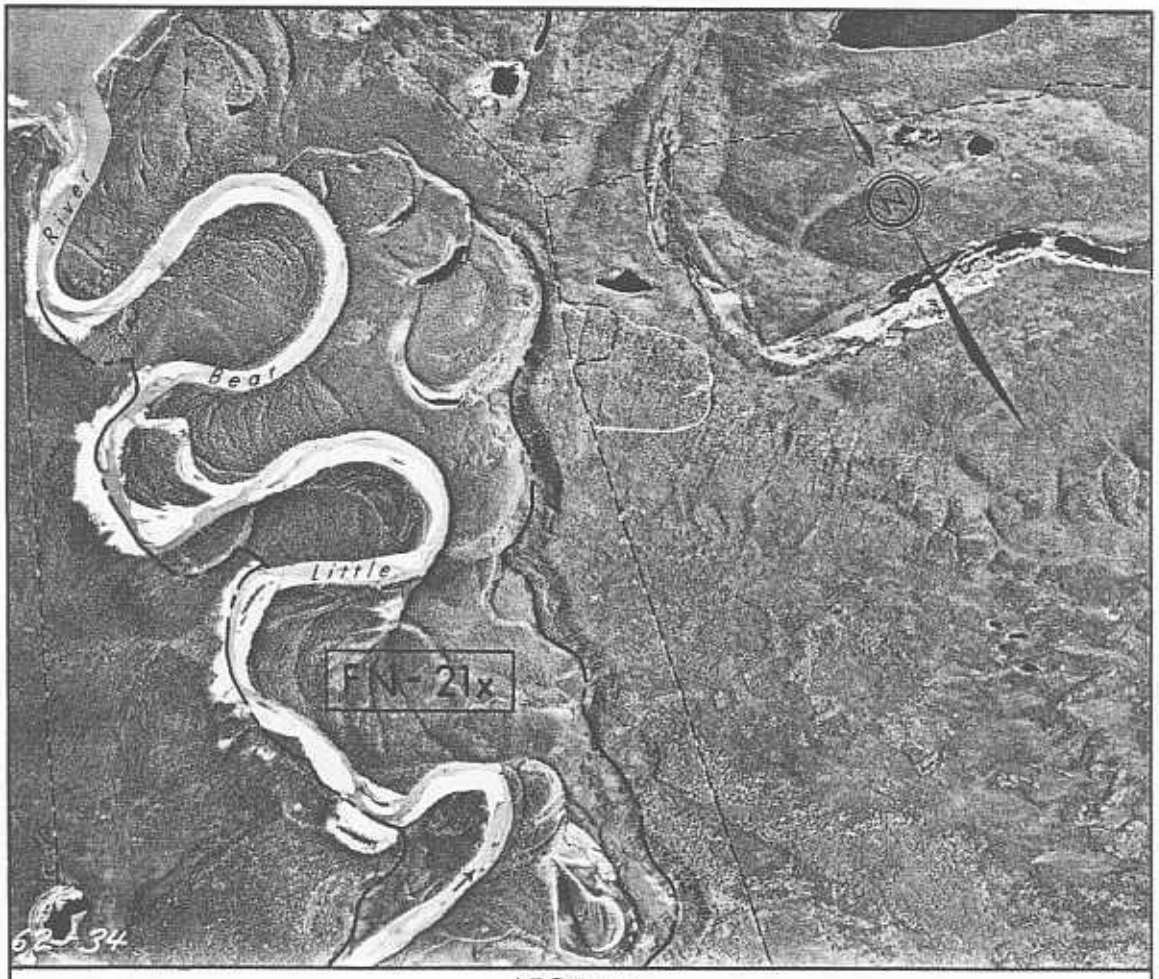
PETROGRAPHIC ANALYSIS:

Quartzite	47.3 %	Granite, pegmatite, rhyolite etc.	17.3 %
Chert and flint	31.2 %	Limestone & dolomite	3.7 %

SITE NO. FN 21X

Located approximately 10 miles southwest of Fort Norman, Site FN 21X consists of alluvial deposits in the active floodplain of Little Bear River.

Type of Material:	Gravel; coarse to medium grained, well graded, clean
Estimated Volume:	Not established
Assessment:	Site FN 21X is not recommended for development because much of the source is located in the active stream channel of Little Bear River.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22862/34

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 21X is located approximately 10 to 11 miles southwest of Fort Norman and consists of alluvial deposits within the active and meandering stream channel of Little Bear River. The granular deposits are encountered in numerous exposed gravel bars and shallow river terraces on the active floodplain. This site extends upstream along the Little Bear River for several miles, however, the area examined during the field reconnaissance only encompassed the active alluvial floodplain area extending 3 miles upstream from the mouth of Little Bear River.

The granular materials in the exposed river bars consist of coarse to medium grained, clean, well graded gravels. A very shallow layer of organic topsoil mantles the elevated floodplain of the Little Bear River and supports sparse growths of spruce, birch and occasional poplar.

The Little Bear River contains extensive areas of potential fish spawning gravel in this section of the stream; also, it is reported that flathead chub migrate up the river during June.

The only existing access to this site consists of the Mackenzie River and Little Bear River channels. No seismic cutlines nor other trails were noted in the site area.

DEVELOPMENT

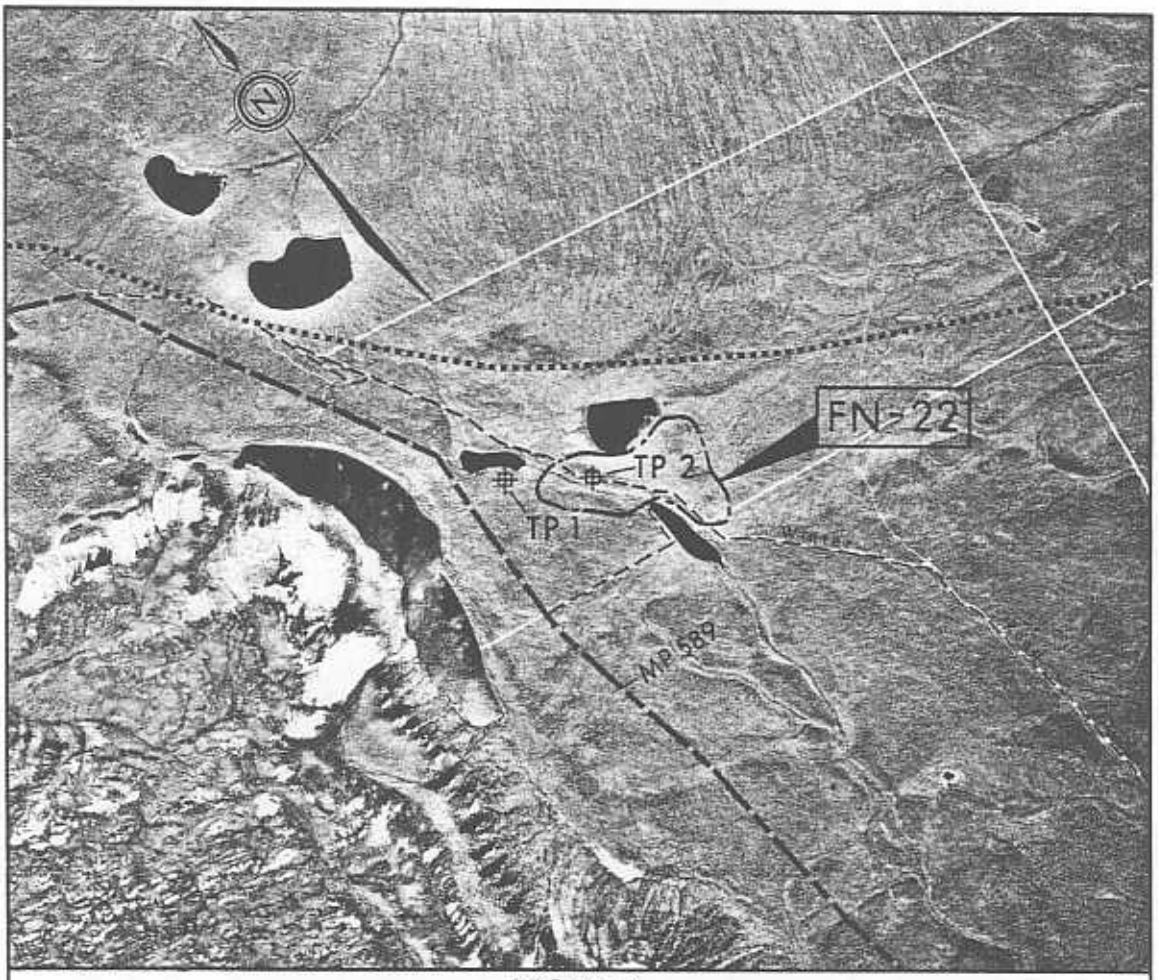
Site FN 21X is not recommended for development for the following reasons:

- The site is located in the active flood plain of Little Bear River, therefore, most granular material deposits are located below the high water level of the river.
- Granular materials of similar quality can be secured from other sites in the Study Area where the surrounding environmental setting is less severe.
- The access to the site is very difficult and also involves a relatively long haul by water transportation to the community of Fort Norman.

SITE NO. FN 22

Located approximately 7 miles northwest of Fort Norman near the northeast base of Bear Rock, Site FN 22 consists of a small outwash remnant.

Type of Material:	Sand; some gravel and silt
Estimated Volume:	100,000 cubic yards
Assessment:	This site is not currently recommended to supply the granular materials requirements for Fort Norman; however, this site could be utilized as a source of general fill materials in the construction of local utilities.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/157

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 22 is located approximately 7 miles northwest of Fort Norman and consists of a small outwash remnant near the northeast base of Bear Rock. The site is approximately 3000 feet by 1000 feet in area and the adjacent terrain is generally flat. Three small lakes border the site area on the north and southeast perimeters.

The granular materials encountered at Site FN 22 consist of gravelly sands with a high silt content; minor till bodies may also be incorporated. The in situ soil is water saturated at a depth of approximately 3 feet below ground surface and frost was encountered at a depth of one foot in Test Pit 1. A shallow organic topsoil horizon, 4 to 8 inches in depth, overlies the entire site area and supports sparse growths of spruce and birch. The understory growth consists of moss, small plants and brush.

There are no known critical wildlife areas in the immediate vicinity of the site.

The existing access consists of the winter road which traverses the entire site area. In addition, both the proposed gas pipeline and Machenzie Highway routes pass immediately adjacent to this site.

DEVELOPMENT

Site FN 22 is not recommended for development because of the low quality of the available material, limited quantity of recoverable material and the limited seasonal access relative to the need for a river crossing at Great Bear River. The recoverable material is generally only suitable for general embankment or backfill requirements.

However, if Site FN 22 should be considered for development at a future date for general fill requirements for proposed facilities in the immediate area of the source, then the following guidelines should be considered:

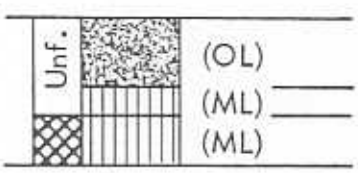
- The existing vegetation and organic topsoil should be cleared and stripped prior to borrow pit excavation.
- Buffer zones of vegetation should be retained between the working areas and small lakes that border the site.
- The waste material should be stockpiled for easy recovery for future use in restoration of the borrow pit areas.
- Dozers, overhead loaders and backhoes should be adequate for the removal of the in situ material above the permafrost horizon.

ABANDONMENT AND REHABILITATION

Abandonment procedures should include the recontouring of the pit area by utilizing the stockpiled waste materials. Rehabilitation might include reseeding although existing cutlines in the area indicate that the understory growth and eventually spruce will be naturally reestablished.

DETAILED TEST PIT LOG

FN 22/TP 1

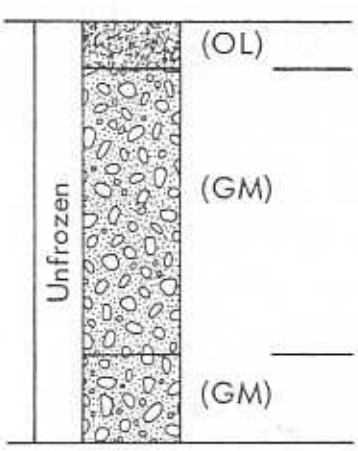


0.0 – 0.7 Topsoil; organic, black, roots

0.7 – 1.0 Silt; little sand, trace of clay, light brown, saturated

1.0 – 1.5 Silt; little sand, trace of clay, frozen, ice crystals and lenses

FN 22/TP 2



0.0 – 0.5 Topsoil; organic, black, roots

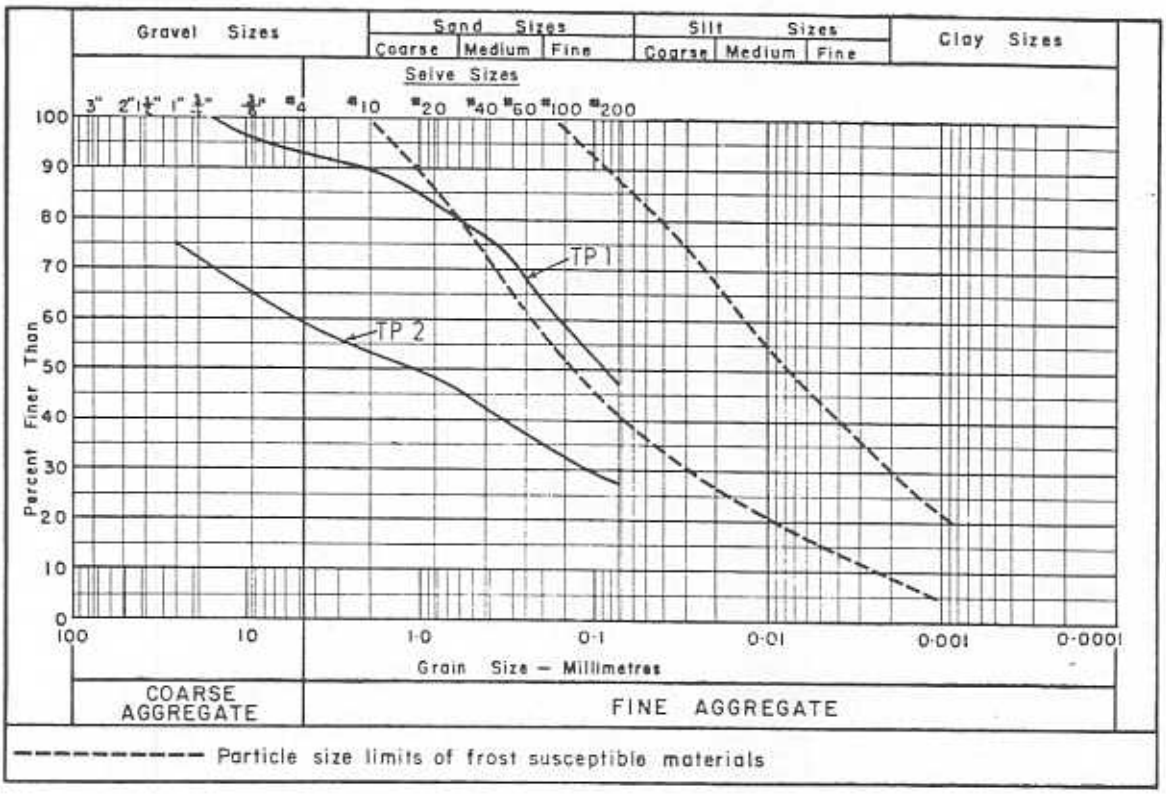
0.5 – 3.5 Gravel; some sand and silt, frequent cobbles and boulders, wet, brown

3.5 – 4.4 Gravel; some sand and silt, frequent cobbles and boulders, saturated, pockets of sand with pebbles to $\frac{1}{2}$ inch.

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 22/TP 1	FN 22/TP 2
Sample Depth (Feet):	1.0	1.0 - 3.5
Moisture Content (%):	12.2	11.8
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

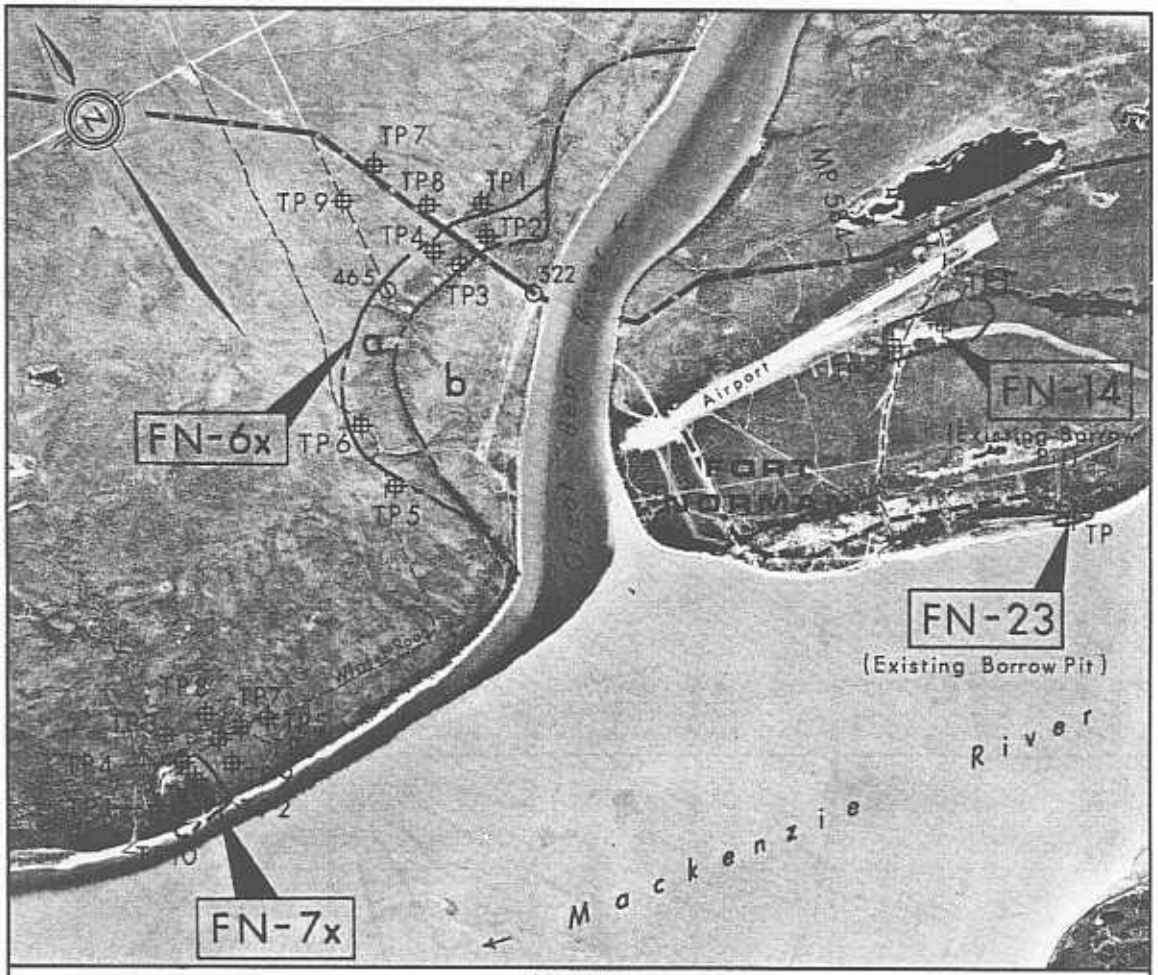
Igneous material	81.6 %	Limestone & dolomite	6.7 %
Quartzites	9.5 %	Chert	1.5 %

Deleterious ironstone	0.5 %
Deleterious siltstone, shale etc.	6.5 %

SITE NO. FN 23

Located approximately $\frac{1}{2}$ mile south of the centre of Fort Norman, Site FN 23 consists of an exposed gravel bar or terrace on the north shore of the Mackenzie River.

Type of Material:	Sand and Gravel; stratified, medium grained.
Estimated Volume:	5,000 cubic yards
Assessment:	This site should only be utilized to provide the periodic, domestic requirements for granular materials in the Fort Norman community.



Airphoto No. A22889/146 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 23 is located approximately $\frac{1}{2}$ mile south of the center of the existing Fort Norman townsite, at the steep north bank of the Mackenzie River. The site consists of a narrow bar or terrace, slightly elevated above the shoreline, with its surface at or below the high water level of the Mackenzie River. Coarse alluvial deposits, consisting of sands and gravels, are apparently limited to the upstream tip of the terrace and fine grained silty and sandy sediments prevail in the remainder of the deposit. The site encompasses an area approximately 500 feet long by 100 feet wide and a borrow pit to supply the periodic community requirements for granular materials is being currently operated.

The material at Site FN 23 consists of medium grained stratified sand and gravels with a trace of silt. The entire site is completely devoid of vegetation. The depth of recoverable material is approximately 5 feet.

Although the site is within the broad waterfowl flyway as shown in Figure 2, the proximity of the site to the community negates any severe environmental implications.

The site is only accessible during the low flow periods of the Mackenzie River. A modest access road has been developed from the existing borrow pit area to the community.

DEVELOPMENT

Site FN 23 is only recommended for exploitation to supply the periodic domestic requirements for granular materials for Fort Norman. The following guidelines should be considered in the removal of material from this site:

- The encroachment of the steep north bank of the Mackenzie River during the removal of material should be controlled.
- The removal of material should be restricted below the high water level of the river.
- The borrow pit area should be contoured during development and exploitation to maintain surficial drainage towards the river channel.

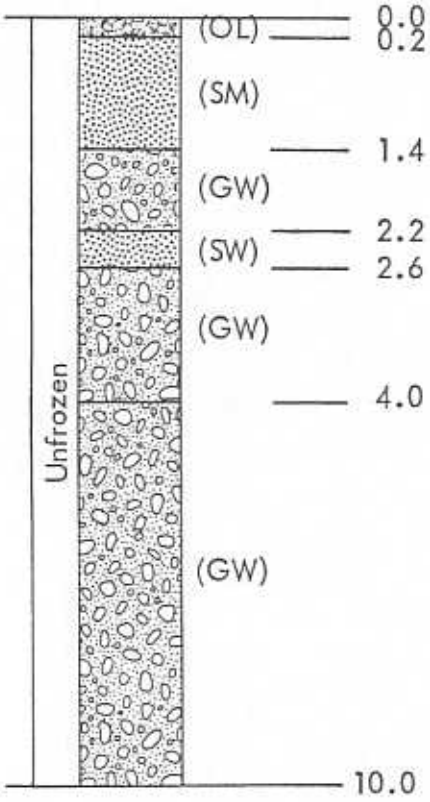
ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures that should be considered include:

- Borrow pit areas should be recontoured in a manner that matches the configuration of the adjacent beach areas.
- Abandoned pits should be breached so that restoration will naturally occur during high water flow.

DETAILED TEST PIT LOG

FN 23/TP 1



Topsoil; organic, roots

Sand; little silt, fine grained, brown silt lenses

Gravel; some sand, coarse, damp, brown

Sand; little silt, fine to coarse grained, damp, brown

Gravel; coarse sand, well graded, brown

Gravel and Sand; greyish

SUMMARY OF LABORATORY TEST DATA

Sample Location: FN 23/TP 1

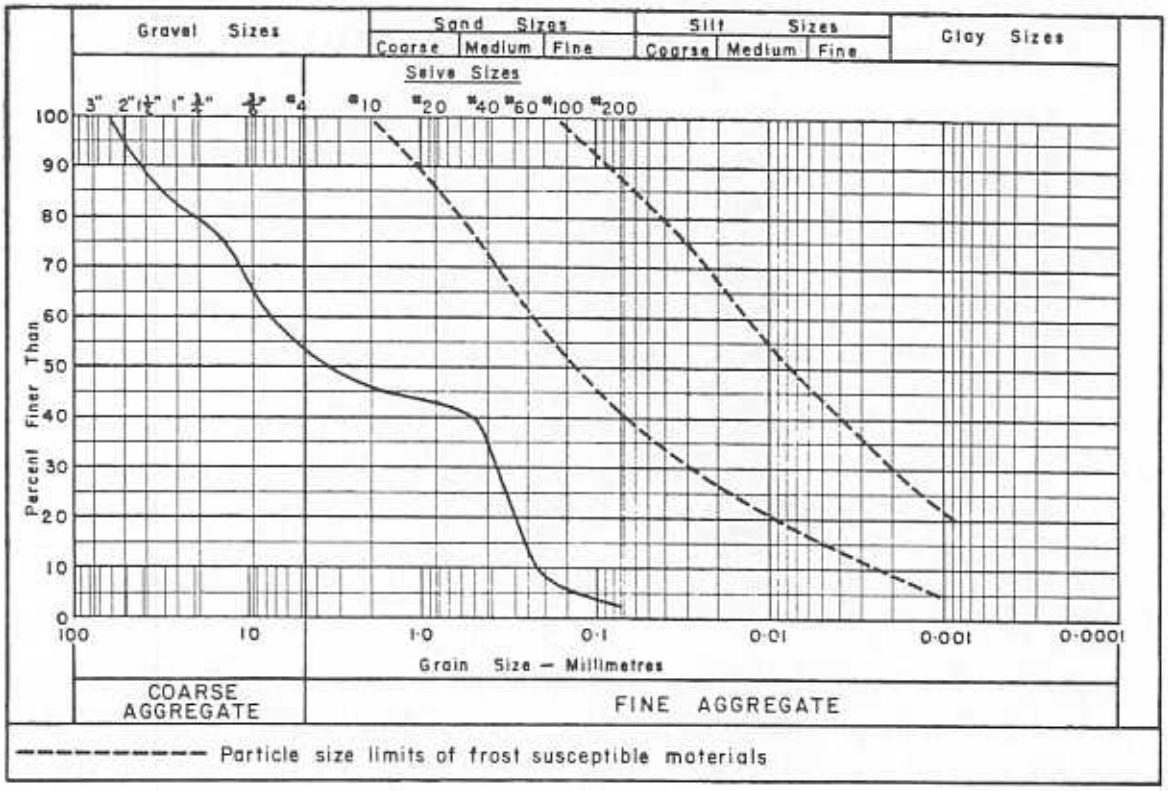
Sample Depth (Feet): 4.0 - 6.0

Moisture Content (%): 1.2

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

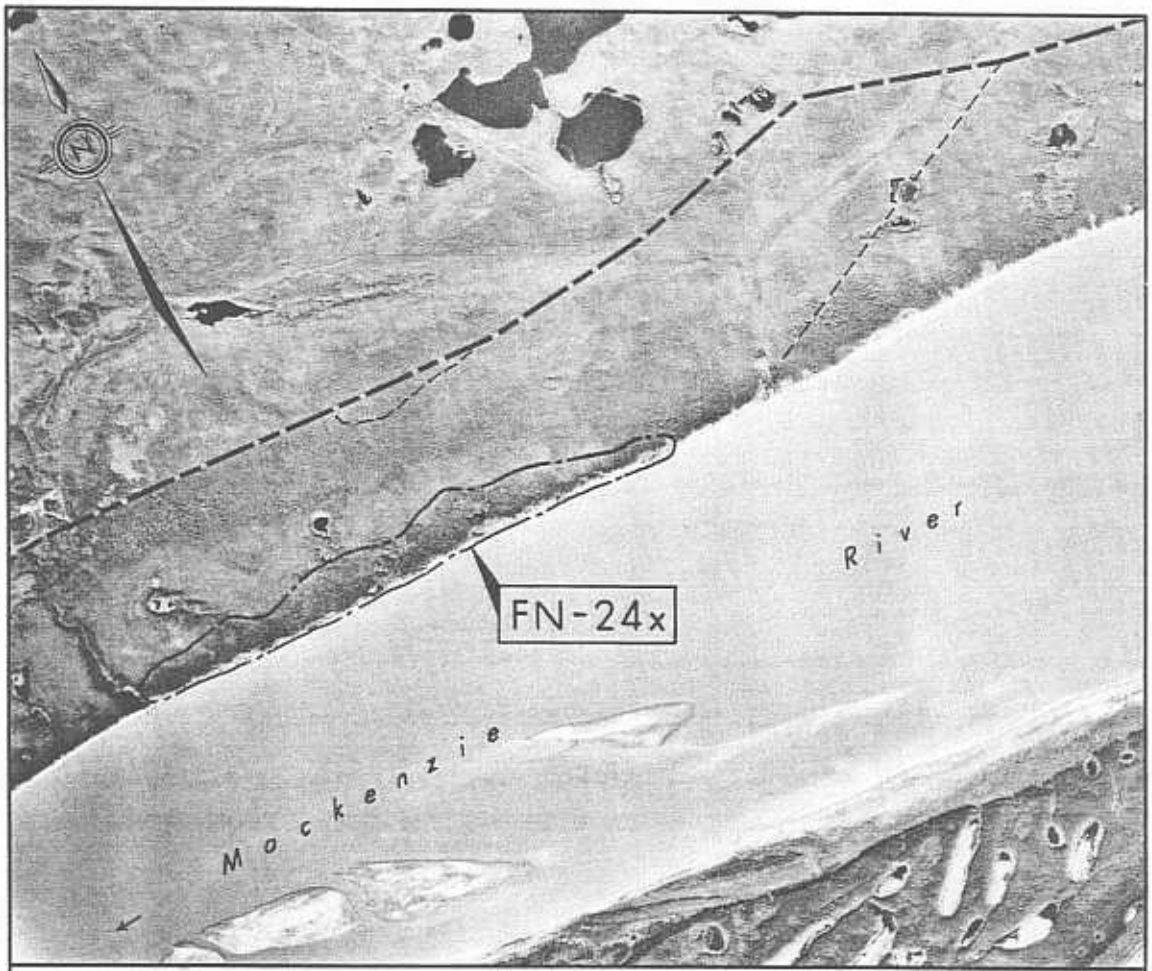
SITE NO. FN 24X

Located immediately upstream from Fort Norman on the northeast bank of the Mackenzie River, Site FN 24X consists of interbedded clay and coal strata. Smoke emissions and slumping along the bank indicate that subterranean fires are burning in the coal seams. Overlying silty and clayey glaciolacustrine sediments had been locally burned.

Type of Material: Burned silts and clays

Estimated Volume: Not established

Assessment: The burned silt and clay deposits are not considered as a granular materials source according to the terms of reference; however, future studies to determine the quality of the clay should be considered if excessive requirements for general fill material are anticipated for Fort Norman.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/161 Approximate scale: 1" = 3,000'

ENVIRONMENT

The clay deposits are interbedded with coal seams along and in the northeast bank of the Mackenzie River. At several locations along the bank, smoke emissions and slumping indicate that subterranean fires are burning in these deposits.

The heat resulting from the burning coal seams has caused partial consolidation of originally soft silty and clayey strata which locally are altered into reddish or yellowish coloured solidified layers. This material resembles the characteristics of weakly cemented silstone or mudstone.

DEVELOPMENT

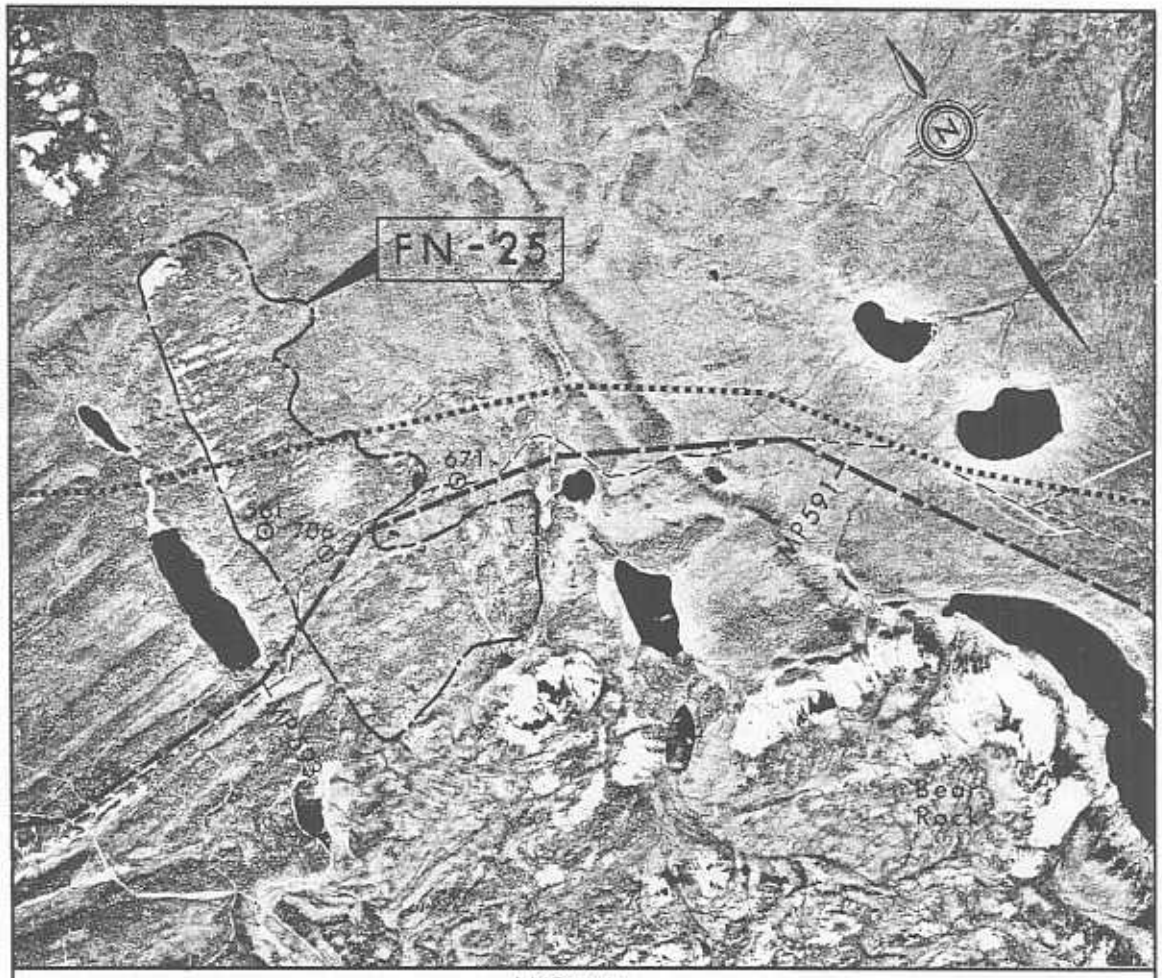
Development of this source is not considered practical at this time. However, if at some future date the requirements for general fill material become excessive, then the site should be further evaluated to determine the quality, volume and physical characteristics of the altered clay.

Future development of this site should also include operation procedures that are designed to protect the adjacent bank and water areas of the Mackenzie River.

SITE NO. FN 25

Located approximately 10 miles northwest of Fort Norman, Site FN 25 consists of Devonian limestone exposures which can be considered as the northern extension of the pronounced Bear Rock massif.

Type of Material:	Limestone; dolomitic, weathered and fractured.
Estimated Volume:	Unlimited in terms of requirements for Fort Norman.
Assessment:	Granular materials for various categories of construction requirements can be produced. The exploitation of this site will entail a quarry operation.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/156 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 25 is located approximately 10 miles northwest of Fort Norman and can, generally, be considered as the northern extension of the pronounced Bear Rock massif. The site encompasses an area approximately $1\frac{1}{2}$ miles in length by $\frac{1}{2}$ mile in width.

The ridge is basically comprised of Devonian and Ordovician limestone. The bedrock exposures are generally weathered and extensively fractured. Residual soil and colluvium in localized depressions together with discontinuous pockets of glacial till, support very sparse growths of spruce and tamarack.

There are no known critical wildlife areas in the immediate vicinity of the site.

The existing access to Site FN 25 consists of the winter road which passes through the centre of the designated site area. However, any transportation of material from this site to Fort Norman will involve a major river crossing of Great Bear River. The proposed routes of the Mackenzie Highway and the gas pipeline traverses the southern extremity of this site.

DEVELOPMENT

Site FN 25 may represent a very significant source for the granular material requirements for the community of Fort Norman because of the scarcity of naturally occurring unconsolidated granular materials in this Study Area. This site has numerous bedrock exposures which are easily accessible from the existing winter access road.

The following broad and general comments relative to development of this site for granular materials are outlined herewith:

- Quarry operations including extensive blasting and crushing of the limestone material will be required for the extraction of granular materials.

- The best quarry locations, based upon quality of extractable limestone, general access to exposed rock outcrops and approachability are in the southern portion of the site area generally adjacent to the existing winter road. When the proposed Mackenzie Highway is completed, this area would become very attractive for any future quarry operation.

- Selective excavation can be anticipated. The material from the surficial, weathered and fragmented zone meets the requirements for general fill while better quality aggregates can be produced from fresh limestone beds at greater depths below existing rock faces.

- The exploitation of manufactured aggregates from Site FN 25 would, currently, be restricted to a winter operation because the access from this site to the community of Fort Norman is limited to the existing winter road facilities and, also, requires a major crossing of the Great Bear River.

ABANDONMENT AND REHABILITATION

In general, if a well organized and controlled operation is maintained during the development and extraction of material from the quarry locations, then the problems related to abandonment and restoration would, inherently, be managed.

Shipped and discarded material should be placed in areas adjacent to the quarry base. Upon completion of the operation in a specific section of the quarry the stockpiled material may be spread evenly over the quarry floor, thus allowing for natural revegetation.

DETAILED DRILL HOLE LOG

SITE NO. FN 25 HOLE NO. 561

DATE: FEB. 24, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	MOSS:					0
0.3		OH	CLAY: organic		Nbn			
1.0		Cl	CLAY (TILL): sandy, silty stones, pebbles, cobbles		Nf			2
4								4
5.0			BEDROCK (LIMESTONE): - weathered - grey-white - rcd = 0 ? - cores shattered - 1" - ¼" thickness					6
8								8
10								10
12								12
12.0			END OF HOLE 12.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 25 HOLE NO. 671

DATE: FEB. 25, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0		Pt	PEAT: Category #14		Vx	M		0
1.0								
2		Cl	CLAY (TILL): sandy, silty rust and coal specks, stones, medium plastic, brown, cobbles		Vx	M		2
4								4
5.0								
6			BEDROCK (LIMESTONE): badly weathered		Nbn			6
8								8
10								10
12								12
14								14
16								16
18								18
20								20
20.0			END OF HOLE 20.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

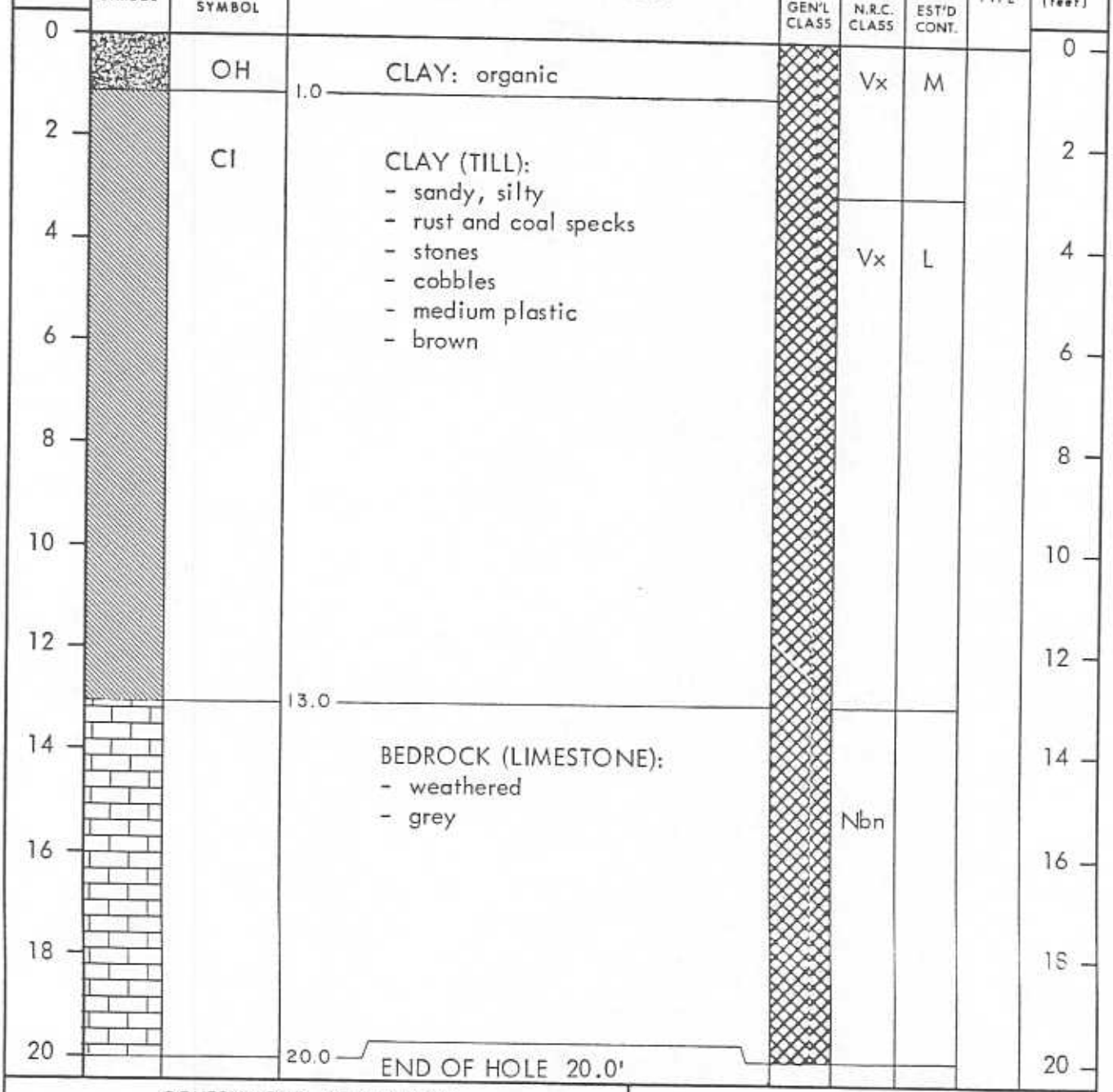
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 25 HOLE NO. 706

DATE: MAR. 5, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

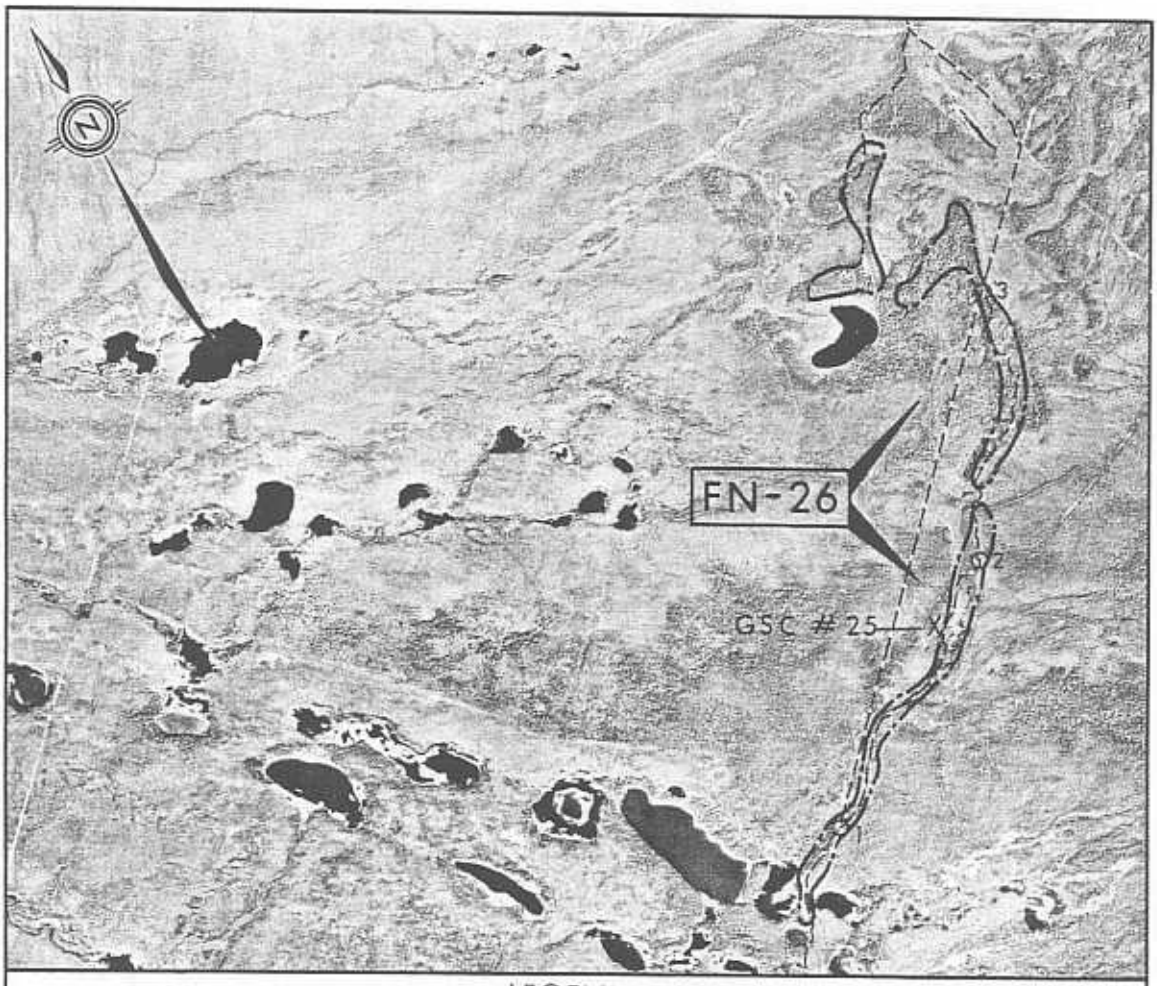
SITE NO. FN 26

Located approximately 11 miles northwest of Fort Norman on the west flank of Bear Rock, Site FN 26 consists of a narrow, sinuous esker ridge.

Type of Material: Sands and Gravels; fine to medium grained, little silt.

Estimated Volume: 2,000,000 cubic yards.

Assessment: Granular material for good quality fill and base course aggregates can be produced. The site is recommended for future development.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/150

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 26 is located approximately 11 miles northwest of Fort Norman and consists of a narrow, sinuous esker ridge along the west flank of the Bear Rock massif. The site is approximately 2 miles in length and 700 feet in width at the base. The esker ridge rises 10 to 30 feet above the gently sloping adjacent terrain and the slopes of the esker ridge are well drained. The site is approximately 12 miles from Fort Norman along the winter road and existing seismic cutlines.

The material in the esker ridge fromation consists of sands and gravels with a little silt. Minor pockets of glacial till may be irregularly incorporated. A shallow organic topsoil layer covers the entire site area and supports sparse growths of spruce and birch.

There are no known critical wildlife areas in the immediate vicinity of the site; however, the site roughly parallels a small stream that eventually flows into the Mackenzie River. Development procedures would have to be adopted whereby the stream would be isolated from active work areas of the site.

The existing access to the site from Fort Norman consists of the winter road, seismic cutlines and trails along the top of the esker ridge. The proposed Mackenzie Highway and the gas pipeline routes are located approximately 2 miles north of the northern extremity of this site.

DEVELOPMENT

The information obtained during the winter drilling program has outlined the following conditions relative to the quality and quantity of available granular materials at Site FN 26.

- The overburden, consisting of a thin veneer of topsoil and silt, is very shallow varying in depth from a few inches to approximately 4 feet below existing ground surface.

- The materials in the esker ridge consists of fine to medium grained, well graded sands and gravels which are considered suitable for use in road base, backfill, embankment, and base course construction requirements.

- The granular materials in the esker ridge appear to be partially sorted during deposition and the coarser grained material (ie. gravels) are more prevalent at greater depths and towards the northeastern portion of the esker ridge.

Site FN 26 may represent a possible source for granular materials for the community of Fort Norman although the haul distance is quite significant and entails the crossing of Great Bear River. It is considered that the relative importance of any recoverable granular materials in Site FN 26 may be more significant to supply the granular material requirements for the construction of utilities on the west side of Bear Rock.

The following operational guidelines should be considered if Site FN 26 is developed and exploited for the granular material requirements of the Fort Norman community or in

the construction of local utilities.

- The development of borrow pits for Site FN 26 should be initiated from the north-eastern portion of the esker ridge where better quality and better graded granular materials are anticipated.

- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.

- The thin veneer of organic topsoil and inorganic silt should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.

- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain into the small stream channel on the southwest flank of the esker ridge.

- Vertical excavation procedures should be adopted to minimize the extent of the exposed borrow pit area to erosion by wind and water. Also, vertical excavation will permit selective removal of varying types of granular materials because the in situ orientation of the deposited material is in a vertical sequence.

- Conventional excavation equipment such as dozers, overhead loaders and minor ripping equipment can be utilized for extracting the borrow material from this site.

- A new access road would have to be constructed from the north end of Site FN 26 to the existing winter road or to the routes of the proposed gas pipeline or Mackenzie Highway routes for the transportation of removed borrow material.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site FN 26 is developed as a borrow pit.

- Recontouring of borrow pit areas to maintain good drainage to the adjacent terrain.

- Replacement and spreading of organic topsoil from pre-production stockpiled onto the recontoured exposed borrow pit areas.

- Revegetation of the restored borrow pit areas.

DETAILED DRILL HOLE LOG

SITE NO. FN 26 HOLE NO. DH-1

DATE: JAN. 29, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		ML-SM	SILT: some sand, medium brown		Vs	M		0
3								3
4.0		SM-SP	SAND AND SILT: medium to rust brown					
6							MC	6
6.0		SW-SP	SAND: trace silt, fine to medium grained, few pebbles to 3/8", rust brown		V			
9								9
12				UF				12
15								15
18								18
21								21
22.0			TOTAL DEPTH 22.0'					
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 26 HOLE NO. DH-2

DATE: JAN. 29, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		GM-GP	GRAVEL: some silt, little sand, fine grained, medium to dark brown		V	L-M		0
2								2
3.0								
4		ML	SILT: some sand, medium brown					4
			clay pockets, greyish blue from 5.0'		Vs	M		
6								6
7.0								
8		SM-SP	SAND: little silt, fine grained, rust brown, wet	UF				8
10								10
12								12
12.0			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 26 HOLE NO. DH-3

DATE: JAN. 29, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		SM-SP	SAND: some silt, few pebbles, medium to dark brown					0
1.0								
3			SAND: little silt, fine grained, medium brown					3
6		SM-SP			Vs	M	MC	6
9								9
12			12.0					12
15		GW-GP	GRAVEL: some sand, little silt, fine grained, few boulders, medium brown		V	L-M		15
18								18
21							MC	21
			22.0					
24			TOTAL DEPTH 22.0'					24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

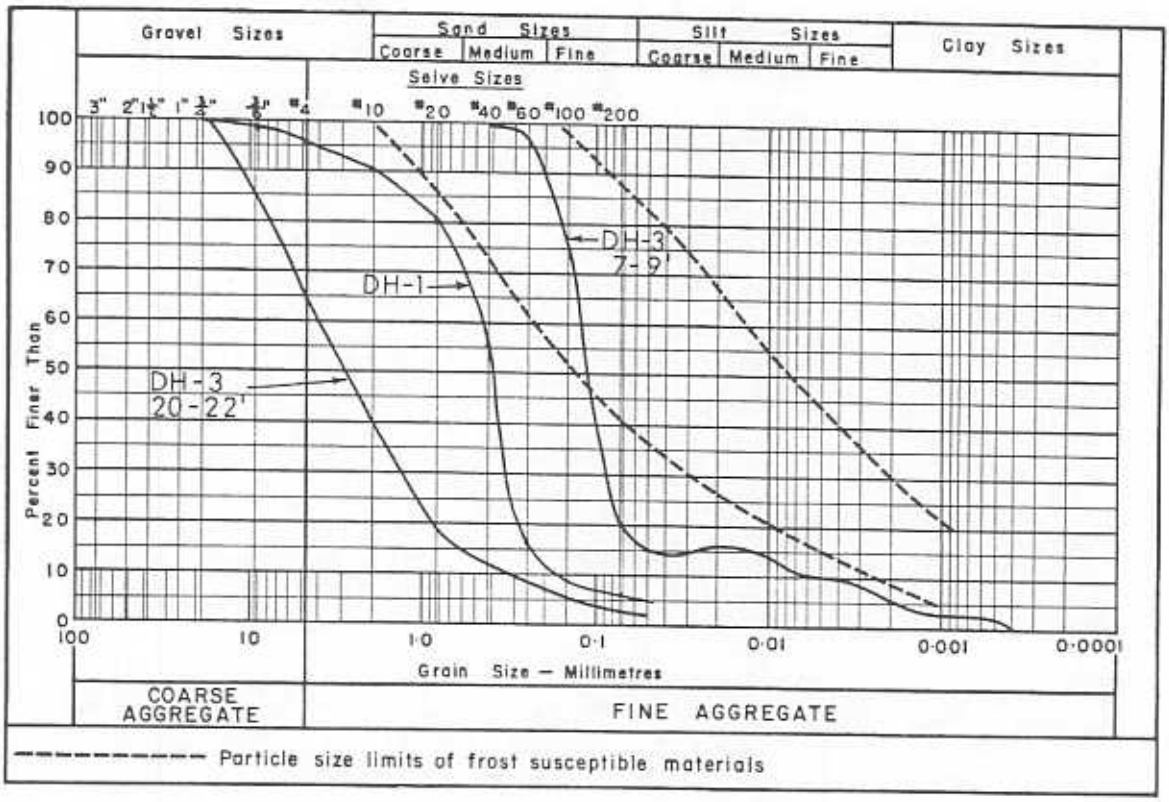
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 26/ DH 1	FN 26/ DH 3	FN 26/ DH 3
Sample Depth (Feet):	8.0-10.0	7.0-9.0	20.0-22.0
Moisture Content (%):	3.7	12.5	7.4
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location: GSC #25

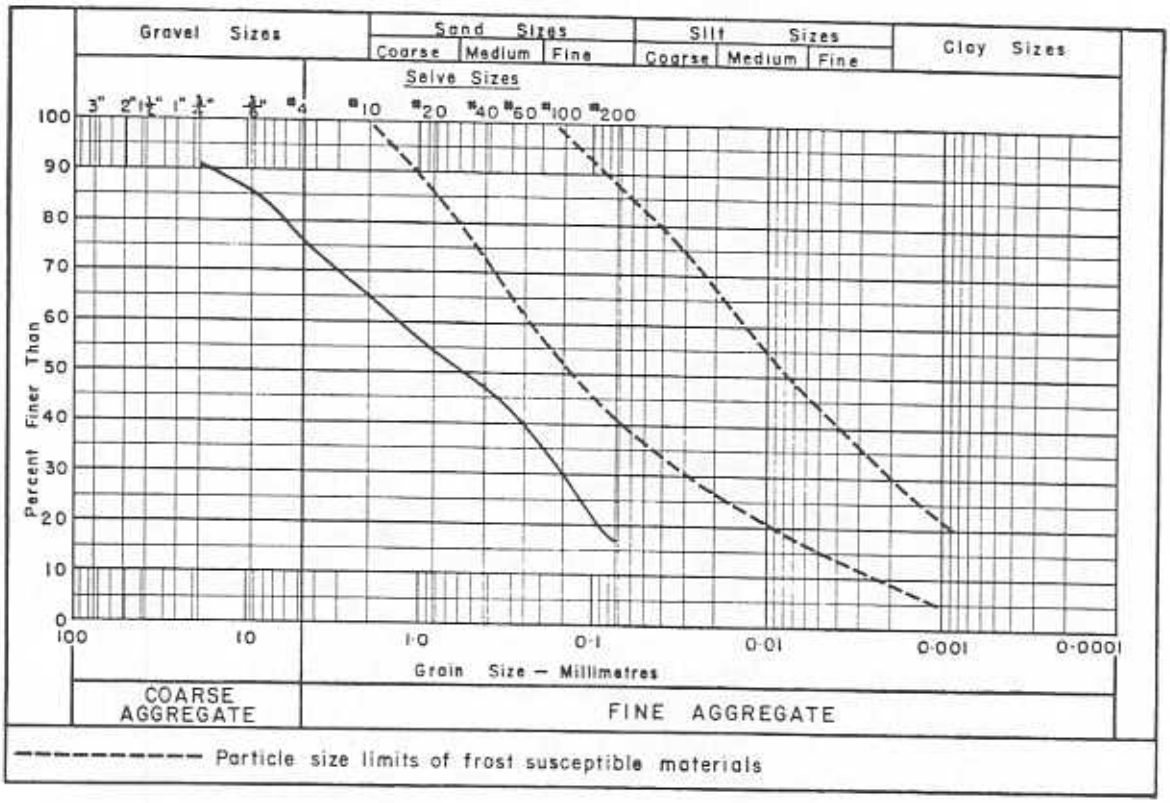
Sample Depth (Feet): +5

Moisture Content (%): 4.7

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

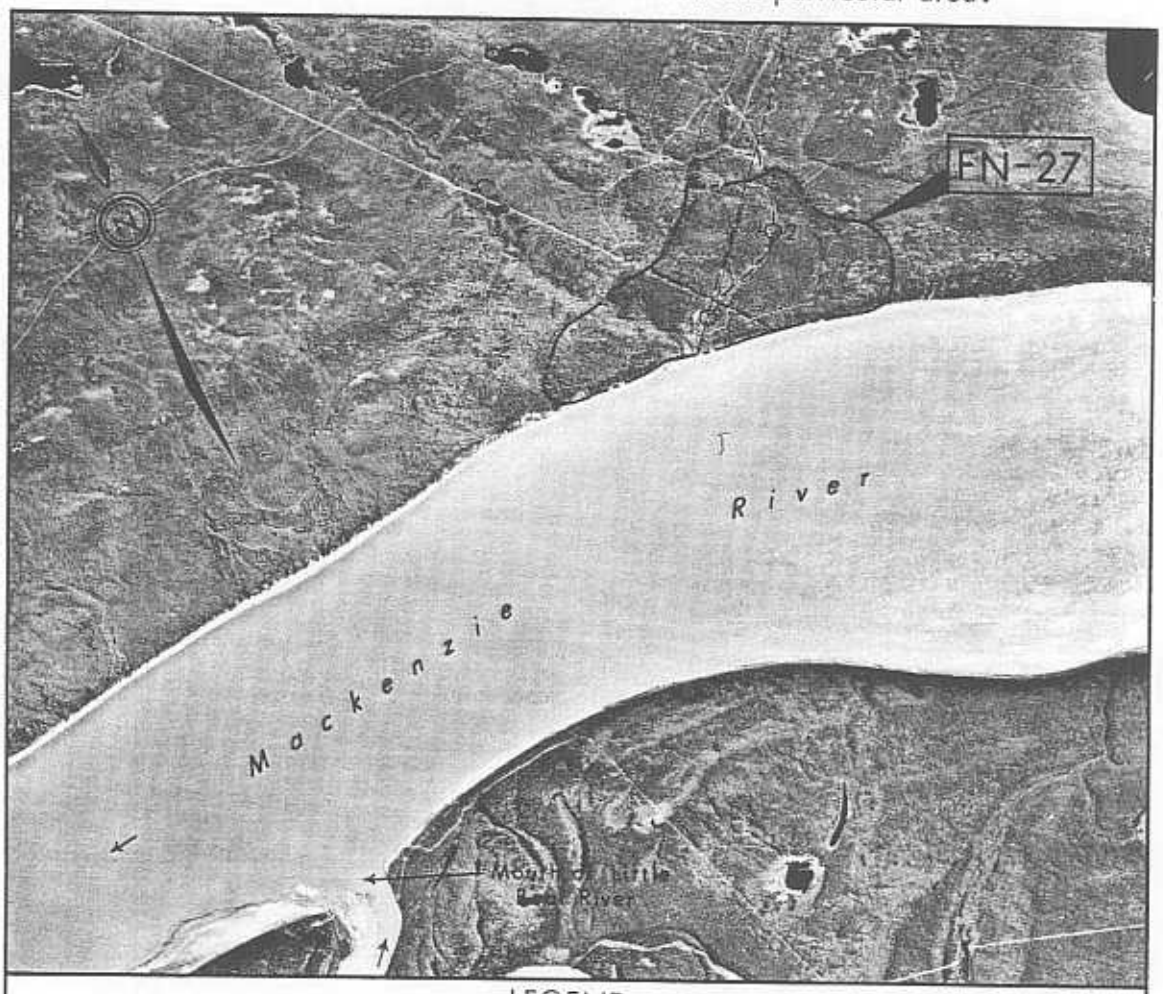
SITE NO. FN 27

Located approximately 9 miles west of Fort Norman, Site FN 27 consists of an elevated terrace deposit on the north bank of the Mackenzie River.

Type of Material: Sand; some silt, small pockets of gravel.

Estimated Volume: 700,000 cubic yards.

Assessment: Poor quality material suitable only for very marginal general fill. Because transportation of material from this site to the community would not be justified, the site should only be developed if a need for general fill material arises within this particular area.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22862/33

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 27 is located approximately 9 miles west of Fort Norman and $2\frac{1}{2}$ miles downstream of the west escarpment of Bear Rock. The site consists of elevated terrace deposits on the north bank of the Mackenzie River and encompasses an area approximately 4000 feet in length and 1000 feet in width.

The material in the terrace deposit consists of silty sands with some gravel pockets. The adjacent terrain is relatively flat, thermally sensitive and is inundated with numerous lakes of various size. A small creek draining into the Mackenzie River flanks the southwest perimeter of Site FN 27.

There are no known critical wildlife areas in the immediate vicinity of the site; however, the site is within the broad flyway that is utilized by waterfowl during spring and fall migration. Site FN 27 parallels the north bank of the Mackenzie River for approximately 3,000 feet and is also intersected by a small stream that traverses across the site prior to flowing into the Mackenzie River. Development procedures should be adopted whereby all watercourses are protected in the event the site is exploited.

DEVELOPMENT

In view of the scarcity of granular materials within the Fort Norman Study Area, Site FN 27 was investigated in detail during the winter drilling program. The results of the drilling program confirmed the preliminary assessment of the site relative to the lack of coarse granular materials. The subsurface soils encountered in the drill holes consisted of very fine grained sands with very high silt contents which are unsuitable for any granular material requirements.

Therefore, it is considered that transportation of very marginal general fill material would not be justified. If a need for such material arises within this general area, the site can be developed.

DETAILED DRILL HOLE LOG

SITE NO. FN 27 HOLE NO. DH-1

DATE: JAN. 29, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, dark brown					0
1.0								
3		ML-CL	SILT: some clay, low to medium plastic, medium to light brown, pebbles to 3/8"					3
6			6.0					6
9		SW	SAND: some gravel, rust brown, few pebbles to 3/8" size		V	M	MC	9
11.0								
12		SM-SP	SAND AND SILT: medium brown, wet from 14.0'					12
15				UF				15
18								18
21			21.0 TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 27 HOLE NO. DH-2

DATE: JAN. 29, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		ML-CL	SILT: some clay, brown.					0
2			2.0					2
		ML	SILT: little sand, few pebbles to 3/8" size, light-brown.		Vs	M		
4								4
6			6.0					6
		SM-SP	SAND AND SILT: dark brown, few pebbles to 3/8"					
8								8
10			----- - very moist at 10' depth					10
				UF				
12			12.0					12
			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

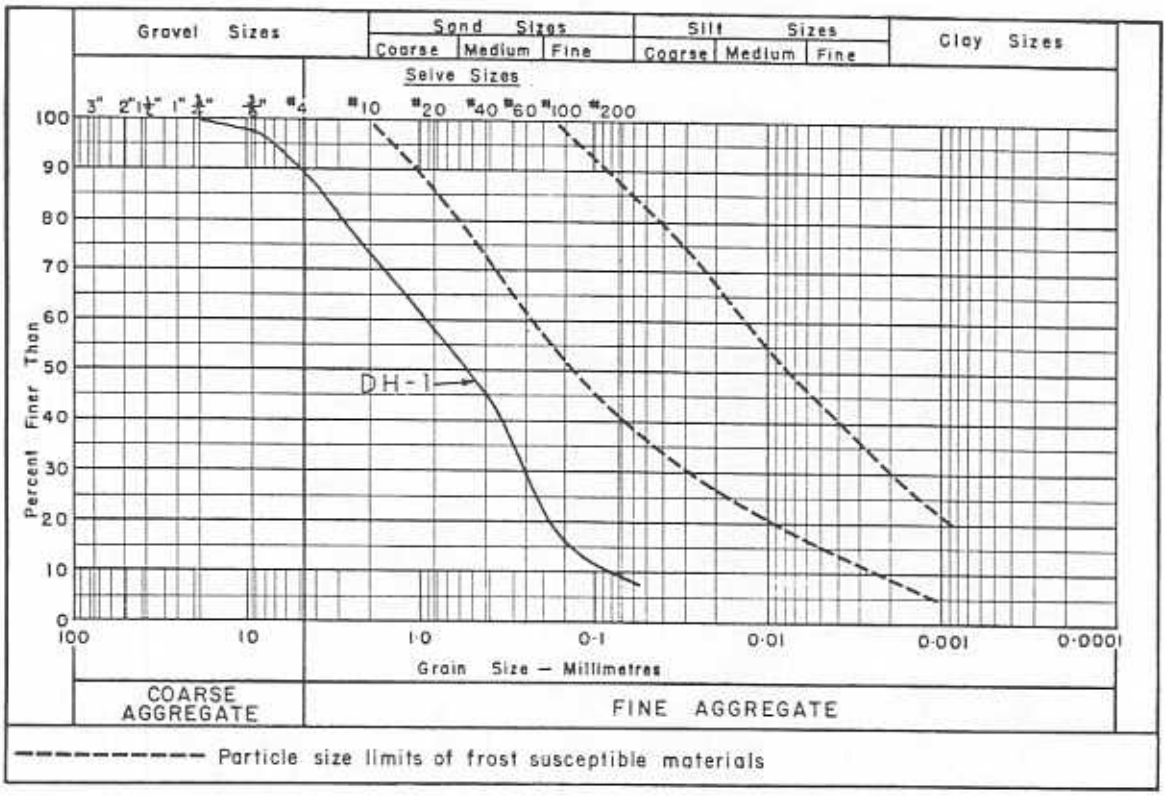
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 27/ DH 1
Sample Depth (Feet):	7.0-9.0
Moisture Content (%):	4.6
Ice Content (%):	-
Organic Content (%):	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SITE NO. FN 28X

Located approximately 11 miles northwest of Fort Norman along the base of the western escarpment of Bear Rock, Site FN 28X consists of glacial outwash deposits partially overlain by talus cones.

Type of Material:	Silt; some clay, few pebbles (TILL LIKE).
Estimated Volume:	Not established.
Assessment:	Site FN 28X is not recommended for development.

LEGEND

----- All weather road	..... Required access
----- Existing trails and cutlines	-·—·- Site limit
..... Proposed Gas Pipeline	-·-·-·- Proposed Mackenzie Highway
⊙ DH Drill Hole	⊕ TP Test Pit

Airphoto No. A22889/148 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 28X is located approximately 11 miles northwest of Fort Norman along the base of the western escarpment of Bear Rock. The site consists of glacial till deposits partially overlain by more recent talus cone deposits. Site FN 28X is located immediately east of Site FN 26 and approximately $2\frac{1}{2}$ miles north of the Mackenzie River.

The in situ material at Site FN 28X consists of silt with some clay and a few scattered pebbles and is generally till-like in texture. Mixture of silt and angular limestone fragments may be expected in the adjacent upslope talus cone deposits. The organic topsoil horizon is very shallow and supports a very sparse growth of spruce, occasional poplar and birch. The surficial drainage of the adjacent terrain is southwesterly into the Mackenzie River.

There are no known critical wildlife areas in the immediate vicinity of the site.

The existing winter road and the seismic cutline which is located approximately $\frac{1}{2}$ mile west of Site FN 28X provide the only equitable access to Fort Norman. The proposed routes of the gas pipeline and the Mackenzie Highway are located approximately 2 miles north of Site FN 28X.

DEVELOPMENT

Site FN 28X was investigated in detail during the winter drilling program. Based upon geomorphic features, coarser slope wash deposits and slope debris were expected. The material encountered in drill holes, however, consisted primarily of silt with some clay and a few scattered pebbles with a general till-like texture. Therefore, Site FN 28X is not recommended for development as no granular materials are available for exploitation.

DETAILED DRILL HOLE LOG

SITE NO. FN 28 X

HOLE NO. DH-1

DATE: JAN. 29, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0		Pt	PEAT: organic, fibrous, muskeg					0
1.0								
2			SILT: some clay, few pebbles to 3/8", medium brown					2
4		ML-CL	- becoming light brown at 4.0', stones to 1" size (TILL LIKE)		Vs	M		4
6								6
8								8
9.0								
10		ML	SILT: some sand, few pebbles					10
12								12
12.0			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 28 X

HOLE NO. DH-2

DATE: JAN. 29, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: organic, fibrous					0
1.0								
2		ML	SILT: some clay, medium to dark brown.					2
4					Vs	M		4
6		ML-CL	- few pebbles to $\frac{1}{4}$" size at depths greater than 5.0' (TILL LIKE)					6
8								8
10								10
12								12
12.0			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 28 X

HOLE NO. DH-3

DATE: JAN. 29, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, dark brown.			M		0
2			2.0					2
			SILT: medium to dark brown.		Vs	H		
4								4
6		ML	- trace sand from 6.0', few pebbles, medium brown. (TILL LIKE)		V	M		6
8								8
10								10
12			12.0					12
			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 28 X

HOLE NO. DH-4

DATE: JAN. 29, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, dark brown			M		0
2								2
3.0								
4			SILT: trace sand, medium to dark brown			H		4
6		ML			Vs			6
7.0			- little sand from 7.0', few pebbles to ½" size, light brown (TILL LIKE)					
8								8
10						M		10
12								12
12.0			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 28 X

HOLE NO. DH-5

DATE: JAN. 29, 1973 | LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0								0
2		OL	SILT: organic, dark brown			H		2
4								4
5.0								
6		ML	SILT: little sand, few pebbles to 3/4" size, medium to dark brown (TILL LIKE)		Vs	M		6
8								8
10								10
12								12
13.0			TOTAL DEPTH 13.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

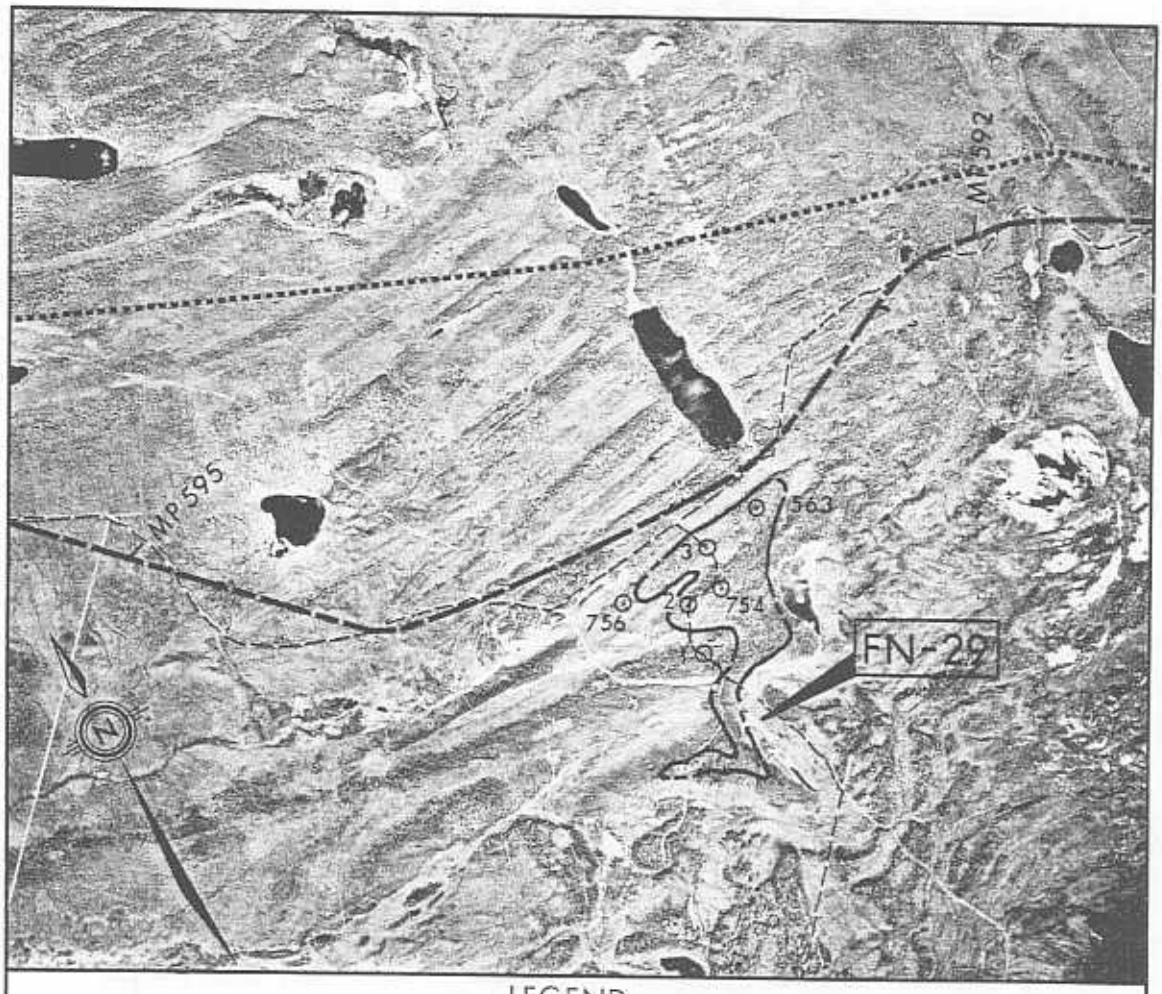
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SITE NO. FN 29

Located approximately $8\frac{1}{2}$ miles north of Fort Norman, Site FN 29 consists of a glacial outwash deposit on the western flanks of the Bear Rock massif.

Type of Material:	Sands and Gravels; well graded, fine to medium grained.
Estimated Volume:	300,000 cubic yards.
Assessment:	Good quality material for road bases, building pads, and marginal surface course aggregates. Site FN 29 is recommended as a possible source of granular materials.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22934/155

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 29 is located approximately $8\frac{1}{2}$ miles north of Fort Norman on the western slopes of the Bear Rock massif immediately adjacent to the south side of the existing winter road. The site is generally comprised of shallow glacial outwash deposits overlying morainal fill.

The in situ material at Site FN 29 consists of well graded, medium to coarse grained sands and fine grained gravels. Minor bodies of glacial till may be irregularly scattered throughout the outwash deposit. The organic topsoil is relatively shallow, varying in thickness from 1 to $1\frac{1}{2}$ feet, and supports a moderate growth of spruce with occasional stands of poplar and birch. The adjacent terrain immediately north of Site FN 29 consists of drumlinized ground moraine, longitudinally orientated in an east-west direction. The surficial drainage of the site area and adjacent terrain is westerly.

There are no known critical wildlife areas in the immediate vicinity of the site.

The existing winter road provides excellent access to this site area. Furthermore, the proposed location of the Mackenzie Highway is nearby coincident with the existing alignment of the winter road and will ensure excellent future access to Site FN 29. Any proposed development of Site FN 29 for the granular material requirements for the community of Fort Norman will entail a major river crossing of the Great Bear River.

DEVELOPMENT

The results of the winter drilling program have confirmed the following conditions relative to the quality and quantity of available granular materials at Site FN 29.

- The quality of granular materials available at Site FN 29 varies from well graded, medium to coarse grained sands to fine grained gravels. The detailed description of the subsurface conditions is noted on the individual drill hole logs.

- The depth of topsoil and silt overburden is relatively shallow and varies from a few inches to 4 feet.

- In general, it is considered that the granular materials from this site are suitable good quality fill material in the "Pit Run" condition for building pads, road bases and, also, for marginal surface course aggregate requirements.

- An estimated quantity of 300,000 cubic yards of granular materials is available at this site.

Site FN 29 is recommended for development as a possible source of granular materials for the community of Fort Norman. This site would, in particular, become very attractive when the proposed Mackenzie Highway is completed and provides good all weather access for the exploitation of granular materials. The following guidelines for borrow pit operations should be followed:

- The development of borrow pits for Site FN 29 should be initiated from the northern extremity of the site area in the immediate vicinity of DH-3 where proven depths of good quality gravels have been noted.

- Adequate buffer zones of existing till growth should be retained between the existing winter road or proposed Mackenzie Highway route and any proposed borrow pit debelopment.

- The existing tree growth and related vegetation should be cleared and removed from borrow pit locations in accordance with current land use regulations.

- The thin veneer of organic topsoil and underlying silt should be stripped, removed and stockpiled in designated locations adjacent to the borrow pit areas.

- The use of conventional excavation equipment such as dozers, overhead loaders, back-hoes and light ripping equipment is considered adequate for removing material from this site.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

- Precontouring of the pit area to provide general drainage compatible with the natural drainage of the adjacent terrain.

- Replacing stockpiled surficial waste material onto the abandoned borrow pit areas.

- Reseeding of the recontoured pit areas may be considered, although existing cutlines in the area indicate that understory growth and eventually spruce will be naturally reestablished.

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. DH-1

DATE: JAN. 30, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, little organic, dark brown		Vr			0
1.5								
2		ML	SILT: little sand, trace clay, occasional rounded pebbles to 2", medium plastic, greyish brown (TILL)			M		2
4								4
6								6
6.5								
8		ML-SM	SILT AND SAND: fine grained, medium brown		Vx			8
10								10
12								12
12.0			TOTAL DEPTH 12.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. DH-2

DATE: JAN. 30, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt and organic, dark brown					0
1.0								
2		ML-GM	SILT: some gravel, trace sand, gravel sizes ¼" to 2", rounded to subangular pebbles					2
4								4
4.0								
6		GM	GRAVEL: little sand, trace silt, predominantly subangular to sub-rounded pebbles to 2", occasional cobbles, grey		Vx	M		6
8								8
8.0								
10		GM-GP	GRAVEL AND SAND: poorly graded, medium grained, sub-rounded pebbles of limestone and quartzite, few granite and cherts, maximum 1", greyish brown				M.C.) G.S.)	10
12								12
14								14
15.0			TOTAL DEPTH 15.0'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. DH-3

DATE: JAN. 3, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, little organic, dark brown					0
1.5								
2		GM-GP	GRAVEL AND SAND: coarse grained, poorly graded, sub-rounded to subangular pebbles predominantly limestone and quartzites, few granites and cherts, maximum 1" size, greyish brown		Vx	M		2
4								4
6								6
8							M.C. G.S.	8
9.0								
10		SM-SP	SAND: little silt, trace gravel and clay, medium grained, poorly graded, pebbles to 1" size, damp, brown	UF			M.C. O. G.S. P.	10
12								12
14								14
14.0			TOTAL DEPTH 14.0'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. 563

DATE: FEB. 25, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	SILT: organic		Vx	M		0
1.0								
2		SM	SAND (TILL): silty, low-nonplastic, stones brown		Vx	L		2
4								4
6								6
8								8
10								10
12			- siltier					12
14								14
16								16
16.0								
		CH	CLAY (TILL): silty, sandy, high plastic, coal, rust, stones, grey					
18								18
20								20
20.0			END OF HOLE 20.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. 754

DATE: MAR. 5, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		GP	GRAVEL (TILL): sandy, silty, rust and coal specks, cobbles, brown		Nf			0
8.0			- sandier					8
16.0		CI	CLAY (TILL): sandy, silty, rust and coal specks, stones, medium plastic, brown		Nbn			16
20.0			END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 29 HOLE NO. 756

DATE: MAR. 5, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0								0
		CI	CLAY (TILL): silty, rust and coal specks, stones, medium plastic, brown		Vs	M		
2								2
4			4.0					4
			- sandier		Vs	L		
			- cobbles					
6			- boulders		Nbn	L		6
8					Vc	L		8
					Vx	L		
10								10
					Nbn			
12								12
14								14
16								16
18			18.0					18
			- grey		Nbn			
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

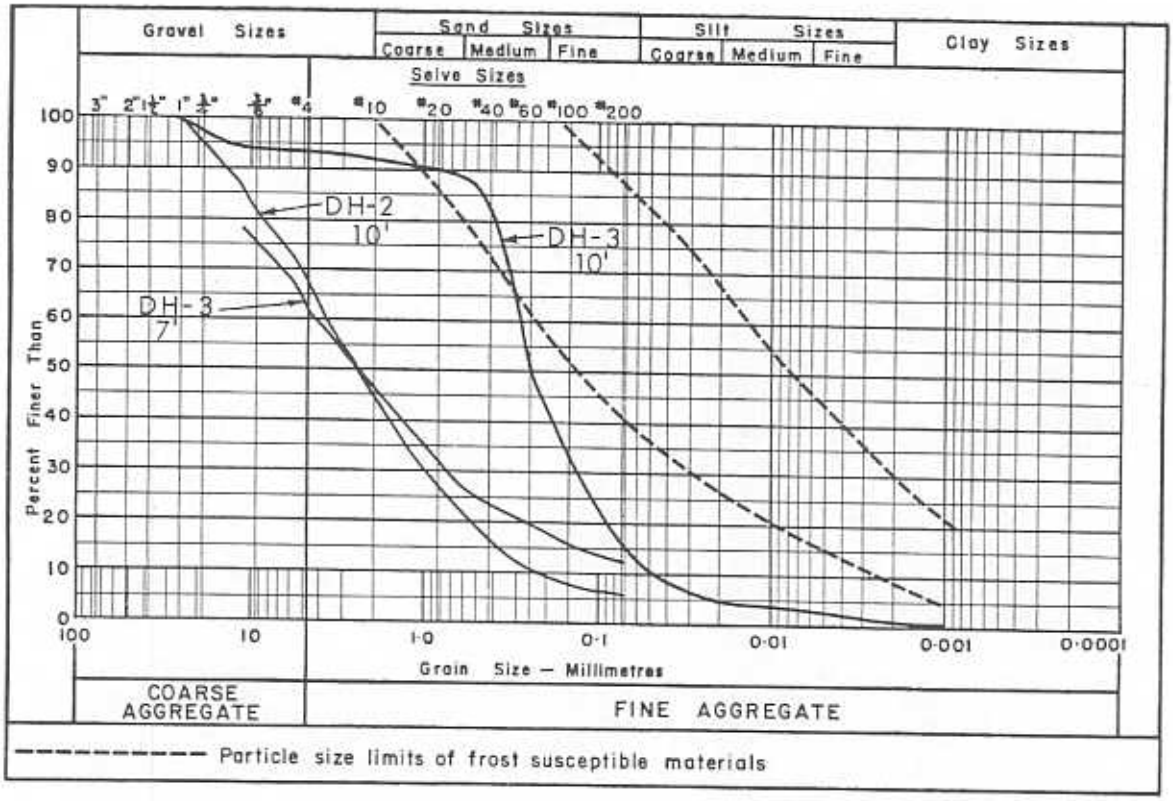
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FN 29/DH 2	FN 29/DH 3	FN 29/DH 3
Sample Depth (Feet):	10.0	7.0	10.0
Moisture Content (%):	3.7	3.5	4.8
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



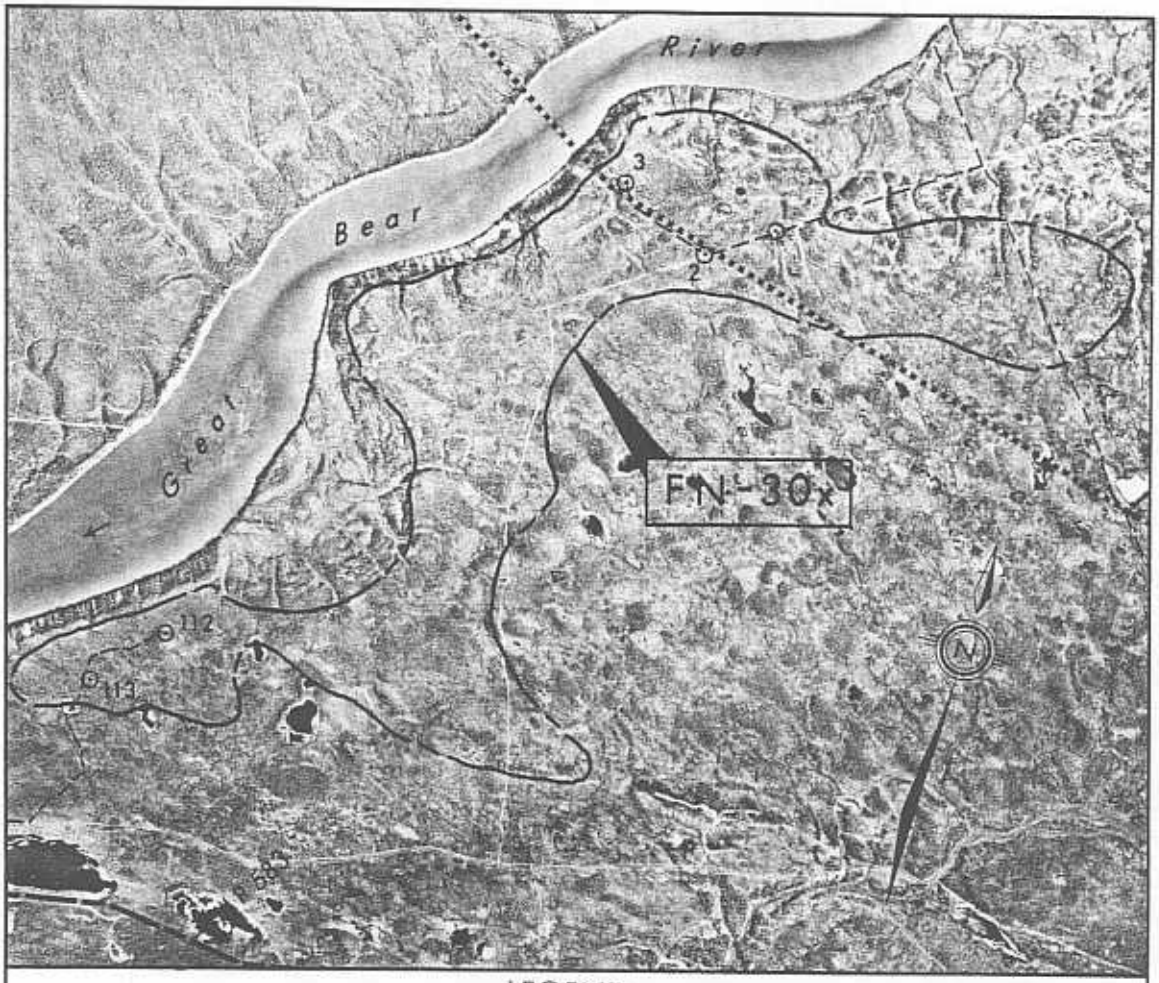
PETROGRAPHIC ANALYSIS: (FN 29/DH 3 at 10.0')

Limestone and dolomite (sound)	56.4%
Quartzite	31.0%
Igneous	8.2%
Chert	2.5%
Deleterious ferruginous siltstone and sandstone	2.0%

SITE NO. FN 30X

Located approximately 1 mile north of Fort Norman along the eastern banks of the Great Bear River, Site FN 30X consists of glaciolacustrine plain.

Type of Material:	Sand; some silt, very fine grained.
Estimated Volume:	Not established.
Assessment:	Site FN 30X is not recommended for development because of poor quality material. Material of the same quality is available in the immediate vicinity of the townsite.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22887/108

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 30X is located approximately 1 mile north of Fort Norman and extends upstream along the eastern shoreline of Great Bear River for approximately 4 to 5 miles. The site, consisting of glaciolacustrine deposits surficially reworked by wind action, forms the plateau flanking the Great Bear River channel.

The material at Site FN 30X consists of very fine grained, poorly graded sands with a relatively high silt content. This silty sand is considered quite frost susceptible and unsuitable for most construction requirements.

The adjacent terrain to the east is relatively flat, poorly drained, has numerous small lakes and bogs and supports moderately dense growths of spruce in excess of 30 feet in height. The western periphery of the site is incised with numerous, steep, dry, erosional gullies.

There are no known critical wildlife areas in the immediate vicinity of this site. However, this site is opposite and slightly downstream from the mouth of the Brackett River which is reported to contain gravel spawning beds which are utilized by grayling.

An existing seismic line traversing the entire site area, represents the only available access. The proposed Mackenzie Highway is located $\frac{1}{2}$ mile immediately south of the site.

DEVELOPMENT

Site FN 30X is not recommended for development because the in situ material encountered to depths investigated is of very low quality and similar material is available in the immediate vicinity of the townsite (ref. Site FN 14). Moreover, the access to the site is across a poorly drained terrain which may, locally be thermally sensitive, especially if protective vegetation cover is removed.

DETAILED DRILL HOLE LOG

SITE NO. FN 30X

HOLE NO. DH-1

DATE: FEB. 2, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: little silt, organic, fibrous, dark brown to black		Vx	M		0
0.5			SAND: trace silt, fine grained, poorly graded, grey					
2								2
4								4
6								6
8								8
10		SM-SP					M.C. G.S. H. O.	10
11.0			- silt pockets from 11.0'					
12								12
14								14
16								16
18								18
18.0			TOTAL DEPTH 18.0'					
20								20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 30 X

HOLE NO. DH-2

DATE: FEB. 2, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	TOPSOIL: trace silt, organic, fibrous, dark brown		Vs			0
1.0								
2		SM-SP	SAND: trace silt, fine grained, poorly graded, frequent clean sand layers ½' to 1.0' thick, grey		Vx & Vs	M		2
4								4
6								6
8								8
10								10
12								12
14								14
15.0			TOTAL DEPTH 15.0'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 30 X

HOLE NO. DH-6

DATE: FEB. 2, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	TOPSOIL: trace silt, high organic, fibrous, dark brown		Vs	H		0
0.5								
2		SM-SP	SAND: trace silt, fine grained, poorly graded, grey		Vx & Vc			2
4								4
6						M		6
8								8
10							M.C.	10
15					Vc	L		15
20								20
22.0			TOTAL DEPTH 22.0'					
25								25

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 30X HOLE NO. B1 112

DATE: DEC. 12, 1972 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: Category #4		Nbn			0
1.0								
3			SAND: silty, non-plastic, brown					3
4.0		SM	-slightly clayey					
6								6
6.5			-silty					
9								9
12								12
13.0			- slightly silty					
15								15
18								18
21								21
23.0		CH			Vx	M		
24			CLAY: high plastic, grey					24
24.0			END OF HOLE 24.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 30X HOLE NO. B1 113

DATE: DEC. 12, 1972 | LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: category #4					0
		SM	SAND, SILT: fine sand, silty, non-plastic, brown		Nbe			
3					Nbn			3
5.0			- very silty - low plastic					
6								6
9								9
11.0			- less silt - non-plastic					
12								12
15								15
18								18
21								21
23.0		CH	CLAY: high plastic, grey		Vx	M		
24								24
24.0			END OF HOLE 24.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

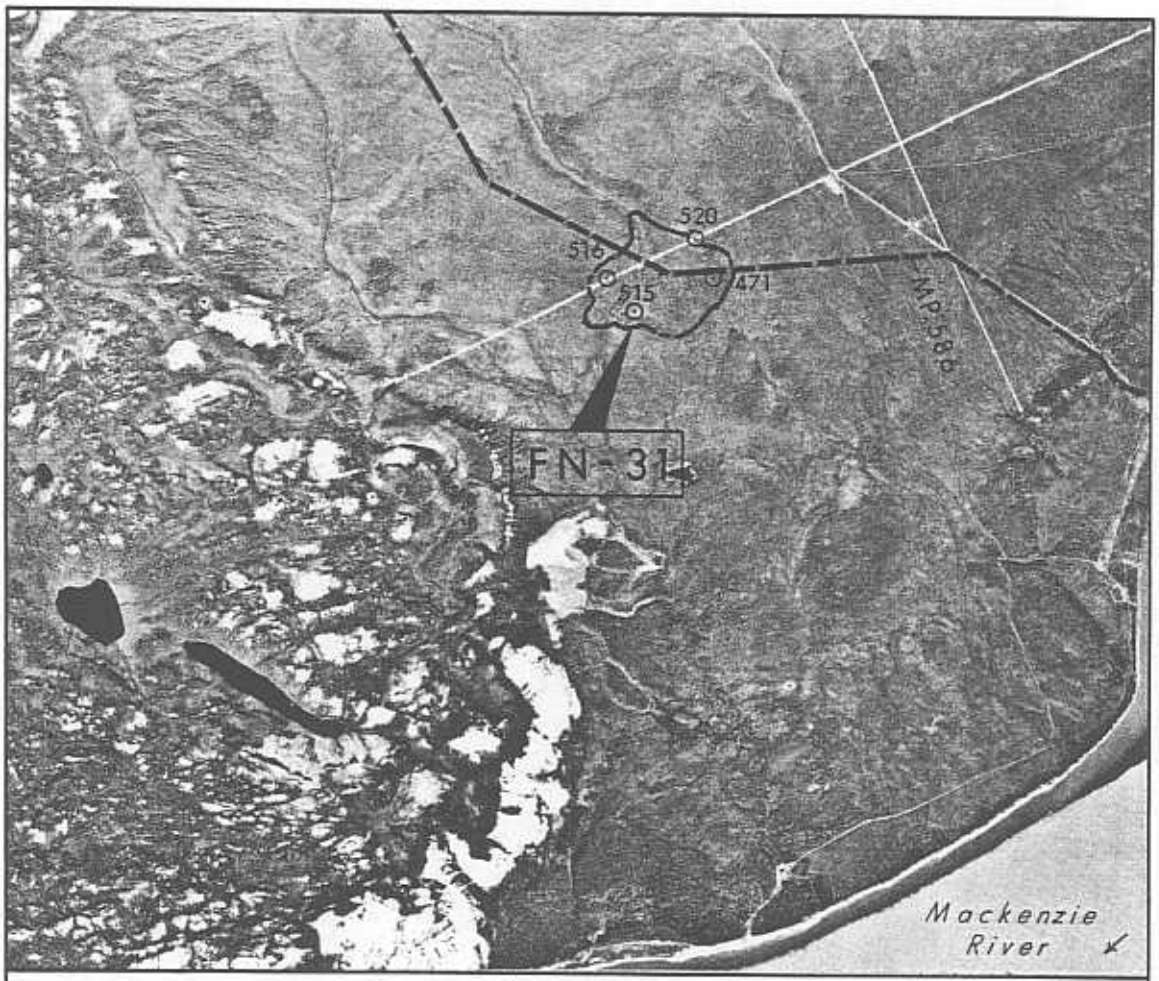
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SITE NO. FN 31

Located approximately $2\frac{1}{2}$ miles west of Fort Norman, Site FN 31 consists of a fluvial fan deposited at the mouth of a former meltwater channel.

Type of Material:	Sand; some silt, gravel pockets.
Estimated Volume:	75,000 cubic yards.
Assessment:	Fair quality material for embankments, building pads and other general fill purposes. The proposed highway crosses the site area.



LEGEND

- All weather road
- Existing trails and cutlines
- Proposed Gas Pipeline
- ⊙ DH Drill Hole
- Required access
- Site limit
- Proposed Mackenzie Highway
- ⊕ TP Test Pit

Airphoto No. A22889/147

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FN 31 is located on the proposed Mackenzie Highway right-of-way, approximately $2\frac{1}{2}$ miles west of the Great Bear River. It encompasses a shallow and flat fluvial fan approximately 1000 feet wide and 2000 feet long. The fan had been deposited at a mouth of a gully incised into a rolling and ridged ground moraine composed of glacial till. Southern reaches of the fan overlie a gently sloping glacial lake basin with deltaic sands and silts at the ground surface.

The in situ material at Site FN 31 consists of medium to coarse grained sands with isolated pockets of medium to coarse gravel. The organic topsoil layer is generally about 2 to 3 feet in thickness, and supports a moderate growth of spruce with occasional stands of poplar and birch. The surficial drainage of the site area is to the south.

There are no known critical wildlife areas in the immediate vicinity of the site.

The proposed location of the Mackenzie Highway traverses the site thus providing excellent future access. Any proposed development of Site FN 31 for the granular material requirements for the community of Fort Norman will entail a major river crossing of the Great Bear River.

DEVELOPMENT

The results of the winter drilling program have confirmed the following conditions relative to the quality and quantity of available granular materials at Site FN 31.

- The quality of granular materials available at Site FN 31 varies from medium grained sands to isolated pockets of gravel. The detailed description of the subsurface conditions is noted on the individual drill hole logs.

- The depth of overburden is relatively shallow and varies from a few feet to a maximum of about 5 feet.

- In general, it is considered that the granular materials from this site are marginally suitable for general fill material in the "Pit Run" condition for building pads, road bases and utility berms.

- An estimated quantity of 75,000 cubic yards of granular materials is available at this site.

The following guidelines for borrow pit operations should be followed if Site FN 31 is developed at a future date:

- Adequate buffer zones of existing tree growth should be retained between the proposed Mackenzie Highway route and any proposed borrow pit development.

- The existing tree growth and related vegetation should be cleared and removed from

borrow pit locations in accordance with current land use regulations.

- The thin veneer of overburden should be stripped, removed and stockpiled in designated locations adjacent to the borrow pit areas.

- The use of conventional excavation equipment such as dozers, overhead loaders, backhoes and light ripping equipment is considered adequate for removing material from this site.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

- Precontouring of the pit area to provide general drainage compatible with the natural drainage of the adjacent terrain.

- Replacing stockpiled surficial waste material onto the abandoned borrow pit areas.

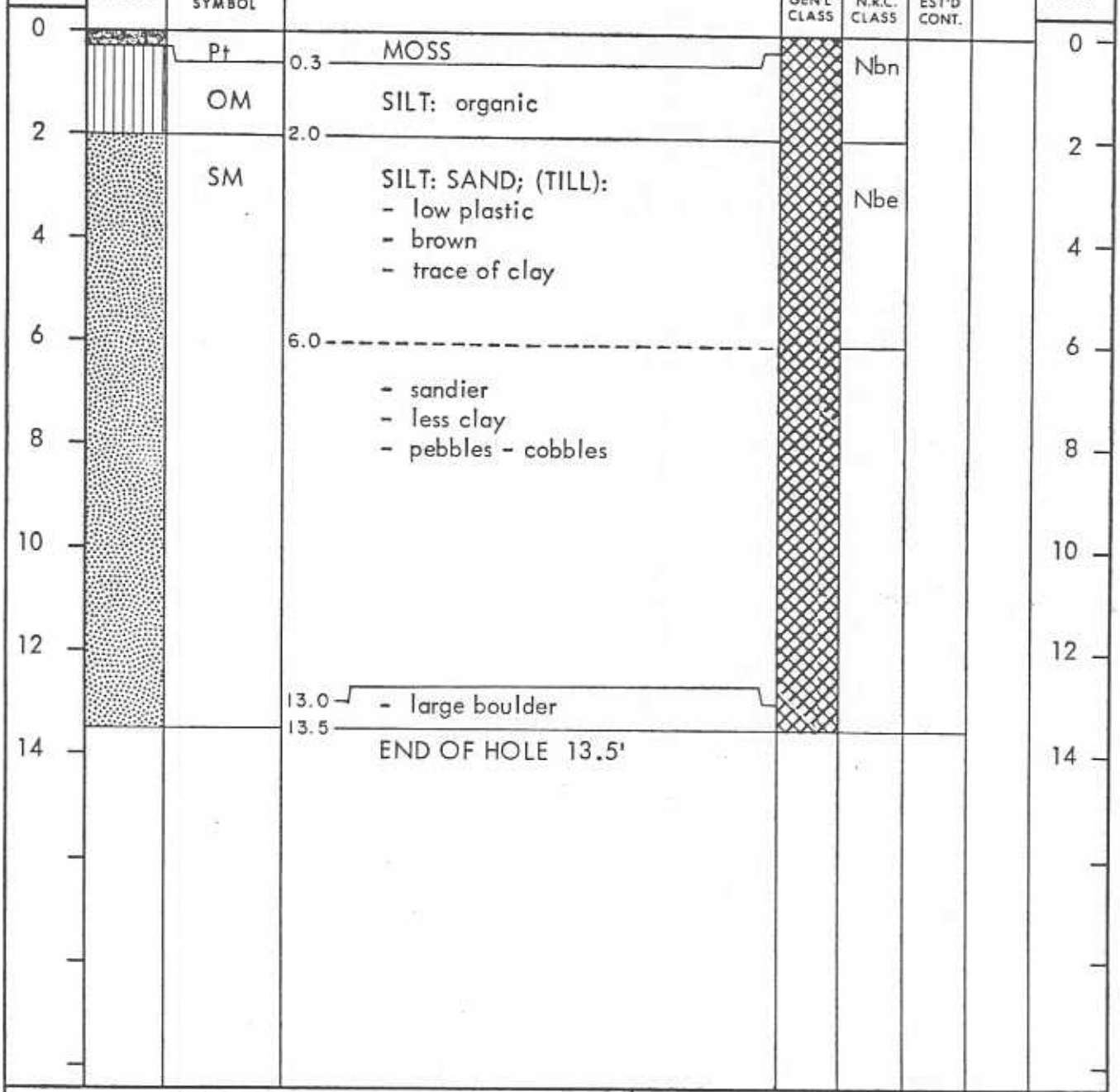
- Reseeding of the recontoured pit areas may be considered, although existing cutlines in the area indicate that understory growth and eventually spruce will be naturally re-established.

DETAILED DRILL HOLE LOG

SITE NO. FN 31 HOLE NO. C 471

DATE: FEB. 6, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 31 HOLE NO. 515

DATE: FEB. 14, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: category #6					0
1.0					Vx	M		
2		Cl	CLAY (TILL):					2
			- sandy, silty		Vx	M		
4			- stones					4
			- medium plastic					
			- brown		Vx	L		
6			- cobbles					6
8								8
10			- sand pockets					10
12								12
14								14
15.0								
16		SM	SILT - SAND:					16
			- low plastic					
18			- brown					18
20								20
20.0			END OF HOLE 20.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 31 HOLE NO. 516

DATE: FEB. 14, 1973 LOGGED BY: ☐ PEMCAN ☐ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OM	SILT: - organic - medium plastic - brown		Vx	M		0
2								2
3.5								
4		SP	SAND: coarse grained (TILL) - pebbles to 1½" - non plastic - brown		Nbn			4
6								6
8			- cobbles - fine grained					8
			- pockets of coarse sand, grey					
10								10
12								12
14								14
16								161
17.5								
18			END OF HOLE 17.5'					18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FN 31 HOLE NO. 520

DATE: FEB. 13, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OH	CLAY: organic, high plastic, dark brown		Vs	M		0
2								2
			2.5					
		CI	CLAY: silty, medium plastic, brown					
4								4
			5.0					
6		GP	GRAVEL: - sandy - non plastic - brown		Nf			6
8								8
			9.0					
10		CI	CLAY (TILL): - sandy, silty - stones - rust specks - medium plastic - brown		Vs	L		10
12								12
14								14
			15.0					
16		SM	SILT - SAND: - low plastic		Nbn			16
18								18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

GLOSSARY

GLOSSARY

Alluvium	Stream deposits of comparatively recent time, does not include subaqueous deposits of seas and lakes.
Anhydrite	A mineral, anhydrous calcium sulfate, $CaSO_4$. Orthorhombic, commonly massive in evaporite beds.
Annuals	A plant that lives only one year or season.
Autoclave Expansion	Laboratory test procedure as designated by ASTM-C151-63 for determination of expansive qualities for all types of Portland Cement and aggregate reactions.
Berm	A horizontal portion of an earth embankment to ensure greater stability of a long slope.
Biotic	Of or pertaining to life or mode of living.
Boreal	Pertaining to the North.
Boulder	A rock fragment larger than 8" in diameter.
Cartographic	Pertaining to a map. In geology a cartographic unit is a rock or group of rocks that is shown on a geologic map by a single color or pattern.
Clay	Soil particles smaller than 0.002 mm. in diameter.
Cobble	A rock fragment between 3" and 8" in diameter.
Colluvium	A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.
Conglomerate	Rounded water-worn fragments of rocks or pebbles, cemented together by another mineral substance which may be of a siliceous or argillaceous nature.
Cretaceous	The third and latest of the periods included in the Mesozoic era; also the system of strata deposited in the Cretaceous period.
Crystalline	Of or pertaining to the nature of a crystal; having regular molecular structure.
Delta Deposits	An alluvial deposit, usually triangular, at the mouth of a river.

Devonian	In the ordinarily accepted classification, the fourth in order of age of periods, comprised in the Paleozoic era, following the Silurian and succeeded by the Mississippian. Also the system of strata deposited at that time.
Dolomite	A mineral, $CaMg(CO_3)_2$, commonly with some iron replacing magnesium; a common rock-forming mineral.
Ecology	The study of the mutual relationships between organisms and their environments.
Eolian	Deposits which are due to the transporting action of the wind.
Escarpment	The steep face of a ridge of high land.
Esker	A narrow ridge of gravelly or sandy drift, deposited by a stream in association with glacier ice.
Excess Ice	Ice in excess of the fraction that would be retained as water in the soil voids upon thawing.
Fauna	The animals collectively of any given age or region.
Flood Plain	That portion of a river valley, adjacent to the river channel, which is built of sediments during the present regime of the stream and which is covered with water when the river overflows its banks at flood stages.
Flora	The plants collectively of any given formation, age or region.
Fossiliferous	Containing organic remains.
Geomorphology	The study of landscape and of the geologic forces that produce it. It is the dynamic geology of the face of the earth. It concerns that branch of physical geography dealing with the origin and development of the earth's surface; features (landforms) and the history of geologic changes through the interpretation of topographic forms.
Glacial Till	Non sorted, non stratified sediment carried or deposited by a glacier.
Glaciofluvial	Fluvioglacial. Pertaining to streams flowing from glaciers or to the deposits made by such streams.

Glaciolacustrine	Pertaining to glacial-lake conditions, as in glaciolacustrine deposits.
Gravel	Soil particles smaller than 3" in diameter and larger than 2.0 mm in diameter.
Ground Moraine	A moraine with low relief, devoid of transverse linear elements.
Gypsum	Alabaster. Selenite. Satin Spar. A mineral, $CaSO_4$, $2H_20$. Monoclinic. A common mineral of evaporites.
Heterogeneous	Differing in kind; having unlike qualities; possessed of different characteristics; opposed to homogeneous.
Hummock	A mound or knoll.
Icing	Mass of surface ice formed during winter by successive freezing of sheets of water seeping from the ground, a river or spring.
Kames	A mound composed chiefly of gravel or sand, whose form is the result of original deposition modified by settling during the melting of glacier ice against or upon which the sediment is accumulated.
Karst	A limestone plateau marked by sinkholes and underlain by cavernous carbonate rocks having subterranean drainage channelways that largely follow solution-widened joints, faults, and bedding planes.
Lacustrine	Produced or belonging to lakes.
Lichen	Any of a group of low growing plant formations composed of a certain fungi growing close together with certain algae.
Massif	A French term adopted in geology and physical geography for a mountainous mass or group of connected heights, whether isolated or forming a part of a larger mountain system.
Meandering	Condition of river that follows a winding path owing to natural physical causes not imposed by external restraint. Characterized by alternating shoals and bank erosion.
Moraine	Drift, deposited chiefly by direct glacial action, and having constructional topography independent of control by the surface on which the drift lies.

Morphological	The scientific study of form. Used in various connections, e.g. landforms (geomorphology).
Muskeg	The term designating organic terrain, the physical condition of which is governed by the structure of peat it contains and its related mineral sublayer, considered in relation to topographic features and the surface vegetation with which the peat co-exists.
Ordovician	The second of the periods comprised in the Paleozoic era, in the geological classification now generally used. Also the system of strata deposited during that period.
Perennial	Lasting through the year.
Permafrost	The thermal condition under which earth materials exist a a temperature below 32°F continuously for a number of years.
Petrography	The branch of science treating of the systematic description and classification of rocks.
Proglacial	Pertaining to features of glacial origin beyond the limits of the glacier itself, as...streams,...deposits,...sand.
Sand	Soil particles smaller than 2.0 mm. in diameter and larger than 0.06 mm. in diameter.
Screes	A heap of rock waste at the base of a cliff or a sheet of coarse debris mantling a mountain slope.
Silurian	The third in order of age of the geologic periods comprised in the Paleozoic era, in the nomenclature in general use. Also the system of strata deposited during that period.
Sinuous	Winding or curving in and out.
Slope Wash	Soil and rock material that is being or has moved down a slope predominantly by the action of gravity assisted by running water that is not concentrated into channels.
Taiga	A Russian word applied to the old, swampy, forested region of the north...that region between the Tundra in the north and the Boreal in the south.

Talus	Coarse angular fragments of rock and subordinate soil material dislodged by weathering (temperature and moisture changes) and collected at the foot of cliffs and other steep slopes and moved downslope primarily by the pull of gravity.
Terrace	A relatively flat elongate stairstepped surface bounded by a steeper ascending slope on one side and a steep descending slope on the other.
Tertiary	The earlier of the two geologic periods comprised in the Cenozoic era, in the classification generally used. Also the system of strata deposited during that period.
Thermal Regression	The thawing of frozen ground due to surface disturbance, increasing temperature, etc.
Thermokarst Lake	(Cave-in Lake), lakes which occupy depressions resulting from subsidence caused by thawing of ground ice.
Tundra	Any of the vast, nearly level, treeless plains of the Arctic Regions.
Turbid.	Having the sediment stirred up hence muddy, impure.

EXPLANATION OF TERMS AND SYMBOLS

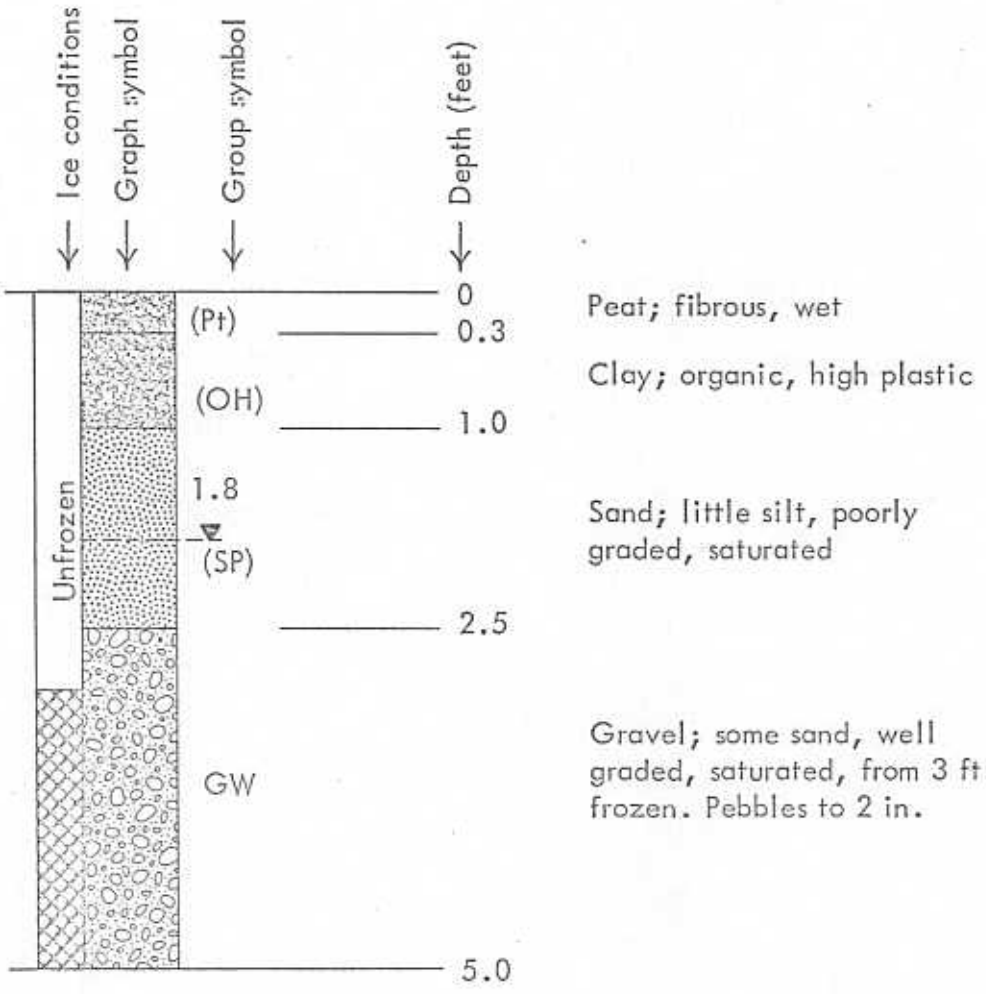
EXPLANATION OF TERMS AND SYMBOLS

DRILL HOLES AND TEST PITS

These pages present an explanation of the terms and symbols used in summarizing the results of field investigations as presented under Site Descriptions. Specifically, the explanations refer to the sheets entitled "Log Description and Laboratory Test Data". The materials, boundaries, and conditions have been established only at the test locations and could differ elsewhere on the site.

TEST PIT LOG DESCRIPTION

Soils of different engineering classification are commonly grouped generically for ease of reference. Seepage and the water level are indicated beside the graphical representation. They are followed by group symbols (according to the Unified Soil Classification System) and depths at individual soil type boundaries. Frost penetration is indicated to the left of the graph symbol as illustrated below:



DRILL HOLE LOG DESCRIPTION

The general information, indicating Site No., Hole No., Date drilled, Drilling Method and the firm responsible for the acquisition of the drill hole data designated under "Logged By", is noted in the upper portion of the standard "Detailed Drill Hole Log" form.

The detailed sub-surface information at each drill hole location has been presented in a columnar form as noted on the "exhibit" drill hole log data sheet on the following page. A description of each column used is outlined herewith:

Column 1 and 9: Depth scale outlining increasing depth of drill hole below existing ground surface.

Column 2: Graph Symbol to pictorially illustrate major soil divisions encountered in the drill hole. A detailed definition of each graph symbol is explained in the Materials Classification section of the Terms and Symbols.

Column 3: Unified Group Symbol indicating the abbreviated material classification in accordance with the Unified Soil Classification system. A detailed definition of each Unified Group Symbol is explained under the Materials Classification heading in the Terms and Symbols section of the glossary.

Column 4: Materials Description contains the engineering classification of each soil strata encountered in accordance with the criteria outlined in the Materials Classification heading in the Terms and Symbols section of the Glossary.

The depths of ground water level and the interface between different soil strata are indicated on the extreme left of this column.

Column 5: General Classification of Ground Ice Conditions indicates whether the material was frozen or unfrozen at the time of drilling.

Column 6: N.R.C. Classification of Ground Ice Conditions contains abbreviated symbols for ground ice in accordance with the National Research Council of Canada's "Guide to a Field Description of Permafrost for Engineering Purposes", Technical Memorandum 79. A detailed outline of the N.R.C. classification is contained in the "Ground Ice Classification" heading in the Terms and Symbols Section of the Glossary.

Column 7: Estimated Content of Ground Ice Conditions refers, generally, to the visual estimate of ice content in the soil formations encountered during the drilling program. The following abbreviations have been utilized for estimated ice content:

"L":- indicates Low ice content with generally less than 10% ice.

"M":- indicates Medium ice content with generally 10% to 50% ice.

"H":- indicates High ice content with generally in excess of 50% ice.

Column 8: Sample Type indicates the depth intervals where field samples were secured during the drilling program and the subsequent types of laboratory tests conducted on each respective sample. The following abbreviations have been utilized for the various types of laboratory tests conducted:

MC:- designates moisture content determinations.

GS:- designates grain size analyses including hydrometer tests.

P:- designates Petrographic analyses.

H:- designates Hardness Tests in accordance with the standard "Morr" classification for rocks and minerals.

O:- designates Organic Content determinations.

DETAILED DRILL HOLE LOG

SITE NO. 131 HOLE NO. DH-1

DATE: FEB. 15, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: organic, dark brown		Nf	L		0
1.0								
2		GM-GP	GRAVEL: some silt, little sand, frequent pebbles to 2½" size, occasional boulders, medium brown		Vs	L-M		2
4								4
6								6
7.0								
8		ML	SILT: some clay, trace of rust and coal specks, frequent pebbles to 1" size, occasional boulders, medium brown					8
10								10
12								12
12.0			TOTAL DEPTH 12.0'					
	①	②	③	④	⑤	⑥	⑦	⑧	⑨

EXHIBIT

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

MATERIAL CLASSIFICATION

Soil types are designated by a modified version of the Unified Soil Classification System ("The Unified Soil Classification System", Technical Memorandum No. 3-357, Vol.I, 1953, the Waterways Research Station, U.S.A.). The following page defines these terms and symbols. Letters appearing in parentheses denote visual identification which have not been verified in the laboratory. If the soil falls close to the boundaries established between the various groups a double symbol (for example GW-GP) is used.

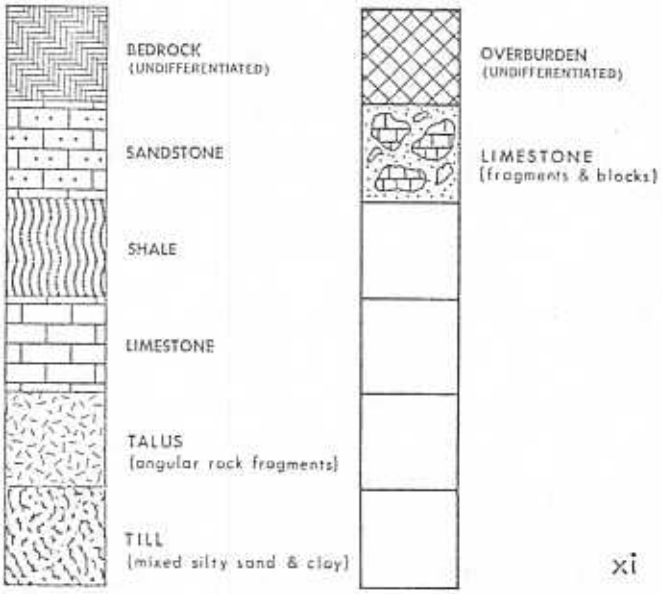
Since the Unified Soil Classification System does not contain detailed subdivisions of granular soils according to percentage proportions of secondary components, the ASTM suggested method for identification of granular soils ("Suggested Methods of Test for Identification of Soils", ASTM Procedures for Testing of Soils, 4th edition, December, 1964) is adopted for soil description as defined below:

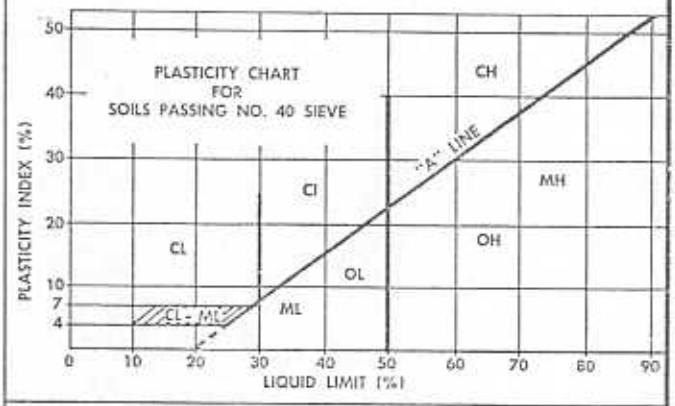
Composite Sand-Gravel Soils		Composite Sand-Silt Soils	
Percentages	Identification	Percentages	Identification
	Gravel; trace Sand		Sand; trace - Silt
90 to 10		95 to 5	
	Gravel; little Sand		Sand; trace + Silt
80 to 20		90 to 10	
	Gravel; some Sand		Sand; little Silt
65 to 35		80 to 20	
	Gravel and Sand		Sand; some Silt
50 to 50		65 to 35	
	Sand and Gravel		Sand and Silt
35 to 65		50 to 50	
	Sand; some Gravel		Silt and Sand
20 to 80		35 to 65	
	Sand; little Gravel		Silt; some Sand
10 to 90		20 to 80	
	Sand; trace Gravel		Silt; little Sand
		10 to 90	
			Silt; trace Sand

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, 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	
			GP		POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, 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	
			SP		POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC		CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 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 BASED UPON 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	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	

SPECIAL SYMBOLS





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%.

GROUND ICE CLASSIFICATION

TABLE I

ICE DESCRIPTIONS

A. ICE NOT VISIBLE[a]

Group Symbol	Subgroup			Field Identification
	Description	Symbol		
N	Poorly bonded or friable	Nf		Identify by visual examination. To determine presence of excess ice, use procedure under note[b] and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation: medium, low. Note presence of crystals or of ice coatings around larger particles.
	No excess ice Well-bonded Excess ice	Nb	Nbn	
			Nbe	

[a] *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 none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group* (see p. 14).

[b] *When visual methods may be inadequate, a simple field test to aid evaluation of volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of total volume.*

FIG A. ICE NOT VISIBLE

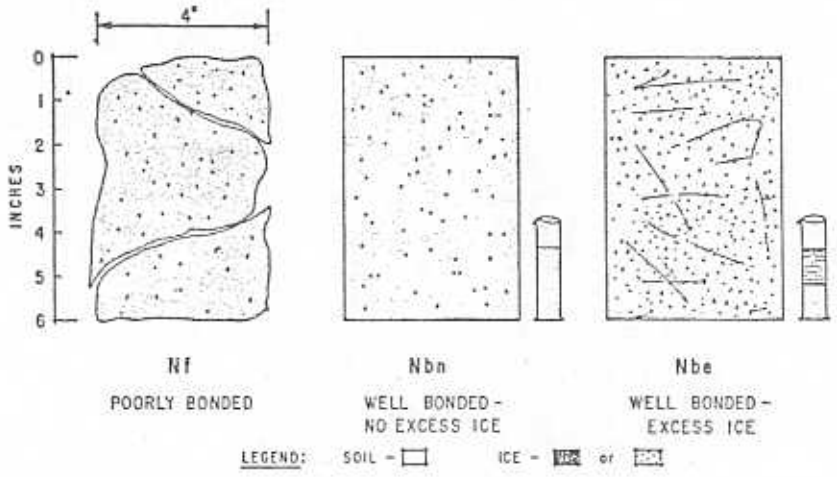


TABLE I (cont'd)

ICE DESCRIPTIONS

B. VISIBLE ICE—LESS THAN 1 INCH THICK[a]

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
V	Individual ice crystal or inclusions	Vx	For ice phase, record the following when applicable: Location, Orientation, Thickness, Length, Spacing, Hardness, Structure, Colour } per Group C (see p. 16) Size, Shape, Pattern of arrangement Estimate volume of visible segregated ice present as percentage of total sample volume.
	Ice coatings on particles	Vc	
	Random or irregularly oriented ice formations	Vr	
	Stratified or distinctly oriented ice formations	Vs	

[a] *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 none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group.*

FIG B. VISIBLE ICE LESS THAN ONE INCH THICK

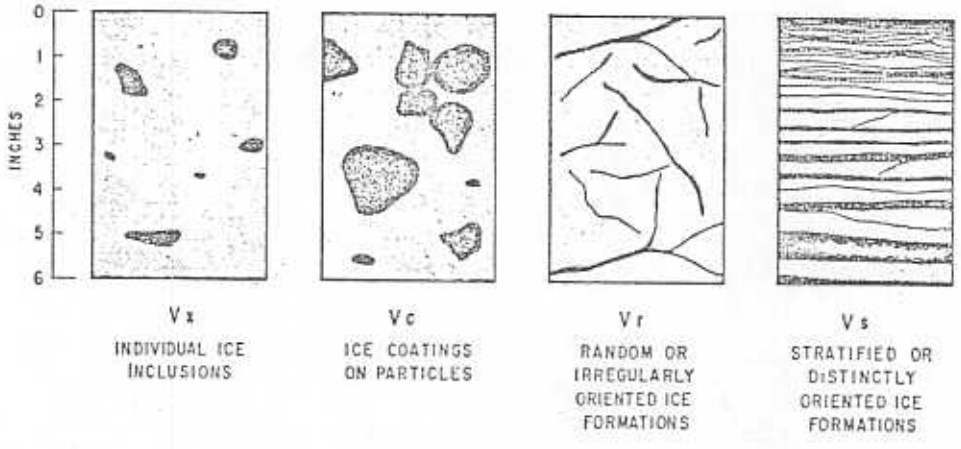


TABLE I (cont'd)

ICE DESCRIPTIONS

C. VISIBLE ICE—GREATER THAN 1 INCH THICK

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
ICE	Ice with soil inclusions	ICE + soil type	Designate material as ICE[a] and use descriptive terms as follows, usually one item from each group, when applicable:
	Ice without soil inclusions	ICE	Hardness: HARD; SOFT (of mass, not individual crystals) Colour (Examples): COLOURLESS, GRAY, BLUE Structure[b]: CLEAR, CLOUDY, POROUS, CANDLED, GRANULAR, STRATIFIED Admixtures (Examples): CONTAINS FEW THIN SILT INCLUSIONS

[a] *Where special forms of ice such as hoarfrost can be distinguished, more explicit description should be given.*

[b] *Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.*

FIG C. VISIBLE ICE GREATER THAN ONE INCH THICK

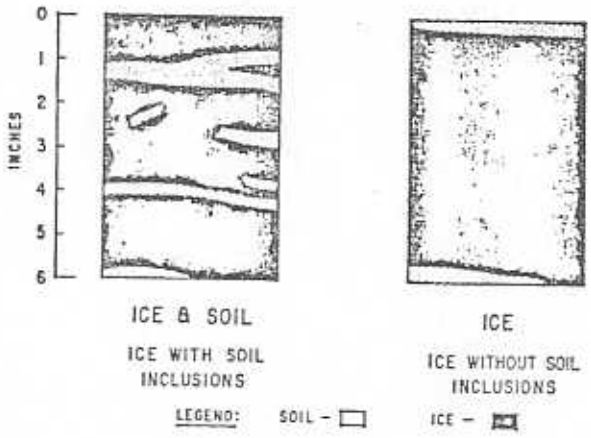


TABLE II

TERMINOLOGY

Ice Coatings on Particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which 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 which is essentially sound and non-pervious.

Porous Ice contains numerous voids, usually interconnected and usually resulting 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 normal 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 and that the frozen soil consequently has poor resistance to chipping or breaking.

Friable denotes extremely weak bond between soil particles. Material is easily broken up.

Excess Ice signifies ice in excess of the fraction that would be retained as water in the soil voids upon thawing.

For a more complete list of terms generally accepted and used in current literature on Frost and Permafrost see Hennion, F. "FROST AND PERMAFROST DEFINITIONS", Highway Research Board, Bulletin 111, 1955.

EXPLANATION OF TERMS AND SYMBOLS

WILDLIFE AREAS

Wildlife boundaries and information presented in the Community and Intercommunity reports has been extracted for the most part from publications prepared by the Canadian Wildlife Service, Government of Canada.

The terms "critical" and "important" as used to designate certain wildlife areas can be generally defined as habitat areas which are critical and/or important to the subsistence and survival of various wildlife species.

COMMUNITY REPORTS

In each Community Study Area, known "critical" and "important" wildlife, waterfowl and fishery resource areas are outlined on the respective map presentations. Any wildlife, waterfowl or fishery resource area which is acknowledged as being "critical" is outlined in red and is noted with the word "critical" within the boundary of the respective area. Non-critical areas are outlined as follows:

- Wildlife areas are outlined in red.

- Waterfowl areas and, in the case of Fort Simpson, hunting locales, are outlined in yellow.

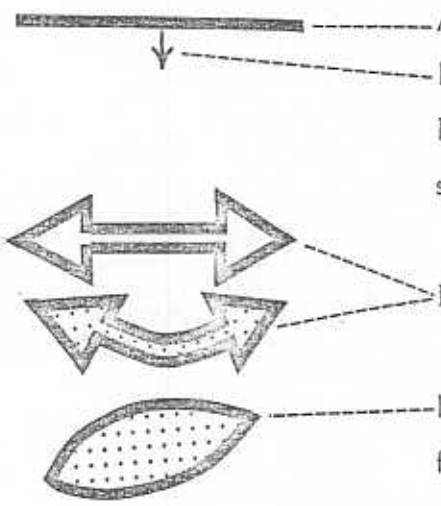
- Fishery resource areas are outlined in blue.

Outlined wildlife areas include both regions of known wildlife habitation and regions which have been historically trapped by northern residents.

Waterfowl areas include migration, staging, molting and nesting locales which are of significance in the respective Study Areas.

Fishery resource areas include migration, spawning and domestic fishing locales which are of significance in the respective Study Areas.

Symbols used on the maps are illustrated and explained as follows:



Approximate boundary of wildlife area.

Indicates which side of boundary line is area defined. In other words the area below the boundary line is of significance to wildlife.

Indicates migration routes; waterfowl and fishery resources.

Indicates known or potential spawning areas or domestic fishing locales.

Pertinent wildlife areas are discussed in the Methodology-Evaluation section of the text in each community report. Similar documentation is also presented for sites which occur in significant wildlife areas in the Site Description section of the report.

INTERCOMMUNITY REPORTS

In each Intercommunity Study Area, known "critical" and "important" wildlife, waterfowl and fishery resource areas are outlined on the respective map presentations. A brief description relating to the significance of each area is included within the outlined boundary. Areas that are classified as "critical" are so noted on the maps.

Symbols used on the maps are illustrated and explained as follows:

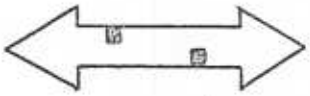
Approximate boundary of wildlife area.

Indicates which side of boundary line is area defined. In otherwords, the area below the boundary line is of signifi-

cance to wildlife.

----------Approximate boundary of waterfowl area.

----------Indicates which side of boundary line is area defined. In other words, the area below the boundary line is of significance to waterfowl.



----------Indicates broad migration flyways utilized by waterfowl.

Significant fishery resource information such as migration routes and potential spawning areas is noted directly on the maps.

Pertinent wildlife areas are discussed in the Methodology-Evaluation section of the text in each Intercommunity report. Similar documentation is also presented for sites which occur in significant wildlife areas in the Site Description section of the report.

BIBLIOGRAPHY

BIBLIOGRAPHY

Alyeska Pipeline Service Co., 1971. Exhibit I, (U.S.) Dept. of Interior Hearings, February 16, 1971.

Alyeska Pipeline Service Co., 1972. Alyeska Project Statement, Excerpts from Project Description. V. 2, 3, 5.

Alyeska Pipeline Service Co., Exhibit I, (U.S.) Hearings, 1971.

American Geological Institute, Glossary of Geology and Related Sciences: Glossary Review Committee. Reprint September, 1966.

Benninghoff, W.S., 1952. Interaction of vegetation and soil frost phenomena: Arctic, V.5, p. 34-44.

Bliss, L.C., 1962. Adaptation of Arctic and Alpine plants: Arctic, V.15, p. 117-144.

Brandon, L.V., 1965. Groundwater Hydrology and Water Supply in the District of Mackenzie, Yukon Territory, and adjoining parts of British Columbia. Paper 64-39: Geological Survey of Canada, Dept. of Mines and Technical Surveys.

Canadian Wildlife Service, Arctic Ecology Map Series,(Preliminary) 1972.

Cayford, J.H., and Birkerstaff, A., 1968. Man-made Forests in Canada: Dept. of Fisheries and Forestry, Forestry Branch Publication No. 1240.

Day, J.H., 1966. Reconnaissance Soil Survey of the Liard River Valley, Northwest Territories: Research Branch, Canada Dept. of Agriculture, Soil Research Institute, Central Experimental Farm, Ottawa.

Day, J.H., 1968. Soils of the Upper Mackenzie River Area, Northwest Territories: Soil Research Institute, Central Experimental Farm, Ottawa, Research Branch of Canada, Dept. of Agriculture.

Dept. of Energy, Mines & Resources, Indian and Northern Affairs, Terrain Classification and Sensitivity Series (Preliminary) 1972.

Dept. of Mines and Technical Surveys. Indian and Northern Affairs. Land Use Information Series Maps: Dept. of the Environment, 1972.

Dept. of Mines and Technical Surveys. Geographical Branch, Ottawa, 157. Atlas of Canada.

Geological Survey of Canada, 4th Edition, 1957; 5th Edition, 1968. Geology and Economic Minerals of Canada.

IUCN (International Union for the Conservation of Nature and Natural Resources), Survival Service Commission. 1966 (and subsequent updatings). Red Book Data: Morges, Switzerland, IUCN.

Jones, M.J., 1971. Mackenzie Delta Bibliography: Dept. of Indian Affairs and Northern Development. (MDRP-6).

Lavkulich, L.M., 1972. Soils, Vegetation and Landforms of the Fort Simpson area, N.W.T.: Dept. of Soil Science, University of British Columbia: Dept. of Indian Affairs and Northern Development.

Lawrence, D.E.; Shnay, F.G.; VanDine, D.F.; 1972. Granular Resource Inventory - Mackenzie - Fort Norman Addendum, NTS 96E (November)
- Norman Wells Addendum, NTS 96E (September 22)(July)
- Carcajou Canyon, NTS 96D (September 22)(July)
- Fort Good Hope, NTS 106I (November):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Lawrence, D.E.; Shnay, F.G.; VanDine, D.F.; Theroux, L.L., 1972. Granular Resource Inventory - Mackenzie
- Carcajou Canyon, NTS 96D (July)
- Sans Sault Rapids, NTS 106/H (July)
- Norman Wells, NTS 96/E (September 22)(July)
- Fort Norman, NTS 96/C (July):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Lindsey, A.A., 1953. Notes on some plant communities in the northern Mackenzie Basin, Canada: Botanical Gazette, V. 115, No. 1, p. 44-55.

MacKay, J.R., 1970. Lateral mixing of the Liard and Mackenzie Rivers downstream from their confluence: Can. Jour. Earth Sci., V. 7, p. 111-124.

McPhail, J.D., and Lindsey, C.C., 1970. Freshwater fishes of northwestern Canada and Alaska: Fisheries Research Board, Ottawa. Bulletin 173.

Minning, Gretchen V.; Domansky, Jeff, 1972. Granular Resources and Bedrock Construction Materials - Camsell Bend (95J)(July): Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Minning, Gretchen V.; Rennie, Jim; Domansky, Jeff, 1972. Granular Resources and Bedrock Construction Materials - Dahadinn River (95N)(July)
- Dahadinn River (95N)(Unedited Preliminary Rpt. July)
- Wrigley (950)(Unedited Preliminary Rpt. July)
- Wrigley (950)(July):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Minning, Gretchen V.; Rennie, J.A.; Domansky, J.L.; Sartorelli, A.N., 1972. Granular Resource Inventory - Southern Mackenzie Valley -
- Camsell Bend (95J)(First Revision)(October)
- Fort Simpson (95H)(First Revision)(November)
- Bulmer Lake (951)(December):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Minning, Gretchen V.; Rennie, J.A.; Domansky, J.L.; Sartorelli, A.N., 1973. Granular Resource Inventory - Southern Mackenzie Valley
- Wrigley (950)(January)
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Rowe, J.S., 1959. Forest Regions of Canada: Canada Dept. Northern Affairs and Natural Resources, Forestry Branch, Bulletin 123.

Stein, J.N.; Hatfield, C.T.; Falk, M.R.; Jessop, C.S. February 28, 1972. Fish Resources of the Mackenzie River Valley, Interim Report I, Volume I: Environment Canada, Fisheries Service.

Stein, J.N.; Hatfield, C.T.; Falk, M.R.; Jessop, C.S.; Sheperd, D.N. February 28, 1972. Fish Resources of the Mackenzie River Valley, Interim Report I, Volume II: Department of the Environment, Fisheries Services.