DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

FORT GOOD HOPE, N.W.T.

COMMUNITY STUDY AREA

PEMCAN SERVICES '72"

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PREFACE

The Government of Canada anticipated the potential need for extensive volumes of granular material for proposed major construction projects in the area of the Mackenzie River Valley and initiated an investigation of granular materials in this region during 1972 and 1973.

In September, 1972 the Department of Indian Affairs and Northern Development engaged PEMCAN Services "72" to conduct Stage 1 of the Territorial Granular Materials Inventory. Stage 1 is defined as the area from Fort Simpson to Fort Good Hope, N.W.T.

The objectives of this investigation were specified as:

Part 1: An investigation of the availability of granular material deposits within a ten mile radius of the communities of Fort Simpson, Wrigley, Fort Norman, Norman Wells and Fort Good Hope.

Part 2: An investigation of the availability of granular material deposits in the intermediate areas between the respective communities.

Part 1 of the investigation for the granular materials has been carried out by PEMCAN Services "72" in accordance with the Terms of Reference as specified by the Department of Indian Affairs and Northern Development. The results of the investigation pertaining to Part I are submitted in five separate reports which cover the respective communities within the Study Area. Part 2 of the investigation includes four separate inter-community area reports and a summary section.

The Terms of Reference specified the following definitions and procedures:

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 from the study and 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 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 locations for the Mackenzie 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, only Site FGH 1 was specifically designated for drilling since the large esker deposit at Site FGH 2 has extensive quantities of excellent quality granular material to supply the requirements of the Fort Good Hope community. The field test drilling of Site FGH 1 was conducted by consultants working under the authority of The Federal Department of Public Works, in conjunction with their geotechnical study for the Mackenzie Highway route in this area. The data from their investigation has been incorporated in this report.

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.

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 were assessed but were not studied in detail because of remoteness from the community or planned utilities. These sites are identified in Figure 2 by the suffix "X" behind the site number.

A total of nine sites were catalogued in the ten mile radius of Fort Good Hope (Figure 2). Of these, four sites were investigated to a greater detail by means of test pits and one site by means of drill holes. Two additional sites were investigated by Geological Survey of Canada personnel and partial information from their studies is incorporated in this report.

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 is based upon airphoto interpretation, field reconnaissance and field drilling records. Except on sites where drill holes 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 Good Hope Study Area lies within two physiographic subdivisions, namely:

- Anderson Plain - which covers the east side of the Mackenzie River.
- Peel Plain - which extends south and west from the Mackenzie River.

Both physiographic units have a very low relief and are characterized by frequent depressions and muskeg areas. River channels, erosional gullies and some of the glaciofluvial landforms are the only major features which disturb the generally flat surface of the Plains.

The bedrock in the townsite vicinity consists of Devonian limestone while Cretaceous sandstones are exposed southwest of Fort Good Hope in steep escarpments along the Mackenzie River channel. In general, the bedrock is near the surface with the exception of the terrain covered by a glaciofluvial delta which extends upstream from Fort Good Hope along the Hare Indian River.

The bedrock is primarily covered with a relatively thin veneer of morainal till, which is a heterogeneous mixture of silt, clay and sand with pebbles and cobbles scattered throughout. Flat terrain, poor drainage and high ice content characterizes the extensive muskeg areas that are prevalent south of Fort Good Hope.

A glaciofluvial delta, consisting of outwash plains, channel deposits, kames and eskers, overlies the till sheet northeast of the townsite. These widely separated geomorphologic units contain variable mixtures of sand and gravel.

Eolian silts and sands are also found in the northeast sector of the Study Area.

Floodplains along present stream channels consist of stratified silts, clays and sands. The Mackenzie and Hare Indian River stream beds may contain some coarse deposits at depth.

With the exception of relatively narrow strips along deeply incised water courses and major glaciofluvial landforms, the terrain is poorly drained. Inadequate drainage, generally high silt and clay content of morainal deposits, low relief of wind blown sands and the proximity of the alluvial deposits to stream channels, usually results in high water tables and ground ice contents which are generally unsuitable for construction purposes.

Moderate to thick organic soil layers cover depressional and poorly drained terrain. Pronounced glaciofluvial landforms are usually topped with a shallow layer of topsoil covered by several inches of peat and moss.

The glaciofluvial deposits found immediately north of Fort Good Hope in kame-esker complexes, individual eskers or outwash plains, represent the only source of good, natural granular material in the Study Area.

The Devonian limestones exposed south of the townsite, can be used for manufactured aggregates for construction purposes whereas the weakly cemented Cretaceous sandstones are porous, incompetent and thus are generally unsatisfactory for manufactured aggregates.

The Study Area lies within the discontinuous permafrost zone. Excess ice is common in fine grained and poorly drained terrain, whereas lesser excess ice exists in well drained, coarse deposits. The average depth of the seasonal freezing and thawing cycles is about one to two feet; however, this depth value will vary locally according to type of material, thickness of vegetation cover and presence or absence of nearby thermal springs and watercourses.

TERRAIN PHOTOGRAPHS

Major kame-esker complex located northeast of Fort Good Hope (Ref. Site FGH 2).

Large esker ridge located northeast of Fort Good Hope. Note the contrast in vegetation growth between the wet sites and the well drained esker ridge (Ref. Site FGH 1).

ENVIRONMENT

The ten mile Study Area around the community of Fort Good Hope 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 all 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 Good Hope Study Area is ideally located in an area that offers considerable use of both water and land environments. The area is particularly enhanced by the Mackenzie and Hare Indian Rivers which flow through the central part of the Study Area.

Terrain sensitivity and reaction to modification is more pronounced in the Fort Good Hope Study Area than in regions to the south. The area is characterized by both Taiga types of vegetation and areas of relatively shallow permafrost as illustrated in part by the high density of shallow ponds.

The 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 disturbed. Thermo-karst 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 area generally contain moderate ground ice content. The glaciated till plains are relatively thin in the Fort Good Hope Study Area and are underlain by shale and grey limestone bedrock

formations at a very shallow depth. Localized contrasts in material type and ice content is oftentimes evident between relatively well drained slopes and low wet depressions. This terrain in general exhibits moderate susceptibility to thermokarst, ground ice slumping and gullying. Usefulness of till material as fill is usually limited by its ice content.

In general, the more favorable granular material sites in the Fort Good Hope Study Area tend to be located on well drained geomorphic features that occasionally contain moderate amounts of ground ice. Therefore, properly managed development procedures are recommended in order to 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 should be established in order to limit detrimental terrain reaction to acceptable levels.

Vegetation

In the Fort Good Hope Study Area, Taiga vegetation is the characteristic terrain cover. Taiga is characterized by open grasslands interspersed with areas of varying size that generally support stunted forest tree growth. Both Boreal forest and Tundra vegetation are represented in the Taiga although very little timber of commercial value is produced.

In the Study Area, evergreen species predominate over deciduous as a common ground cover; aspen and poplar are not abundant and are largely replaced by birch on upland sites. Tamarack is also less common than in areas to the south.

Poorly drained alluvial sites underlain by fine grained soils generally support scrub growths of black spruce, willow and alder. Well drained sites with deep permafrost support white spruce that occasionally reaches commercial growth in the river flood-plain areas. White spruce is also common on well drained geomorphic features such as eskers while the low wet areas adjacent to such features are characterized by stunted black spruce and occasional tamarack.

In the Fort Good Hope Study Area, natural regrowth of vegetation on existing trails and cutlines 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 are common in the Fort Good Hope 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). The entire Fort Good Hope Study Area is classified as an important wildlife region by the Canadian Wildlife Service. In addition, two areas west and southwest of Fort Good Hope are classified as critical habitats for Peregrine falcons.

The entire Study Area is within the broad flyway that is utilized by various waterfowl during spring and fall migration. Parts of this area are also used for nesting and molting by various duck species from early May to late August.

Two critical habitat areas of the rare and endangered Peregrine falcon are located west and southwest of Fort Good Hope. The first area is approximately five miles west of

the community while the second area starts approximately one mile south of Manitou Island and encompasses the Mackenzie River and both bank areas (Figure 2). Both of these areas are considered as critical breeding and nesting locales for the falcons during spring and summer.

The entire Study Area, with the exception of the extreme northwest portion, is an important wildlife hunting and trapping area for the natives of Fort Good Hope (Figure 2). Muskrat, beaver and mink are trapped over the entire area in the late fall and early winter and muskrat and beaver are hunted in the spring in the vicinity of the community.

Fishery resources in the Study Area are predominantly those found in the Mackenzie and Hare Indian Rivers and include both resident species and those that seasonally migrate through the respective river systems. The Hare Indian River and one of its larger tributaries, the Bluefish River, which is located northeast of the Study Area, contain clear waters and bottom deposits that are considered as potential spawning areas for grayling and other fish species. Residents of Fort Good Hope also net fish for domestic use at the mouth of the Hare Indian River. Ontadek Lake, located northeast of Fort Good Hope, is fished for domestic purposes by the local residents of the area from May to September.

There are two well known recreation and sport fishing locales within the Fort Good Hope Study Area. The first area, known locally as Fossil Lake, is located about seven miles west of the community; Fossil Lake is noted for its scenic cliffs and beaches. The second area of significance, is located southwest of the community and is the section of the Mackenzie River that is known as The Ramparts. This area is known for its scenic high cliffs and excellent camping and sport fishing resources.

Archeological sites are located approximately one mile north of the townsite on the east bank of the Mackenzie River and three miles northwest of the townsite on the west bank (Figure 2).

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 results of the completed study indicate that extensive quantities of excellent quality granular materials, suitable for the requirements of most construction purposes, are available in the immediate vicinity of Fort Good Hope. Specifically, the large esker deposit at Site FGH 2 has adequate quantities of excellent quality gravels for the granular material requirements of the Fort Good Hope community. Therefore, it is recommended that granular materials for the community be obtained from the exploitation and development of Site FGH 2.

Site FGH 2: Located less than one mile north of Fort Good Hope, Site FGH 2 consists of a kame-esker complex which is part of an old glaciofluvial delta. The site encompasses an area approximately two miles in length by $\frac{1}{2}$ mile in width and rises some sixty feet above the adjacent terrain.

This site has an estimated quantity of 30,000,000 cubic yards of well graded, medium grained, clean gravels which are suitable for most construction requirements. It is considered that pit run gravels from this site may have to be processed by screening, crushing and washing operations for the production of quality concrete and surface course aggregates.

An existing borrow pit is currently in operation at the south end of Site FGH 2 and an all weather road provides excellent access to the community of Fort Good Hope. Exploitation of granular materials from this site should be continued by extending the existing borrow pit in an easterly direction.

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

site. Terrain disturbance should be minimal since an all weather road exists between the community and the pit at the south end of Site FGH 2.

The detailed assessment and recommendations for the proposed development and exploitation of granular materials from Site FGH 2 is outlined in the Site Description section of the report.

In addition, substantial quantities of slightly poorer quality granular materials are available at Sites FGH 1 and FGH 3 and may be considered as secondary sources for the production of base course, surface course and general pit run aggregates.

In view of the availability of extensive quantities of excellent quality granular materials at Site FGH 2, the development and exploitation of the other sites within the Fort Good Hope Study Area is not considered necessary. However, the remaining sites, FGH 1 and FGH 3 to FGH 9, have been catalogued and assessed during the preliminary reconnaissance phase of this investigation.

For the same reason we do not consider as practical the development of a quarry in the Fort Good Hope area although Devonian limestones exposed immediately south of the townsite in the Upper Ramparts Canyon could be crushed to provide aggregate. Any quarry operation should be economically less attractive than borrowing and production of aggregate from the above mentioned material deposits. Moreover, the prospective quarry areas coincide with known critical wildlife habitats of the Peregrine falcon.

Site locations and physical and environmental data on each site within the Fort Good Hope 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 center.

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.

A detailed evaluation of each site investigated in the Study Area is documented in the Site Description section of the report.

LEGEND

- ..... Bedrock escarpment
- ..... Cone or fan
- ..... Meltwater channel
- ..... Esker
- A ..... Archeological site
- ..... Muskeg
- ..... Defined boundary
- ..... Approximate boundary
- R ..... Bedrock (predominantly limestone)
- R′ ..... Shallow soil overlying bedrock
- F ..... Fluvial deposits (either fine or coarse material)
- L ..... Lacustrine deposits (fine textured soil, flat ground)
- E ..... Eolian sediments (fine windblown sand)
- GL ..... Glacial deposits (mixed silt, sand, clay material)
- TR ..... Terrace deposits (mainly sand and silts with some gravelly beds)
- GF ..... Glaciofluvial deposits (mainly gravel and sand with silt and clay inclusions)

SCALE

DRAWN J. BROWN	GOVERNMENT OF CANADA
CHECKED	DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT
APPROVED	GRANULAR MATERIALS INVENTORY
DATE JAN. 1973	FORT GOOD HOPE COMMUNITY
JOB No. P72-502	SURFICIAL GEOLOGY
SCALE As Shown	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						
FGH 1	Gravel; sandy	GW	All Construc-tion Aggregates	4,000,000	40	Topsoil	½	Strip & Stockpile	Very Low at 10'	Well Drained	Conventional	3	No Critical Wildlife Areas; Some Hunting and Trapping	Recommended for Development
FGH 2	Gravel; sandy	GW	All Construc-tion Aggregates	30,000,000	50	Topsoil	½	Strip & Stockpile	Very Low	Well Drained	Conventional	1	Some Hunting and Trapping	Active; Recommended for Continued Development
FGH 3	Gravel; sandy	GW	Base; Surface Courses; General Fill	7,000,000	30	Topsoil	½	Strip & Stockpile	Low	Fair to North	Conventional	1½	Domestic Fishing Area at Mouth of Hare Indian River	Recommended for Development
FGH 4X	Gravel; sandy	GW	Base; Surface Courses; General Fill	400,000	20	Topsoil	-½	Strip & Stockpile	None	Fair to North	Conventional	1	Adjacent to Airport	Not Recommended for Development
FGH 5	Sand; some gravel	SP-SM	Marginal General Fill	30,000	10	Topsoil	1	Strip & Stockpile	N.D.	Poor	Conventional	9	Some Hunting and Trapping Sensitive Terrain	Possible Future Development
FGH 6	Sand; silty	SP-SM	Marginal General Fill	100,000	10	Topsoil & Silt	1	Strip & Stockpile	N.D.	Fair to North	Conventional	10	Some Hunting and Trapping Sensitive Terrain	Possible Future Development
FGH 7	Sand	SP	General Fill	100,000	5	Topsoil	½	Strip & Stockpile	N.D.	Fair	Conventional	7	No Critical Wildlife Areas Sensitive Terrain	Possible Future Development
FGH 8	Sand & Gravel	SW-GW	General Fill	1,000,000	10	Topsoil	+1	Strip & Stockpile	N.D.	Good to West	Conventional	½	Some Hunting and Trapping	Possible Future Development
FGH 9	Sand; trace silt	SP	Marginal General Fill	6,500,000	+10	Topsoil & Silt	+1	Strip & Stockpile	N.D.	Fair to North	Conventional	10	Domestic Fishing Area at Ontadek Lake Sensitive Terrain	Possible Future Development

Notes:

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

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

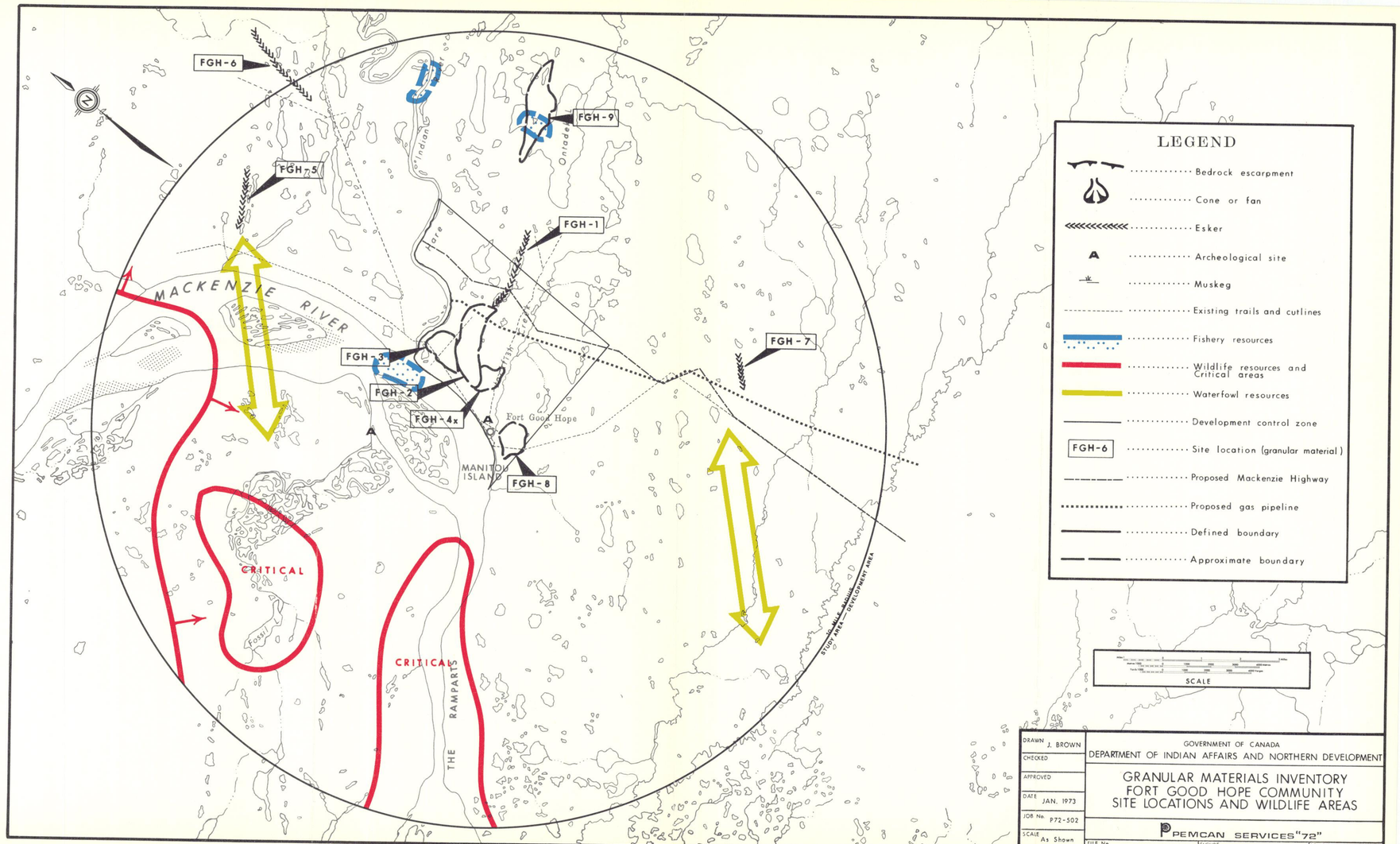
— METHOD OF EXTRACTION: "Conventional" indicates use of standard excavation equipment such as dozers, overhead loaders, backhoes, light rippers.

— HAUL DISTANCE: Is distance from site to the 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 DESCRIPTIONS - FORT GOOD HOPE STUDY AREA

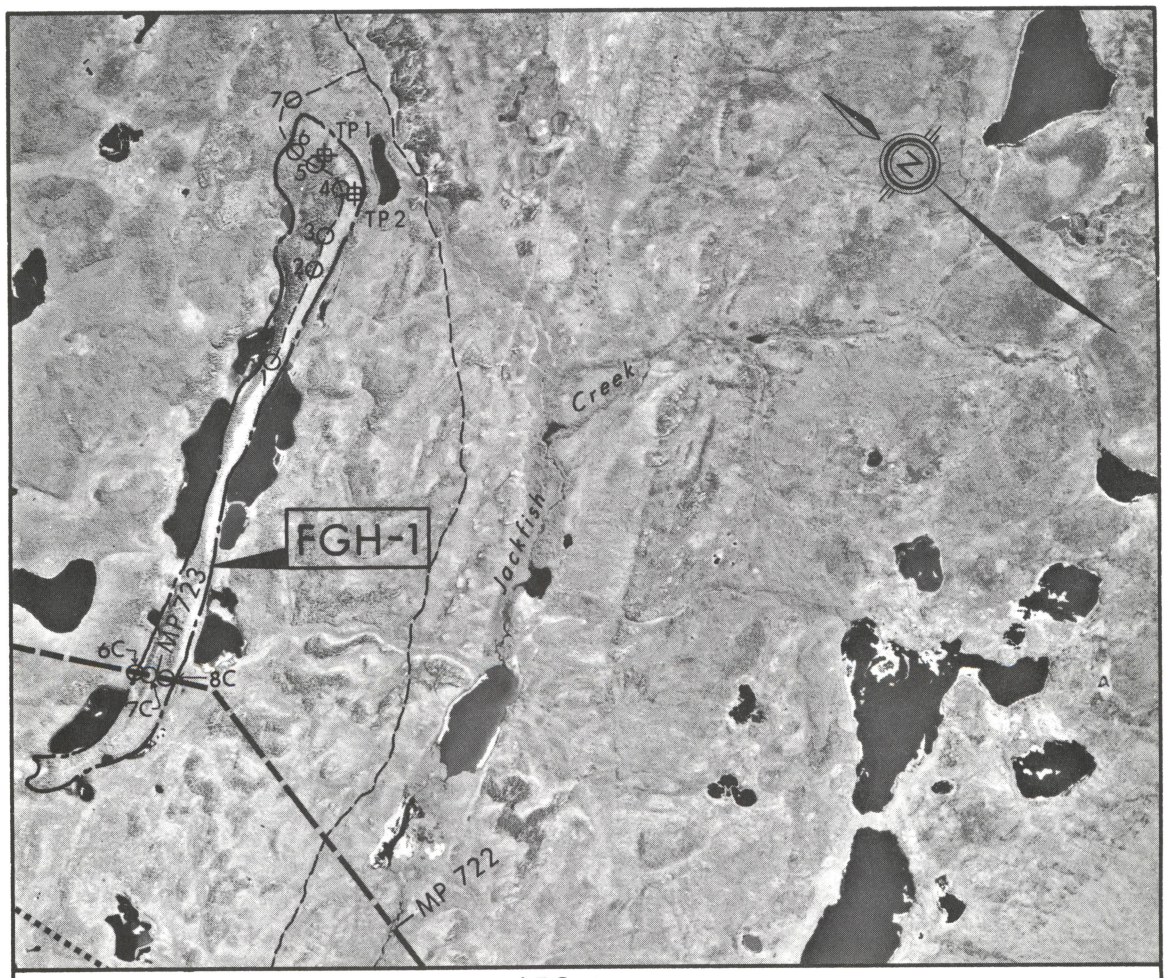
SITE NO. FGH 1

Located approximately 3 miles northeast of Fort Good Hope, Site FGH 1 consists of a pronounced, long esker ridge. Jackfish Creek parallels the esker ridge on the east at a distance of about one mile.

Type of Material: Gravel; some sand, well graded.

Estimated Volume: 4,000,000 cubic yards.

Assessment: Excellent quality material for the production of all types of construction aggregates. This site is not recommended for immediate development because other sites with similar quality material with better access are available in the Study 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. 22858/55

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 1 is located approximately 3 miles northeast of Fort Good Hope and consists of a long pronounced esker ridge. The esker ridge is approximately 3 miles in length, 300 to 500 feet in width and rises in excess of 60 feet above the adjacent poorly drained, flat terrain. Jackfish Creek is located approximately one mile east and parallels the length of the esker ridge.

The material in the esker ridge consists of well graded, medium grained, clean gravels which are considered suitable for the production of most construction aggregates. An organic topsoil layer, 4 to 6 inches in depth, mantles the site area and supports moderate growths of spruce and birch ranging in height from 30 to 50 feet and 3 to 12 inches in trunk diameter. The southeastern slopes of the ridge are very sparsely wooded. The understory growth consists primarily of moss and sedge with clusters of small brush.

The esker ridge appears to be well drained and the depth of the ground water table is considered to be relatively well represented by the level of water in the adjacent lakes. The general surficial drainage of the site area and vicinity is easterly towards Jackfish Creek.

There are no known critical wildlife areas in the immediate vicinity of the site; however, this entire region of the Study Area is occasionally hunted and trapped for fur-bearing animals by the natives in the Fort Good Hope area.

There is no existing access road to Site FGH 1, although a forest trail parallels the west banks of Jackfish Creek at a distance of approximately 1 mile from the eastern flanks of the esker ridge.

The proposed routes of the Mackenzie Highway and gas pipeline are located on the immediate southwestern extremity of Site FGH 1.

DEVELOPMENT

The drill hole information, obtained from the Federal Department of Public Works engineering consultant during their geotechnical study of the proposed Mackenzie Highway in this area, has been utilized in the assessment of this site. Their drill hole logs are identified and incorporated in this section of the Site Description format.

Site FGH 1 is not recommended for immediate development because granular materials of similar quality can be obtained from Sites FGH 2 and FGH 3 which are more accessible to Fort Good Hope.

However, if Site FGH 1 is considered for development and exploitation in the future during the construction of utilities or in order to meet increased local demands for granular materials, then the following operational guidelines should be considered:

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

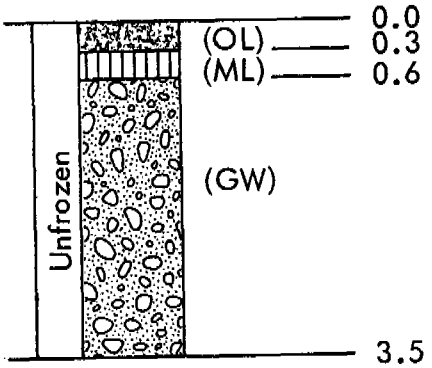
accordance with current land use guidelines.

- 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 to Jackfish Creek or adjacent lakes.

DETAILED TEST PIT LOG

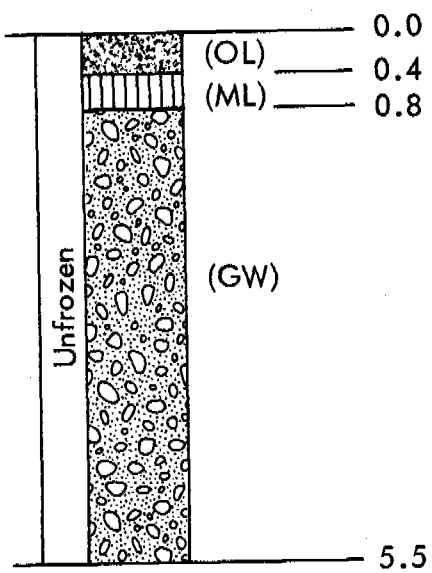
FGH 1/TP 1



Topsoil; organic, black
Silt; some sand, trace of clay, some pebbles, brown, rootlets

Gravel; some sand, coarse. Carbonate coating on bottom side of pebbles

FGH 1/TP 2



Topsoil; organic, black, roots
Silt; some sand, trace of clay, some gravel, brown

Gravel; little sand, brown; pebbles rounded

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-1

DATE: JAN. 12, 1973 | LOGGED BY: ☐ PEMCAN ☒ E.W. BROOKER & ASSOC.

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
		SP	SAND: coarse to medium grained, reddish brown		Nbn	L		
2							MC	2
4			4.0					4
		SM-SP	SAND: some silt, fine to medium grained, loose, light brown	UF			MC	
6								6
8								8
10			10.0					10
			TOTAL DEPTH 10.0'					
12								12
			Note: loose sand and gravel at 10', unable to drill further					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-2

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E.W. BROOKER & ASSOC.

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
2		SM-SP	SAND: some silt, fine to medium grained, loose, light brown		Nbn	L	MC	2
4								4
5.0							MC	
6		GW-SW	GRAVEL & SAND: well graded, rounded particles, light brown	UF				6
7.0			TOTAL DEPTH 7.0'					
8								8

Note: Drillhole caving in at 5'

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-3

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E.W. BROOKER & ASSOC.

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, brown					0
0.7			SILT: some sand, fine grained, light brown					
2					Nbn	L	MC	2
4		ML						4
							MC	
6								6
8				UF				8
10			10.0				MC	10
		SM-SP	SAND: some silt and gravel, fine to medium grained, loose, light brown					
12								12
14				UF			MC	14
			15.0					
16			TOTAL DEPTH 15.0'					16
			Note: Drillhole caving in at 12'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-4

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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
2		ML	SILT: some sand, fine grained, light brown		Nbn	L	MC	2
4			4.0					4
6		SW-SM	SAND: some silt, some rounded gravel, fine to medium grained, well graded - pockets of silty clay	UF			MC GS	6
8								8
10			10.0				MC	10
12		GW	GRAVEL: some sand, little silt, well graded, rounded particles, light brown	UF				12
14							MC	14
16								16
18			18.0				MC	18
20			TOTAL DEPTH 18.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-5

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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
2		SW-GW	SAND & GRAVEL: fine grained, light brown		Nbn	L	MC	2
4		GW	GRAVEL: some sand, little silt, well graded, loose, light brown	UF			MC	4
			4.0					
			TOTAL DEPTH 6.0'					
8								8

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-6

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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
2		SM	SAND: some silt, fine grained, light brown		Nbn	L	MC	2
4			4.0					4
6		MH	SILT: some clay, medium plasticity, medium brown				MC	6
8		MH-ML	- some sand					8
10							MC	10
12					Nbn	L		12
14							MC	14
16		ML	- some sand, trace of clay, fine grained					16
18			18.0 TOTAL DEPTH 18.0'				MC	18
20								20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-6C

DATE: DEC. 9, 1972 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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
			PEAT: black, organic		Vr-Vx	L		
2		Pt					MC	2
4			- becoming woody				MC	4
6			6.0					6
		SM-SC	SAND: coarse grained, some silt, little clay, low plastic, stratified, medium brown		Vx	L		
8								8
10							MC	10
12								12
14							MC	14
16								16
		SM	- some coarse grained sand					
18			18.0				MC	18
			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. FGH-1 HOLE NO. DH-7

DATE: JAN. 12, 1973 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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			SAND: some silt, trace of clay, fine grained, medium brown				MC	2
4		SM			Nbn	L		4
6							MC	6
8								8
10			10.0				MC	10
12			SILT: some sand, fine grained, light brown		Nbn	L		12
14		ML					MC	14
16								16
18			- pockets of clay 18.0 TOTAL DEPTH 18.0'				MC	18
20								20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-7C

DATE: DEC. 9, 1972 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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

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
2		GW-GM	GRAVEL: some sand and silt, well graded, rounded to sub-angular, loose, light brown	UF				2
			3.0				MC	
4			TOTAL DEPTH 3.0'					4
			Note: Unable to drill due to caving in of hole					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FGH-1 HOLE NO. DH-8C

DATE: DEC. 9, 1972 LOGGED BY: ☐ PEMCAN ☒ E. W. BROOKER & ASSOC.

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
		ML	SILT: some gravel and fine sand, non-plastic, light brown	UF				
2							MC	2
4								4
			5.0				MC	
6		SM	SAND: some silt, very fine grained, light brown					6
8								8
10							MC	10
12				UF				12
14		SM-SP	- fine grained, trace of silt				MC	14
16								16
18							MC	18
			19.0					
20			TOTAL DEPTH 19.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

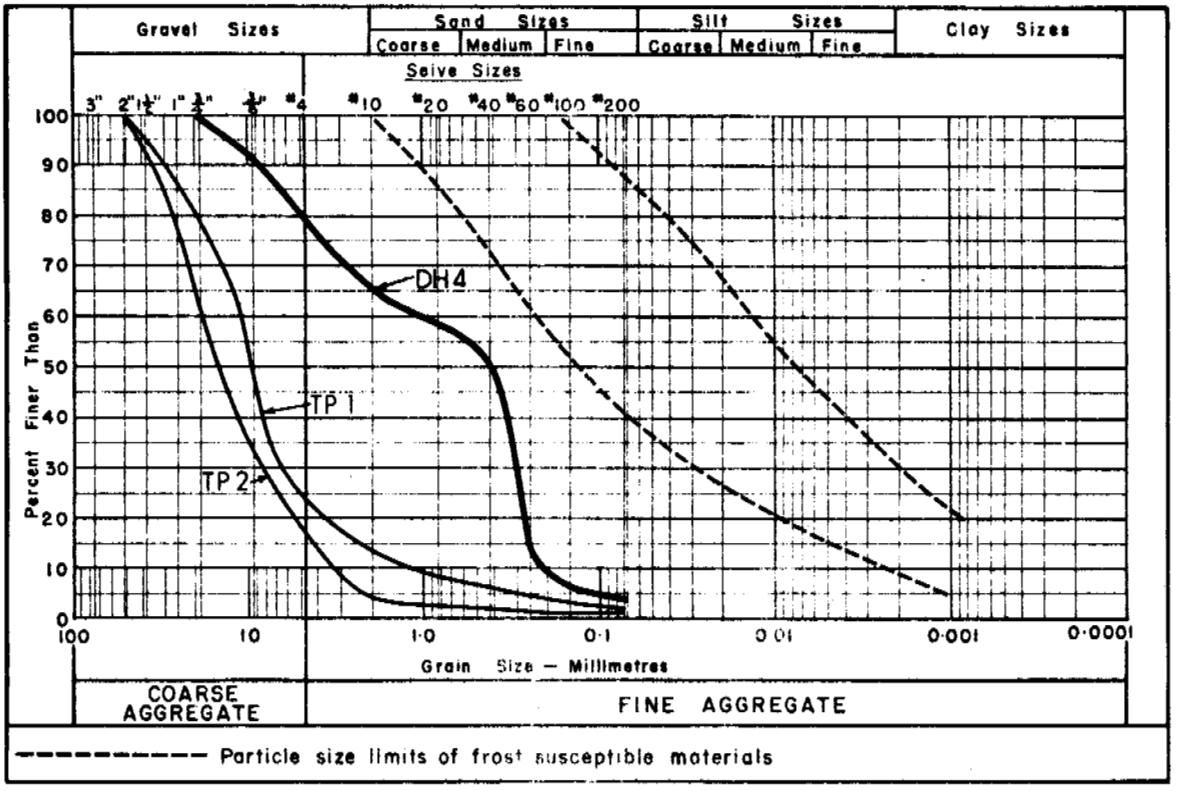
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FGH 1/ TP 1	FGH 1/TP 2	FGH 1/DH 4
Sample Depth (Feet):	2.0	4.0	5.0
Moisture Content (%):	-	-	15.0
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Quartzite; varicolored	50.5 %	Granite & Rhyolite	10.6 %
Chert; varicolored	17.2 %	Limestone	3.7 %
Chert; black	11.3 %	Dolostone	3.4 %

Deleterious Components: Friable sand & mudstone 3.2 %

L.A. ABRASION TEST:

Percent Loss - 15.2

SUMMARY OF MOISTURE CONTENT DETERMINATIONS

Sample Location	Sample Depth (Ft.)	Moisture Content (%)
FGH 1 / DH 1	2.5	3.5
FGH 1 / DH 1	5.0	5.0
FGH 1 / DH 2	2.5	3.5
FGH 1 / DH 2	5.0	4.0
FGH 1 / DH 3	2.5	15.0
FGH 1 / DH 3	5.0	17.0
FGH 1 / DH 3	10.0	14.0
FGH 1 / DH 3	14.0	8.0
FGH 1 / DH 4	2.5	18.0
FGH 1 / DH 4	5.0	15.0
FGH 1 / DH 4	10.0	17.0
FGH 1 / DH 4	14.0	17.0
FGH 1 / DH 4	18.0	14.0
FGH 1 / DH 5	2.5	2.0
FGH 1 / DH 5	5.0	3.0
FGH 1 / DH 6	2.5	11.5
FGH 1 / DH 6	5.0	44.0
FGH 1 / DH 6	10.0	26.0
FGH 1 / DH 6	14.0	28.0
FGH 1 / DH 6	18.0	28.0
FGH 1 / DH 7	2.5	14.0
FGH 1 / DH 7	5.0	16.5
FGH 1 / DH 7	10.0	27.0
FGH 1 / DH 7	14.0	15.5
FGH 1 / DH 7	18.0	13.5
FGH 1 / DH 8C	2.0	2.5
FGH 1 / DH 8C	2.5	10.0
FGH 1 / DH 8C	5.0	7.5
FGH 1 / DH 8C	10.0	6.0
FGH 1 / DH 8C	14.0	2.5
FGH 1 / DH 8C	18.0	6.5

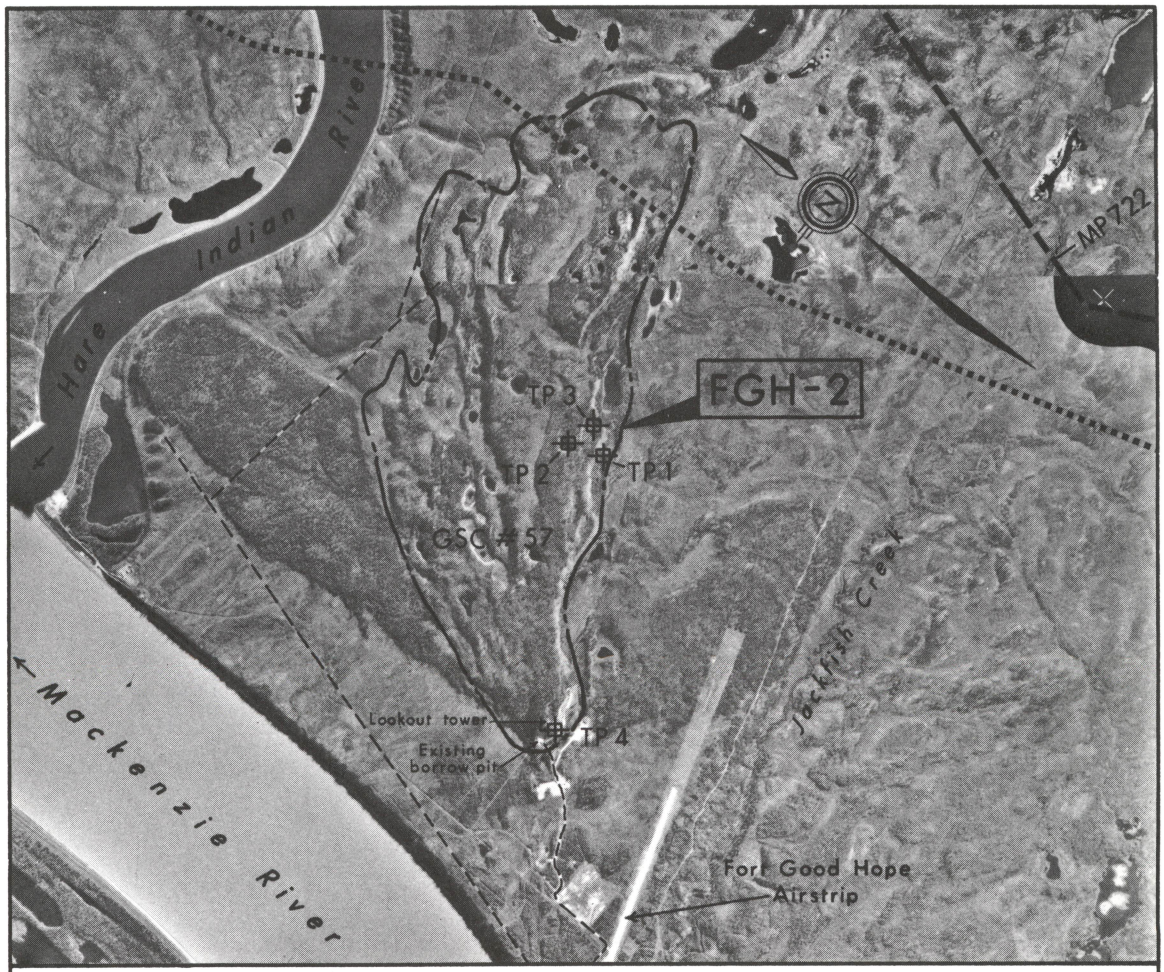
SITE NO. FGH 2

Located less than 1 mile north of Fort Good Hope, Site FGH 2 consists of a kame-esker complex which is a part of an old glaciofluvial delta.

Type of Material: Gravel; some sand, medium grained.

Estimated Volume: 30,000,000 cubic yards.

Assessment: Excellent quality material for the production of all types of construction aggregates. This site is recommended for development and is considered to be a major and primary source of granular materials for the community.



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. A22858/54 & A22889/160

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 2 is located less than 1 mile north of Fort Good Hope and consists of a kame-esker complex which is part of an old glaciofluvial delta. The immediate adjacent terrain is an elevated, large plain with frequent ridges and knolls with numerous small lakes. The site is approximately 1 mile west of Jackfish Creek, $\frac{1}{2}$ mile east of Hare Indian River and $\frac{1}{2}$ mile north of the Mackenzie River. The site encompasses an area approximately 2 miles in length by $\frac{1}{2}$ mile in width and rises 60 feet above the adjacent terrain.

The material in the kame-esker deposit consists of well graded, medium grained, clean gravels that are suitable for the production of most construction aggregates. An organic topsoil layer, 2 to 6 inches in depth mantles the entire site area and supports moderately good growths of spruce along the top and on northwestern exposures. The spruce attains heights of 30-40 feet and trunk diameters that range up to 12 inches. The southeastern slopes support very sparse growths of spruce with occasional birch. The adjacent terrain to the east and west is flat to slightly depressional, poorly drained and is characterized with muskeg and small lakes.

The kame-esker complex is generally well drained. The depth of the ground water table is considered to be relatively well represented by the level of water in the adjacent lakes. An existing borrow pit located at the south end of the main esker formation is currently being operated and exploited for granular materials.

There are no known critical wildlife areas in the immediate vicinity of the site. Existing access to the site and the use thereof, and vehicle traffic to a dump located a short distance southwest of the site negates any severe implications to wildlife in the immediate area. The proximity of the site to Fort Good Hope airport suggests that wildlife in the area have either adjusted to the encroachment by man or have moved further away from these developments.

An existing all weather road from the community to the existing borrow pit provides excellent access to Site FGH 2.

DEVELOPMENT

Site FGH 2 is considered a major and primary source for high quality granular materials and is recommended for development. The following operational guidelines should be considered:

- Exploitation of granular materials should be continued by extending the existing borrow pit in an easterly direction. The lookout tower situated at the top of the esker near the west end would have to be relocated at a future date.

- 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 to Jackfish Creek or the Hare Indian and Mackenzie Rivers.

- Stands of natural growth should be retained between borrow pit areas in order to promote natural regeneration after abandonment.

- Generally, dozers, overhead loaders and standard ripping equipment should be adequate for the removal of material from this site. The selection of equipment required may be governed by in situ ground ice at deeper extremities of this source.

- Operating procedures during the borrow pit development should be maintained whereby the final 2 to 3 feet of material above the natural ground water table or the base of the esker is not removed. The retention of this blanket of gravel will provide a competent working pad for excavation equipment and vehicular traffic.

- The production of quality surface course and concrete aggregates is considered possible by utilization of the granular materials from this site. However, a screening and crushing operation may be required in order to produce aggregates that meet specific construction requirements. In addition, a washing operation may be necessary to reduce the silt content for fine concrete aggregates.

- Additional laboratory tests to evaluate specific physical and chemical properties of the granular material is recommended, if material from this source is considered for the production of concrete aggregates.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

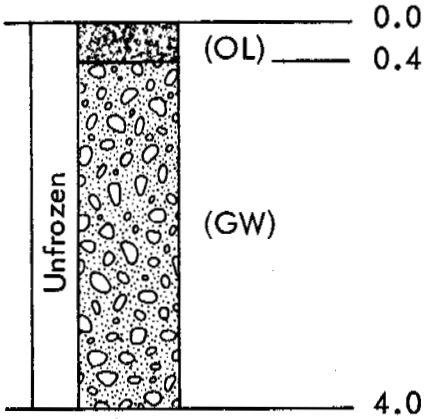
- Recontouring of the pit areas to provide general drainage that is compatible with the natural drainage of the adjacent terrain.

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

- Reseeding of the recontoured pit areas should be considered in areas that may pose erosional problems. At these locations, the artificial reseeding of annuals and perennials will result in a semi-permanent cover growth prior to reestablishment of native species.

DETAILED TEST PIT LOG

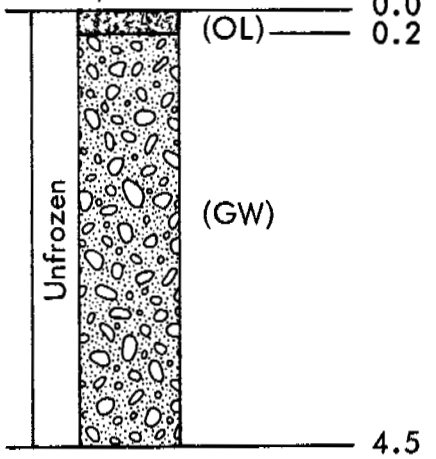
FGH 2/TP 1



Topsoil; organic, black, roots

Gravel; some sand, well graded, coarse, brown. Scattered rootlets

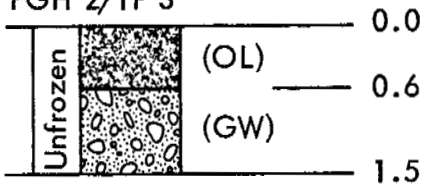
FGH 2/TP 2



Topsoil; organic, black, roots

Gravel; some sand, coarse, frequent cobbles (about 20%), brown

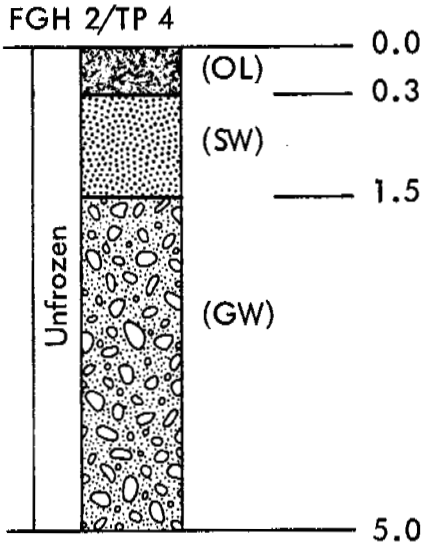
FGH 2/TP 3



Topsoil; organic, black, roots

Gravel; some sand, brown, coarse

FGH 2/TP 4



Topsoil; some sand, dark brown

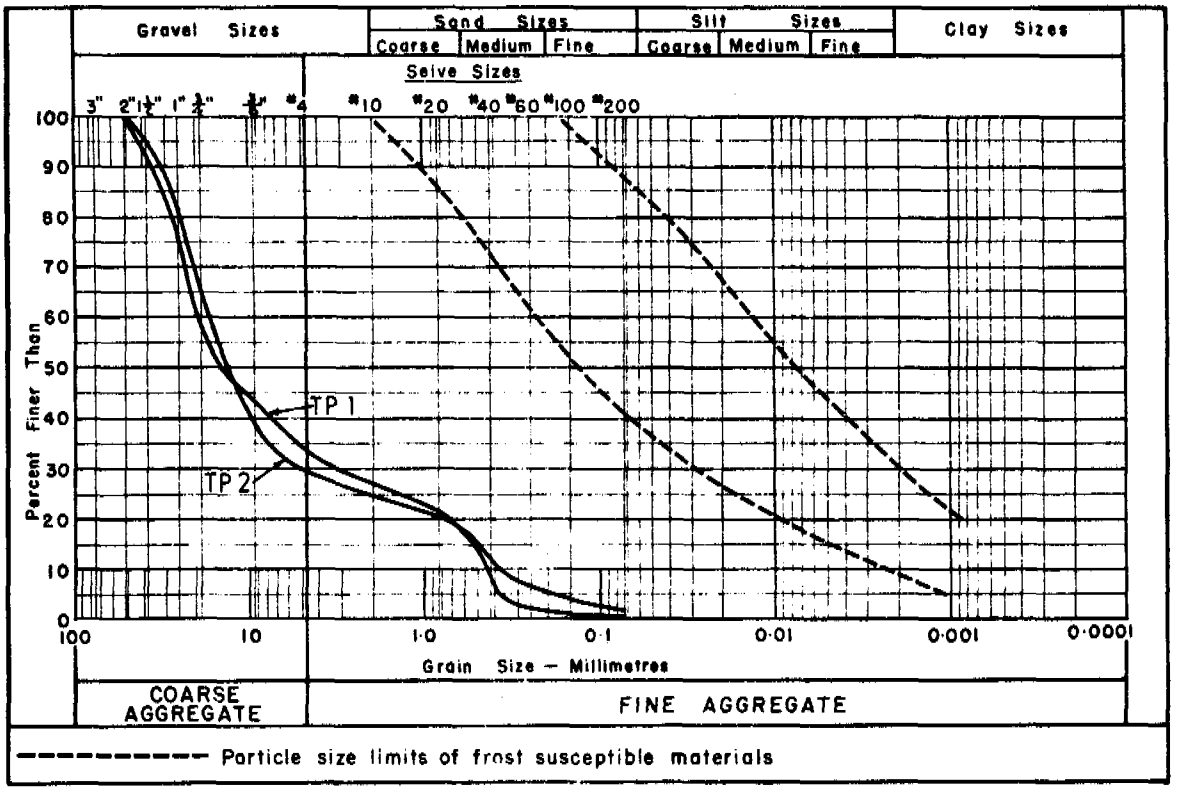
Sand; some silt, brown frequent pebbles to 2 inch, roots

Gravel; some sand, well graded, pebbles predominantly to 2 inches, well rounded, scattered cobbles, brown

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FGH 2/TP 1	FGH 2/TP 2
Sample Depth (Feet):	3.0	4.0
Moisture Content (%):	0.9	1.1
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:

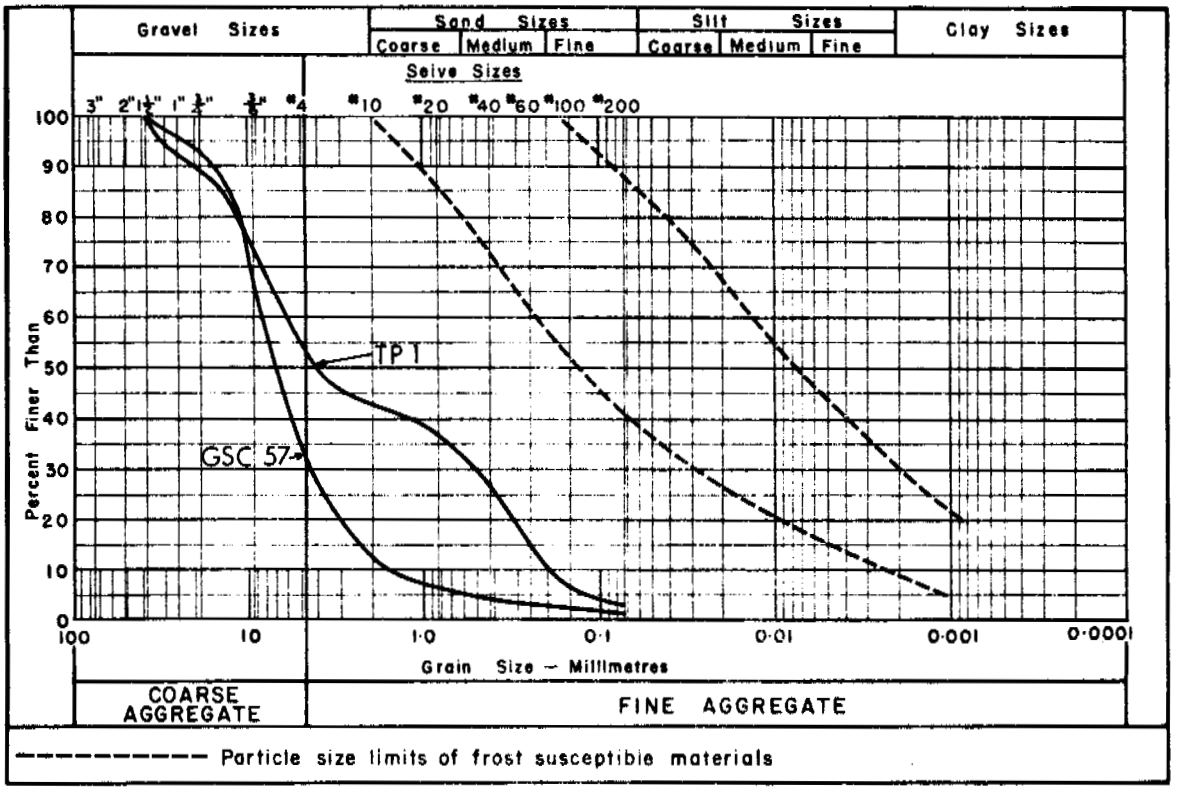


PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FGH 2/TP 3	GSC #57
Sample Depth (Feet):	3.0	-
Moisture Content (%):	-	0.3
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

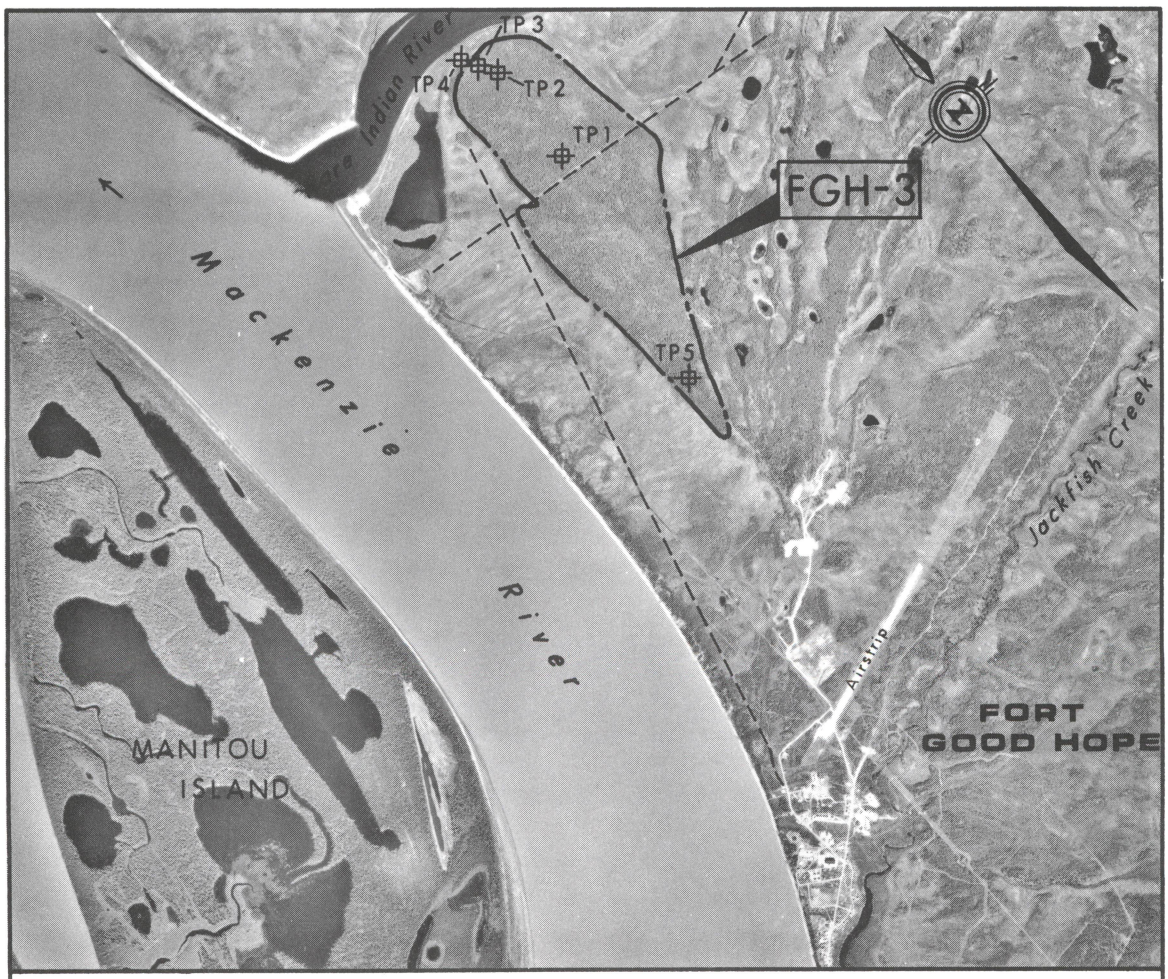
SITE NO. FGH 3

Located approximately $1\frac{1}{2}$ miles northwest from Fort Good Hope, Site FGH 3 consists of a glacial outwash plain.

Type of Material: Gravel; some sand, poorly graded; medium grained.

Estimated Volume: 7,000,000 cubic yards.

Assessment: Fair to good quality material for general fill, base and surface course requirements. This site is not recommended for immediate development because other sites with better quality material and better access are available in the Study 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. A22889/33

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 3 is located approximately 1½ miles northwest of Fort Good Hope and consists of a glacial outwash terrace. The site is approximately 4000 feet in length and 2000 feet in width and is bordered on its northern extremity by the south bank of the Hare Indian River. The flat, poorly drained, alluvial plateau of the Mackenzie River flanks the site along its southwestern periphery.

The material in the terrace consists of medium grained, poorly graded gravel with a trace of silt. The gravel is considered suitable for general fill, base and surface course requirements.

The site area is covered with a layer of topsoil, 4 to 12 inches in depth and supports moderate growths of spruce that range up to 20 feet in height and 6 inches in trunk diameter. The understory growth consists of moss, sedge and small shrubs. The surficial drainage of the site area is to the north and southwest.

There are no known critical wildlife areas in the immediate vicinity of the site; however, the area around the mouth of the Hare Indian River is domestically fished by the residents of Fort Good Hope.

The access to the site consists of the CNT pole line and seismic cutlines.

DEVELOPMENT

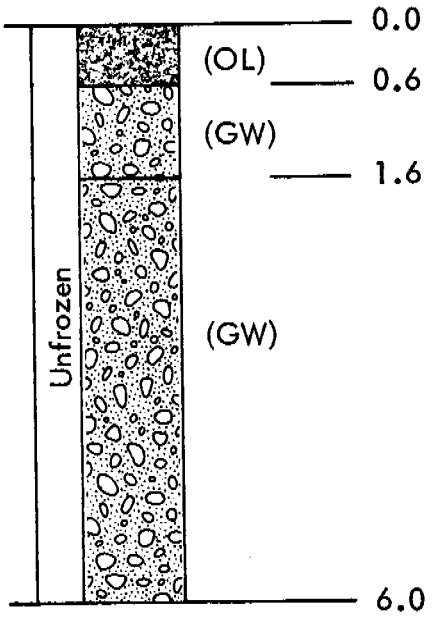
Site FGH 3 is not recommended for immediate development because of the following reasons:

- Extensive quantities of better quality granular materials are available at sites more accessible to Fort Good Hope.
- New access roads to the site as well as inter-site access roads would have to be developed.
- The presence of the Hare Indian River at the northwestern extremities of the site limits development of borrow pits in the area.

However, if in the future the development of this site is considered because of increased local demands for granular materials or for the construction of local utilities, then an assessment should be made relevant to the current physical status of the area and the proposed development of borrow pits.

DETAILED TEST PIT LOG

FGH 3/TP 1

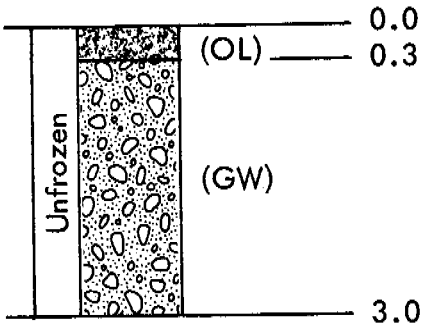


Topsoil; some sand and silt, roots

Gravel and Sand; brown. Sand content about 30-40%, pebbles well rounded, predominantly to 2 inches in diameter

Gravel; some sand, grey; sand content about 20-30%, medium grained, trace of silt, pebbles well rounded, predominantly $\frac{1}{2}$ to 2 inches in diameter, occasionally to 4 inches. Infrequent cobbles.

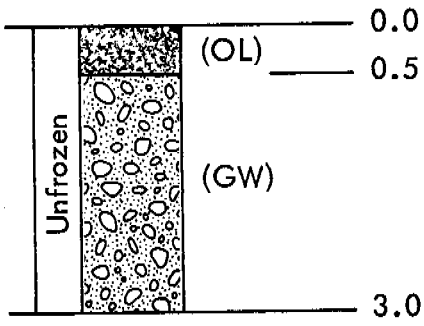
FGH 3/TP 2



Topsoil; organic, some sand

Gravel; some sand, well graded. Sand medium to coarse, sand content about 30%. Pebbles well rounded, predominantly carbonate rocks, $\frac{1}{4}$ to 2 inches in diameter, occasionally up to 4 inches

FGH 3/TP 3

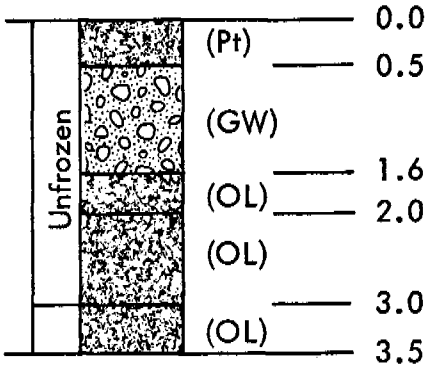


Topsoil; organic, black

Gravel; some sand, well graded, pebbles rounded

DETAILED TEST PIT LOG

FGH 3/TP 4



Topsoil; peat, black

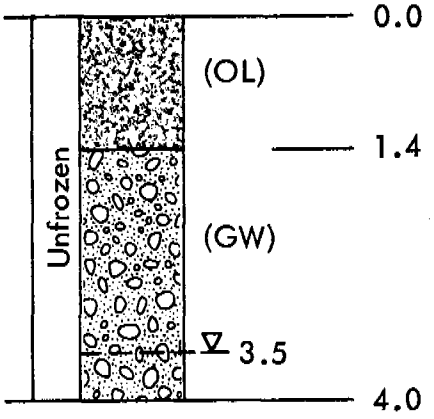
Gravel; some sand, wet, brown

Buried organic soil layer, seepage from the hillside

Organic soil; black, some silt and wood, frequent pebbles

Organic soil; black, frozen, frequent ice lenses

FGH 3/TP 5



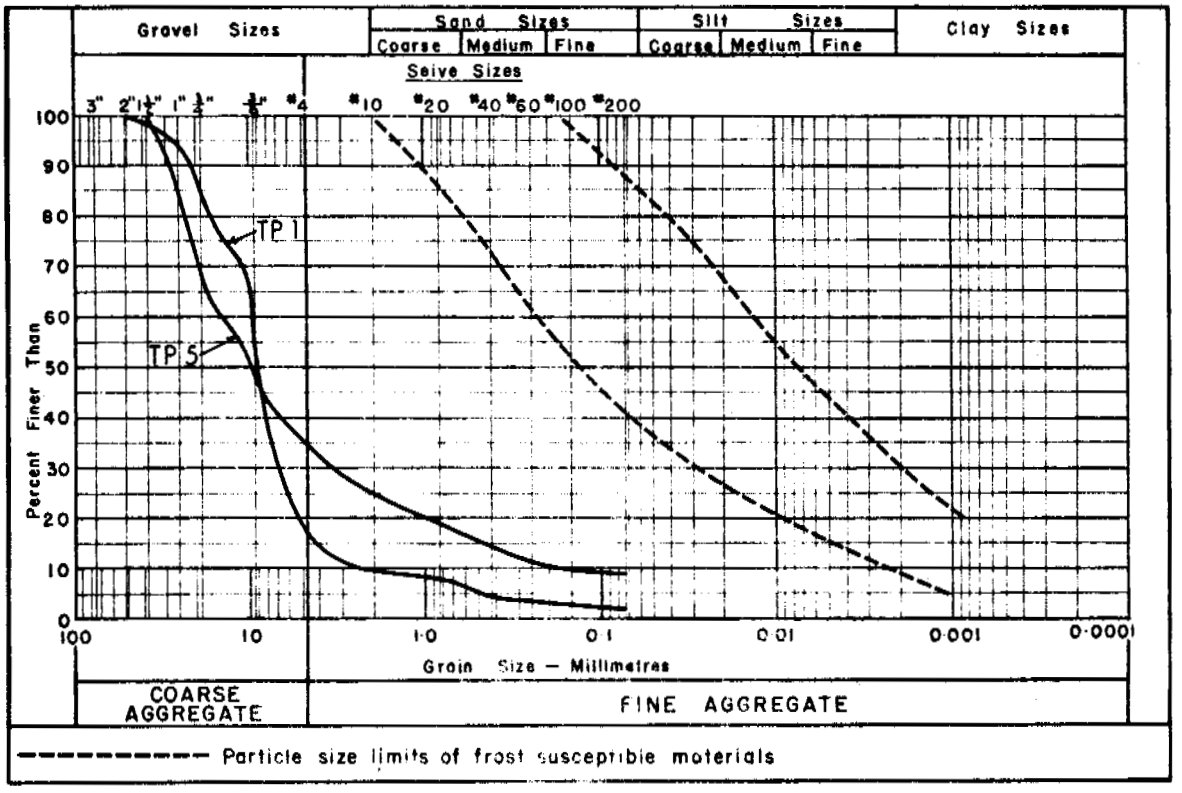
Topsoil; organic, scattered cobbles, black, roots, wet

Gravel; some sand, trace of clay, coarse, frequent cobbles, wet

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FGH 3/TP 1	FGH 3/TP 5
Sample Depth (Feet):	4.0	4.0
Moisture Content (%):	-	-
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Quartzite:	31.6 %	Limestone	4.2 %
Chert; black to varicolored	40.7 %	Dolostone	2.5 %
Igneous Rocks	13.7 %	Siltstone	2.0 %

Deleterious Components: bituminous, limestone, friable mudstone, brittle schist 4.8 %

SITE NO. FGH 4X

Located approximately 1 mile north of Fort Good Hope, and immediately adjacent to the airstrip, Site FGH 4X consists of a glaciofluvial plain. Jackfish Creek borders the eastern perimeter of the site area.

Type of Material: Gravel; poorly graded, medium grained.

Estimated Volume: 400,000 cubic yards.

Assessment: Fair quality material for base and general fill requirements. This site is not recommended for development because better quality material at other sites with better access to the community are available in the Study Area.

Airphoto No. A22889/159 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 4X is located approximately 1 mile north of Fort Good Hope. The cleared northern approach at the airstrip traverses almost the entire site area in an east-west direction. The site consists of a glacial outwash plain and encompasses an area 3000 feet in length and 800 feet in width. Site FGH 4X borders on the southern flank of Site FGH 2.

The material in the glacial outwash plain consists of poorly graded, medium grained gravel with a little sand which is generally suitable for base and general fill requirements. A shallow layer or organic topsoil, approximately 1 foot in depth, overlies the entire site area and supports dense growths of spruce with occasional birch and poplar. The understory growth consists of moss, sedges, Labrador tea and small brush.

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

The adjacent terrain is flat to gently hummocky and generally drains into the Jackfish Creek stream channel.

Access to the site can be attained directly from the airport strip but should not be considered for obvious reasons. Alternate access will necessitate the construction of a new access road.

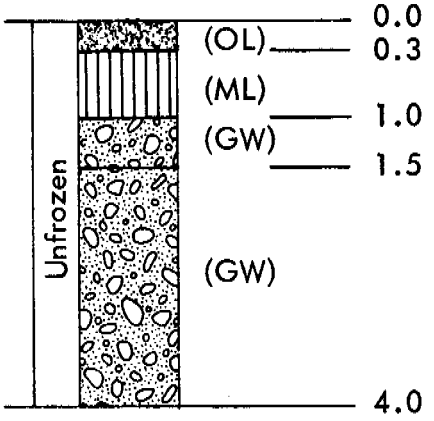
DEVELOPMENT

Site FGH 4X is not recommended for development because of the following reasons:

- Extensive quantities of better quality granular material at sites more accessible to Fort Good Hope are available in the Study Area.
- The proximity of the Fort Good Hope airstrip further negates development of this site.
- The dense growths of timber on this site would involve extensive clearing and stripping prior to exploitation of granular materials.

DETAILED TEST PIT LOG

FGH 4X/TP 1



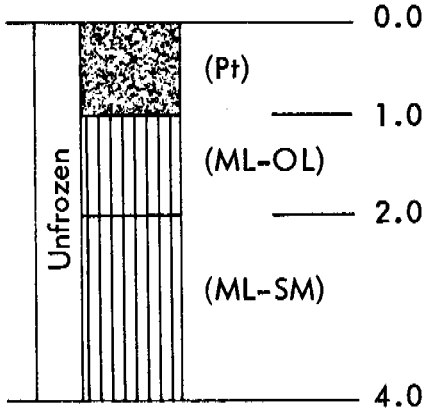
Topsoil, organic, some sand and silt

Silt; some fine sand, light brown, roots

Gravel; little sand, dark brown, trace of silt and loam. Occasional rootlets.

Gravel; some sand, very frequent pebbles $\frac{1}{4}$ - $\frac{1}{2}$ inch, occasional cobbles to 3 inches in diameter.

FGH 4X/TP 2

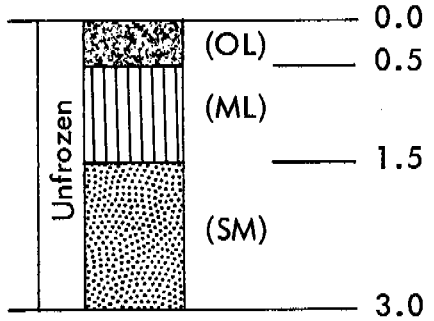


Peat; organic, some silt

Silt; some sand, grey, organic

Silt and Sand; few pebbles

FGH 4X/TP 3



Topsoil; organic, black

Silt; some fine grained sand, roots

Silt and Sand; sand lenses, few pebbles

SUMMARY OF LABORATORY TEST DATA

Sample Location: FGH 4X/TP 1

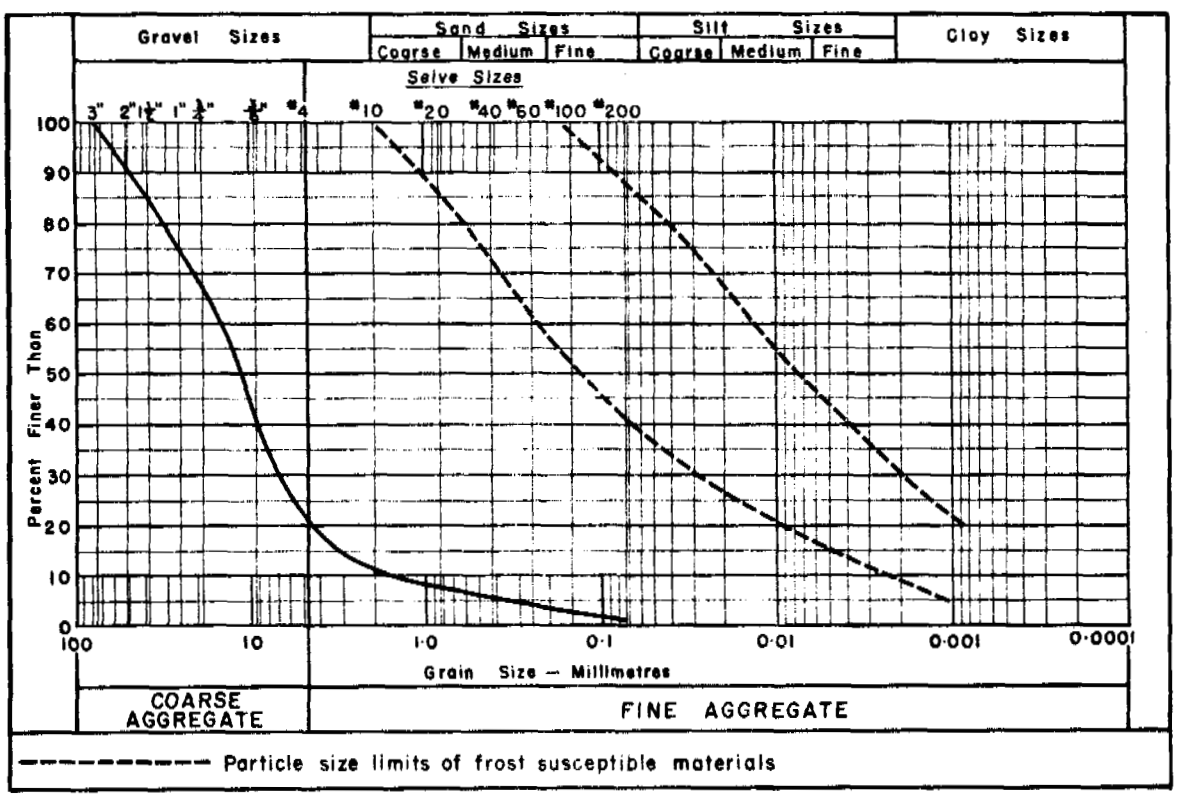
Sample Depth (Feet): 3.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Quartzite:	40.1 %	Chert; black	9.7 %
Limestone; crystalline	16.8 %	Chert; varicolored	9.4 %
Igneous Rocks	9.9 %	Dolostone	3.0 %

Deleterious Components: Weathered quartzdiorite, porous mudstone, carbonitic sinter 11.1 %

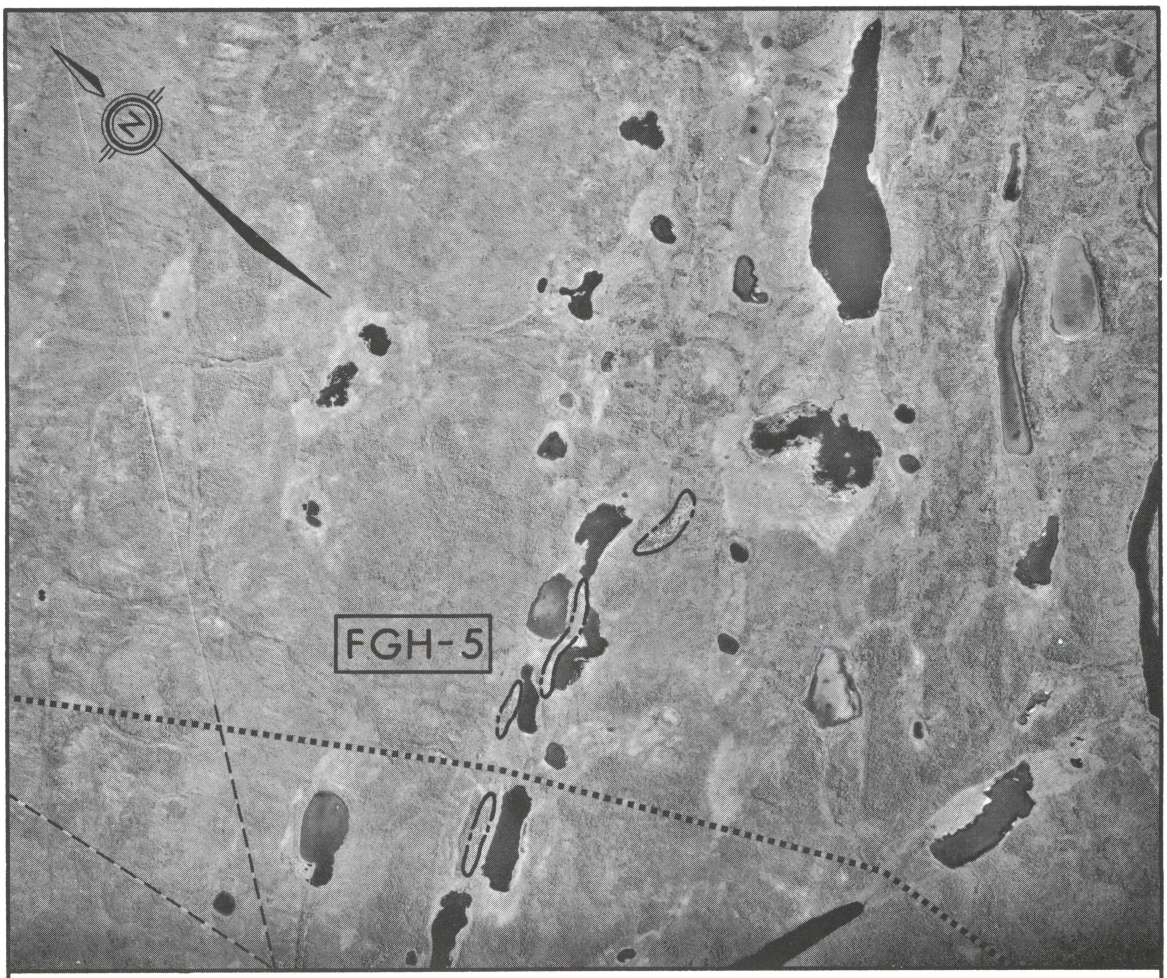
SITE NO. FGH 5

Located approximately 9 miles northwest of Fort Good Hope, Site FGH 5 encompasses four small, separated esker ridges.

Type of Material: Sand; fine, gravel pockets.

Estimated Volume: 30,000 cubic yards.

Assessment: Fair to low quality material for general fill only. This site is not recommended for development for the granular material requirements of the community, but may be considered for 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. A22890/54

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 5 is located approximately 9 miles northwest of Fort Good Hope and consists of four small, separated esker ridges. The total site area is approximately $1\frac{1}{4}$ miles in length and the individual esker ridges vary in length from 600 to 1000 feet and are approximately 150 feet in width and 10 to 20 feet in height.

These esker ridges contain fine grained sand with occasional pockets of gravel suitable for general fill requirements. The ridges are overlain with a sparse growth of spruce, birch and poplar and the organic topsoil layer is generally very shallow.

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

The adjacent terrain is relatively flat, slightly depressional and inundated with numerous lakes. Although the esker ridges are relatively well drained, the surficial drainage of the adjacent terrain is very poor. Access to the site would require traversing thermally sensitive terrain and any disturbance of the existing organic cover may result in subsidence and gullying.

There is no existing access to this site, although the CNT pole line is located approximately $\frac{1}{2}$ mile south of the southern edge of Site FGH 5.

DEVELOPMENT

Site FGH 5 is not recommended for development for the granular material requirements of Fort Good Hope because of its remoteness, poor quality of material and difficult access. However, the in situ material from this site can be utilized in the construction of local utilities, and the following development guidelines should be followed:

- The shallow organic topsoil should be carefully stripped and stockpiled along the lower slopes of the ridges 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 ridge areas.

- The clearing of existing trees and understory growth on the 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.

- Only one or two of the separated esker ridges should be developed at any one time in order to avoid excessive, and possibly wasteful denudation of the total site area.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

- Recontouring of the 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 recontoured pit areas.

- Reseeding of the recontoured pit areas should be considered in areas that may pose erosional problems. At these locations, the artificial reseeding of annuals and perrenials will result in a semi-permanent cover growth prior to re-establishment of native species.

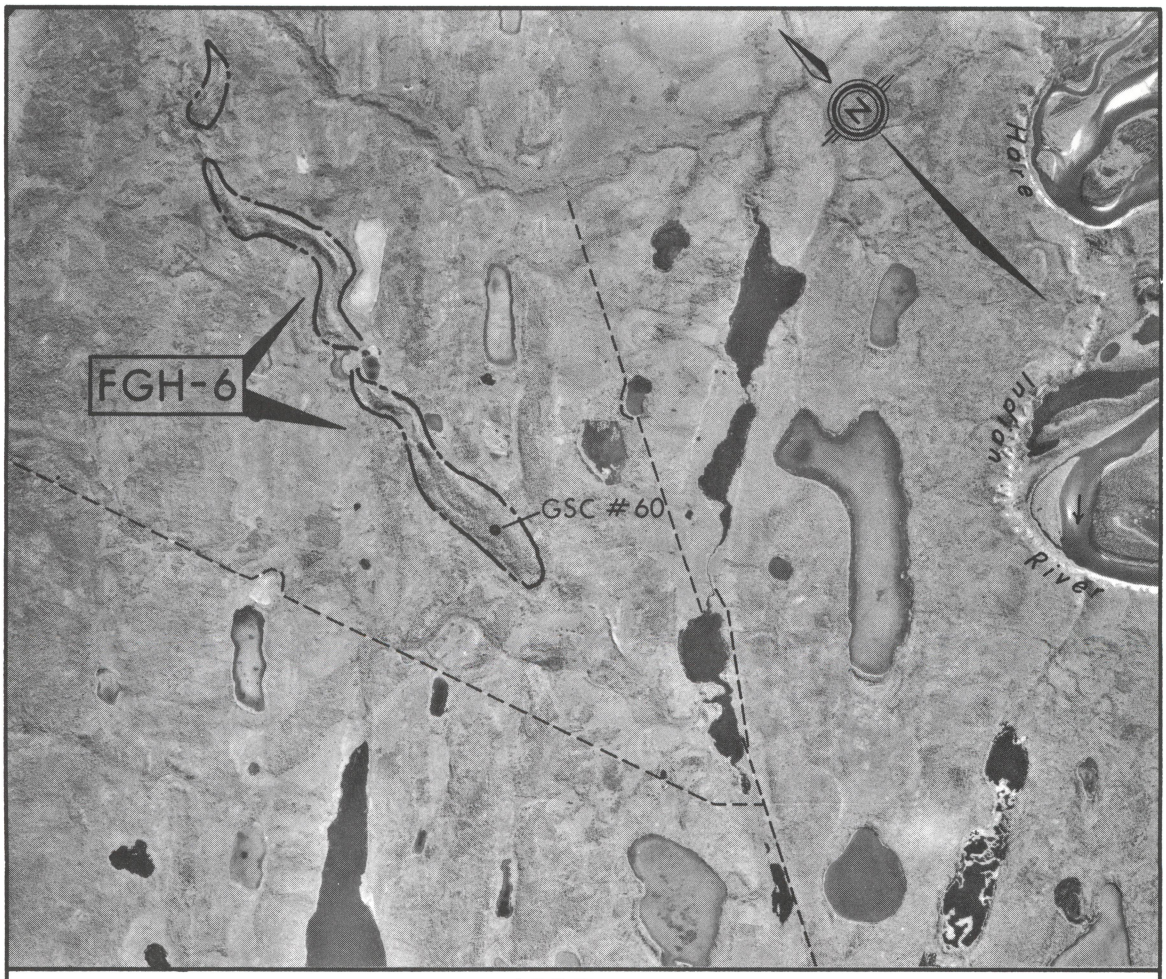
SITE NO. FGH 6

Located approximately 10 miles north of Fort Good Hope, Site FGH 6 consists of a discontinuous, sinuous esker ridge.

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

Estimated Volume: 1,500,000 cubic yards

Assessment: Low quality material only for general fill. This site is not recommended for development for community requirements, but may be considered for 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. A22890/53

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 6 is located approximately 10 miles north of Fort Good Hope, and consists of a long, sinuous and discontinuous esker ridge. The esker ridge is approximately 2 miles in length, 400 feet in width and rises 10 to 30 feet above the adjacent terrain. The adjacent terrain is flat to gently rolling, and the surficial drainage is northerly.

The ridge contains very poorly graded, fine sand with some silt which is only suitable for marginal general fill requirements. The organic topsoil layer is relatively shallow and supports dense growths of birch, spruce and occasional poplar.

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

The only access in the vicinity of Site FGH 6 are seismic cutlines located approximately $\frac{1}{2}$ mile to the east and to the south. Access along existing cutlines and any new access would require traversing thermally sensitive terrain and any disturbance of the organic cover may result in subsidence and gullying. The proposed route of the Mackenzie Highway is in the immediate vicinity of the northern extremity of this site.

DEVELOPMENT

Site FGH 6 is not recommended for development relative to the granular material requirements for the community of Fort Good Hope because extensive sources of better quality material with better access to the community are available in the Study Area.

However, if this source is developed at a future time, to supply the granular fill requirements to construct local utilities, then an assessment should be made relevant to the current physical status of the area and the proposed development of borrow pits.

SUMMARY OF LABORATORY TEST DATA

Sample Location: GSC #60

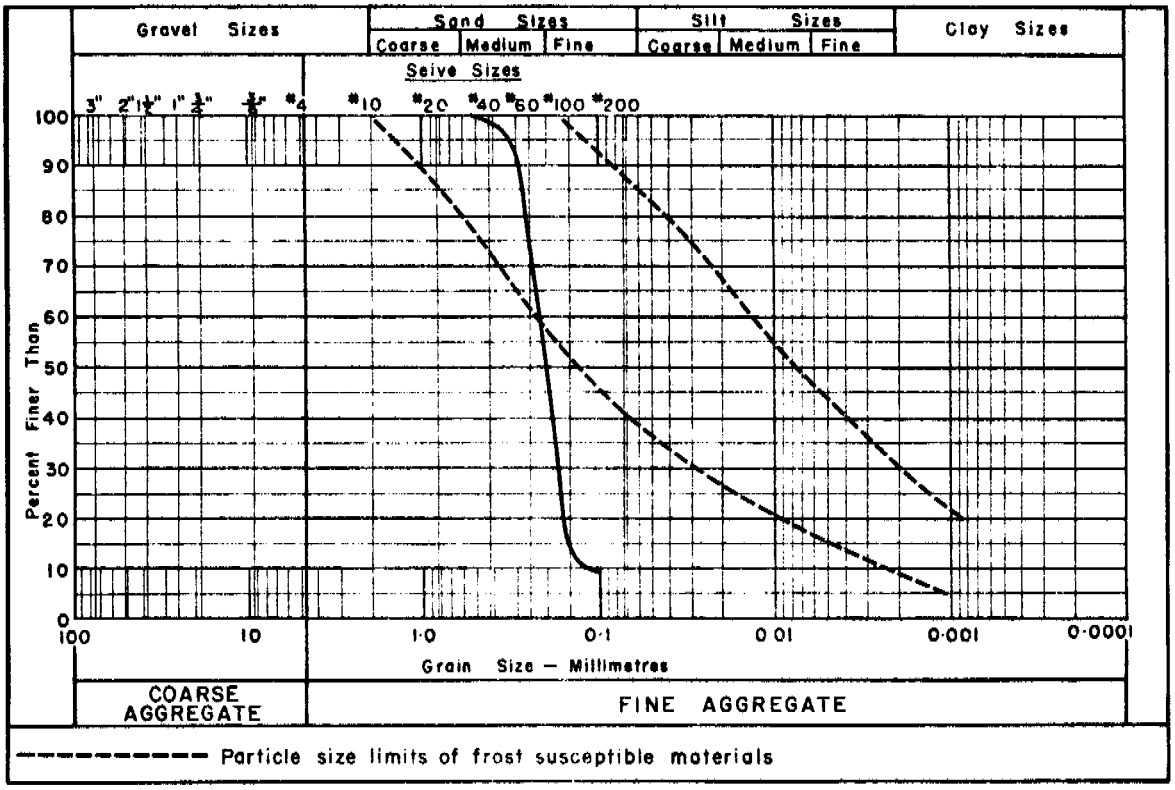
Sample Depth (Feet): -

Moisture Content (%): 3.7

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

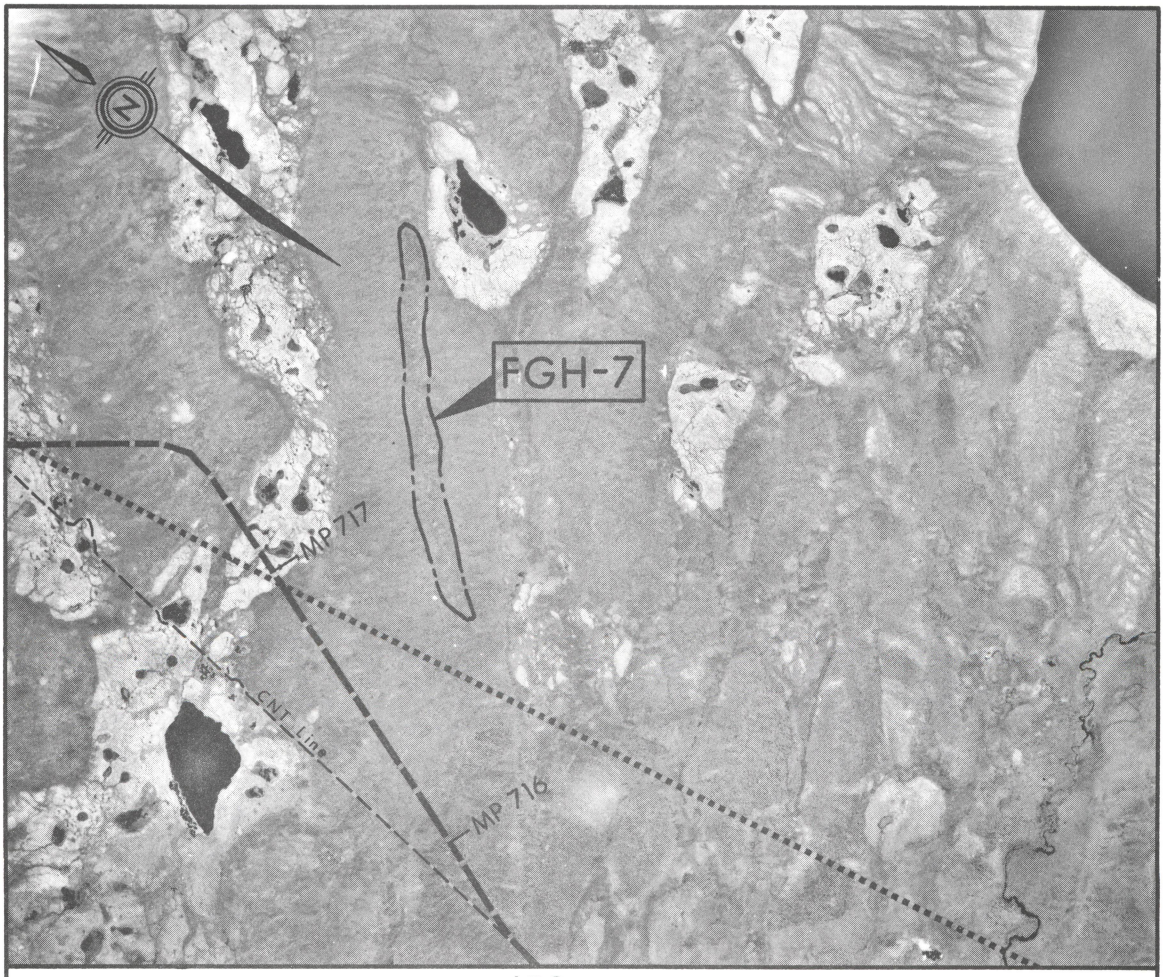
SITE NO. FGH 7

Located approximately 7 miles east of Fort Good Hope, Site FGH 7 consists of a narrow, long esker ridge with a very low vertical profile. The adjacent terrain consisting of a shallow till sheet, exhibits thermokarst features.

Type of Material: Sand; little silt.

Estimated Volume: 100,000 cubic yards:

Assessment: Low quality material suitable only for marginal general fill. This site is not recommended for community granular material requirements, but may be developed and utilized 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. A22890/37 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 7 is located approximately 7 miles east of Fort Good Hope and consists of a relatively straight and narrow esker ridge with a low profile. The esker ridge is approximately 1 mile in length, less than 200 feet in width at the base and generally less than 10 feet in height. The adjacent terrain consists of a till sheet which is relatively flat, poorly drained and exhibits thermokarst features.

The esker ridge contains silty sands suitable only for marginal general fill material. The shallow organic topsoil, generally less than 6 inches in depth, supports moderate growths of spruce with occasional birch.

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

An existing seismic cutline which is located approximately $\frac{1}{2}$ mile south of the site area represents the only visible access to Site FGH 7. The proposed Mackenzie Highway and gas pipeline routes would pass within about 1 mile of Site FGH 7.

DEVELOPMENT

Site FGH 7 is not recommended for development to supplement the granular material requirements for Fort Good Hope because more accessible sites with better quality materials are available in the immediate vicinity of the community.

However, if the site is considered for development of granular material requirements in the construction of local utilities, then an assessment relevant to the current physical status of the site area and the proposed development of borrow pits should be made. In view of the existing thermokarst terrain, the subsurface soils in this area are considered to be relatively sensitive to thermal erosion and any activity in the vicinity of this site must ensure proper techniques to protect the organic vegetation growth from excessive disturbance.

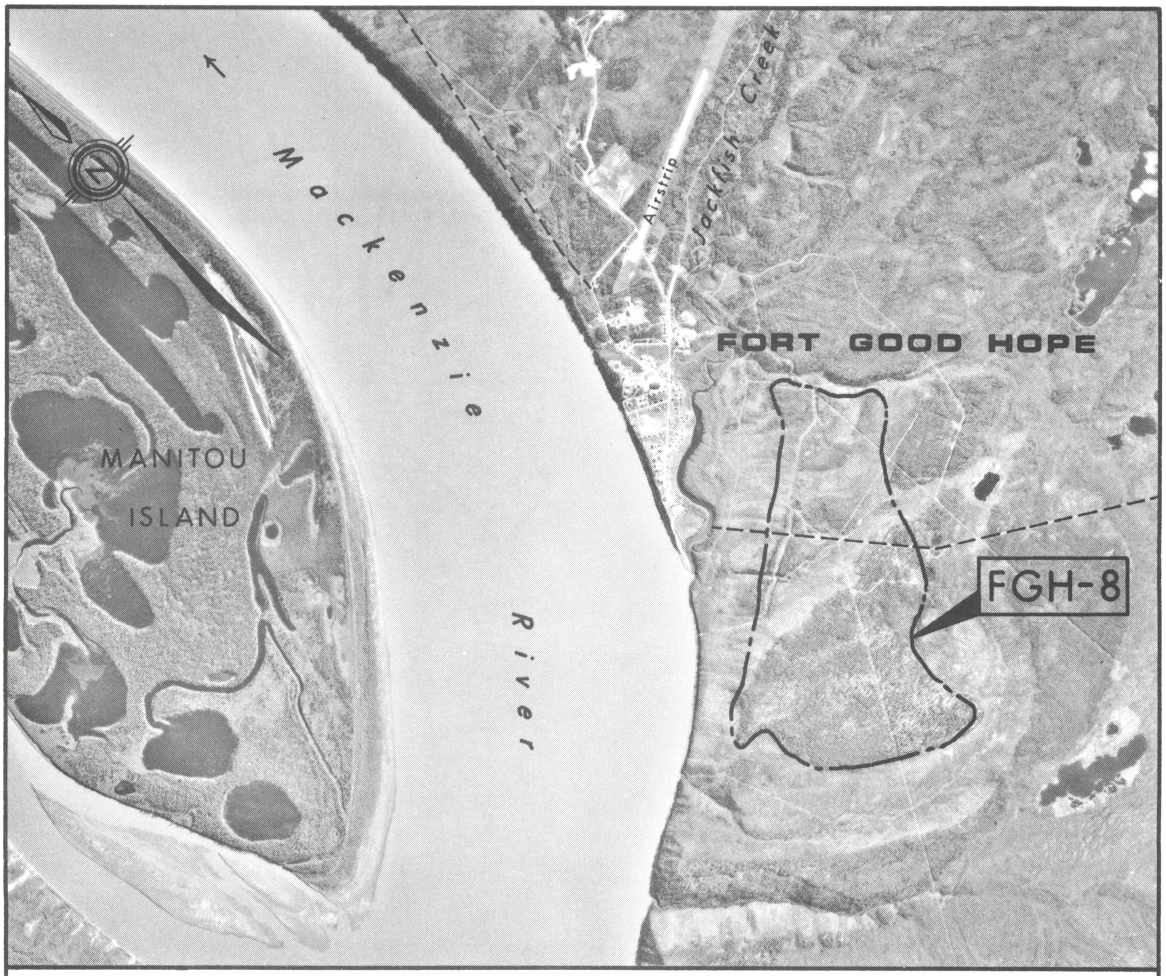
SITE NO. FGH 8

Located approximately $\frac{1}{4}$ mile southwest of Fort Good Hope on the east bank of the Mackenzie River, Site FGH 8 is comprised of a glaciofluvial outwash plain.

Type of Material: Sand and Gravel

Estimated Volume: 1,000,000 cubic yards.

Assessment: Fair quality material for general fill. This site is not recommended for community development purposes, because other sources with better quality material and better access are available in the Study Area.



Airphoto No. A 22889/160 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 8 is located approximately $\frac{1}{4}$ mile southwest of Fort Good Hope on the east bank of the Mackenzie River and consists of a glaciofluvial outwash plain. The site encompasses an area approximately $1\frac{1}{4}$ miles in length and $\frac{1}{2}$ mile in width and is bordered on its western periphery by the Mackenzie River.

The glaciofluvial plain consists of well graded sands and gravels with some silt. The material is suitable for general fill requirements. The organic topsoil layer, approximately 6 to 12 inches in depth, mantles the site area and supports moderate growths of spruce.

The southern half of Site FGH 8 is heavily wooded with dense growths of spruce and birch while the northern half of the site is relatively sparse in tree growth. The surficial drainage of the site area is westerly into the Jackfish Creek and Mackenzie River stream channels.

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

Numerous forest trails and seismic cutlines traverse the site area, and the winter road intersects the northern extremity of the site area. The access to Site FGH 8 is made more difficult by the required crossing of the deeply incised Jackfish Creek stream channel.

DEVELOPMENT

Site FGH 8 is not recommended for development because extensive quantities of better quality granular materials are available immediately adjacent to the community of Fort Good Hope. However, if increased local demands or construction of utilities in the immediate vicinity of Site FGH 8 dictates the development of this site, then an assessment should be made relevant to the current physical status of the area and the proposed borrow pit development.

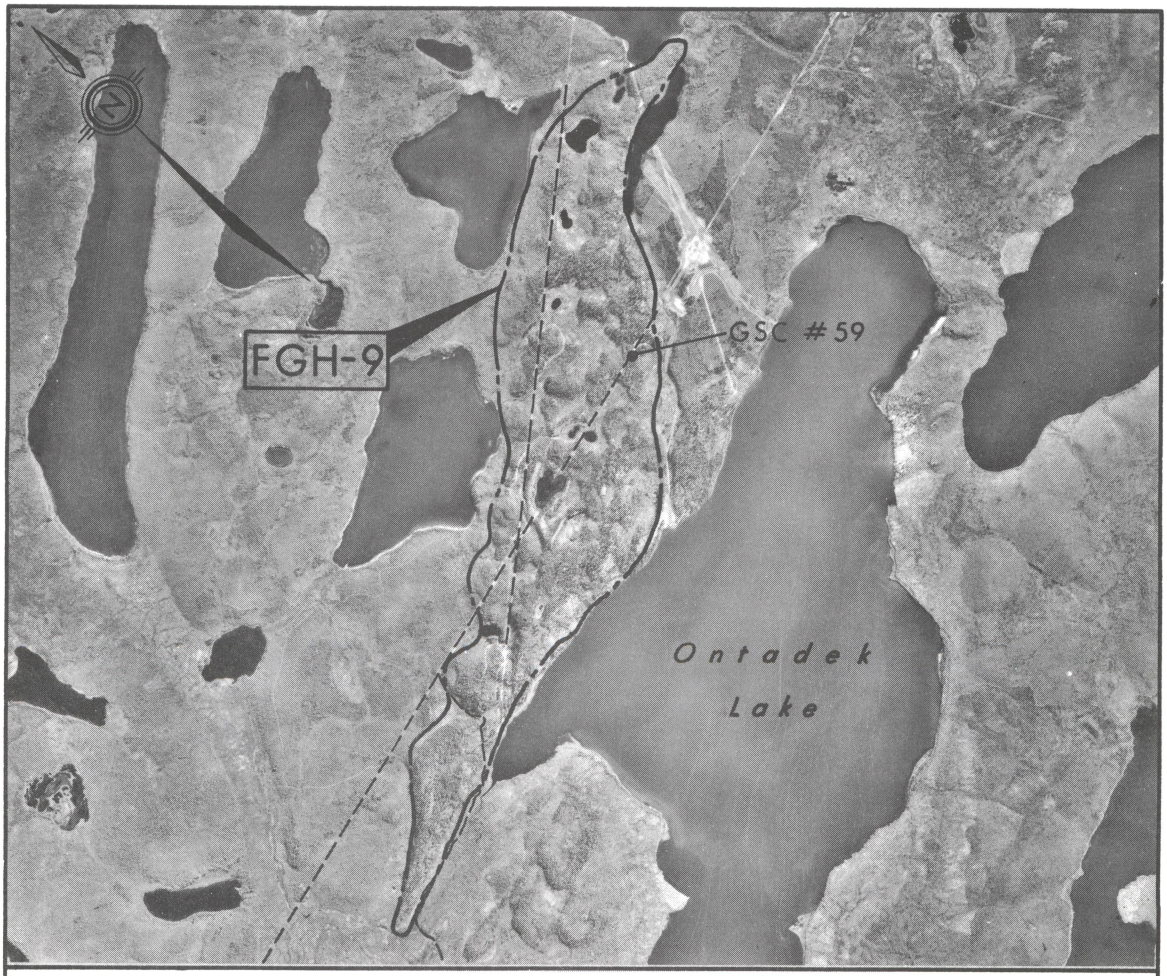
SITE NO. FGH 9

Located approximately 9 miles northeast of Fort Good Hope, Site FGH 9 consists of a glaciofluvial plain. Ontadek Lake borders the site on the east.

Type of Material: Sand; trace of silt.

Estimated Volume: 6,500,000 cubic yards.

Assessment: Low quality material suitable for general fill only. This site is not recommended for immediate 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. A22890/50

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site FGH 9, located approximately 9 miles northeast of Fort Good Hope, consists of a glaciofluvial plain which is pitted with localized depressions some of which are filled with water. The site is approximately 3 miles in length and $\frac{1}{2}$ mile in width and is bordered along its eastern perimeter by Ontadek Lake.

The outwash plain is comprised of poorly graded, fine sand with a little silt which may be suitable for general fill requirements. The very shallow layer of organic topsoil supports dense growths of spruce with occasional birch.

There are no known critical wildlife areas in the immediate vicinity of the site; however, Ontadek Lake is domestically fished from May to September by the residents of Fort Good Hope.

The existing access consists of numerous seismic cutlines which traverse the site area in various directions. The proposed Mackenzie Highway and gas pipeline facilities would pass within about 4 miles of the site.

DEVELOPMENT

Site FGH 9 is not recommended for community development, because other sites with better access and better quality material are available in the community area.

However, if this source is considered for development for the possible construction of local utilities in the immediate vicinity of the source, then an assessment of the relevant current physical status of the area and proposed borrow pit developments should be made.

It should be noted that the terrain adjacent to the site exhibits partial thermokarst features and may be very sensitive to terrain disturbance.

SUMMARY OF LABORATORY TEST DATA

Sample Location: GSC #59

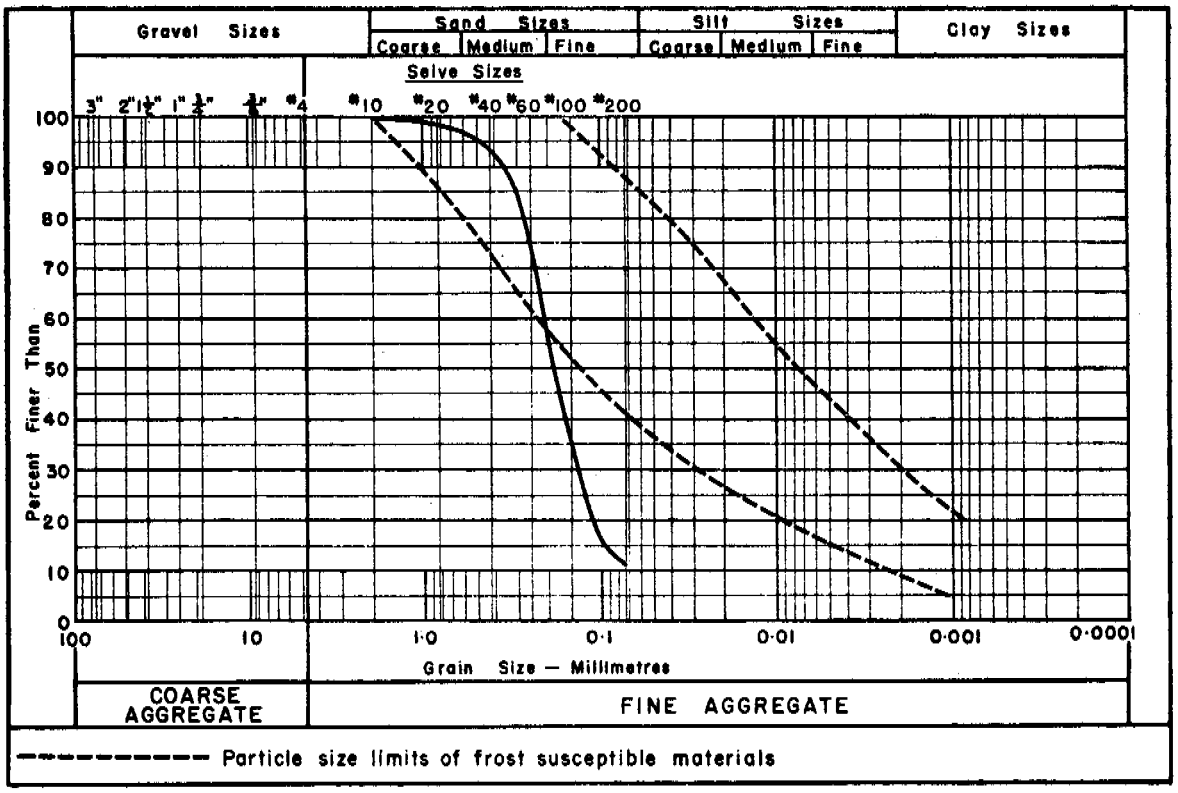
Sample Depth (Feet): -

Moisture Content (%): 4.7

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

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

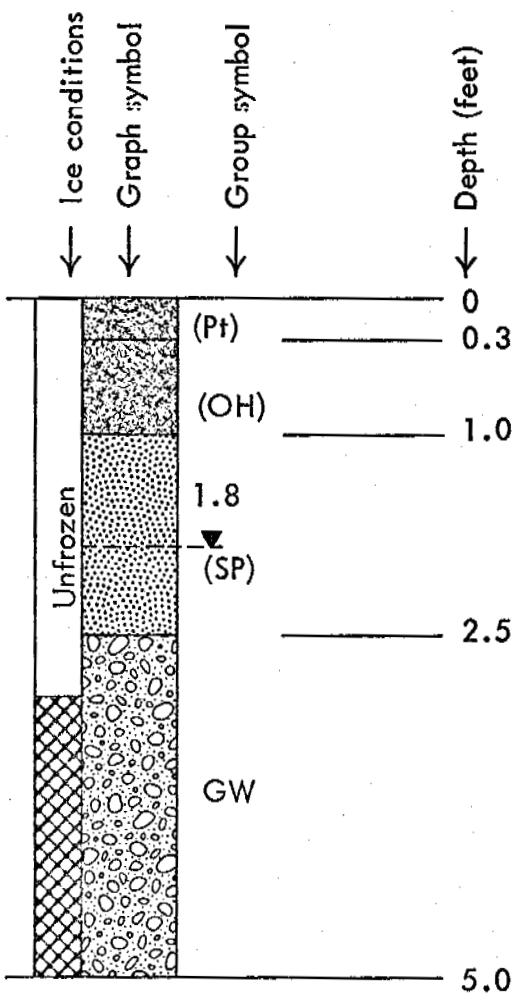
EXPLANATION OF TERMS AND SYMBOLS

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:



Peat; fibrous, wet

Clay; organic, high plastic

Sand; little silt, poorly graded, saturated

Gravel; some sand, well graded, saturated, from 3 ft. frozen. Pebbles to 2 in.

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

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.

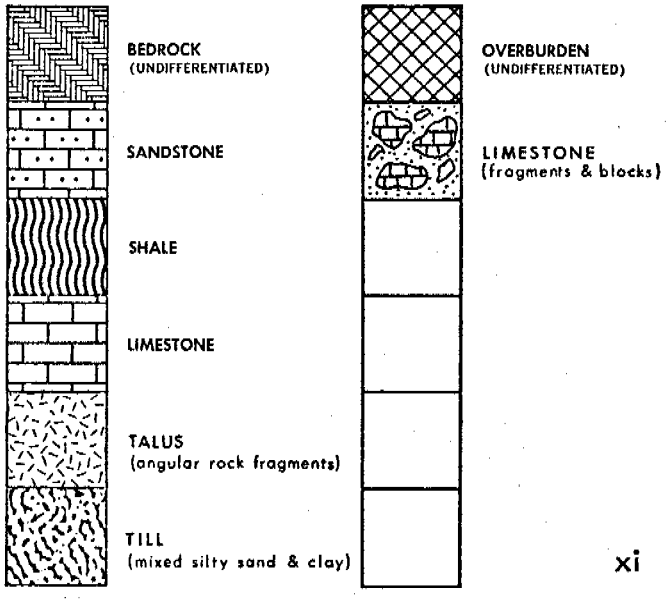
Since the Unified Soil Classification System does not contain detailed subdivisions of granular soils according to percentage proportions of secondary components, the ASTM suggested method for identification of granular soils ("Suggested Methods of Test for Identification of Soils", ASTM Procedures for Testing of Soils, 4th edition, December, 1964) is adopted for soil description as defined below:

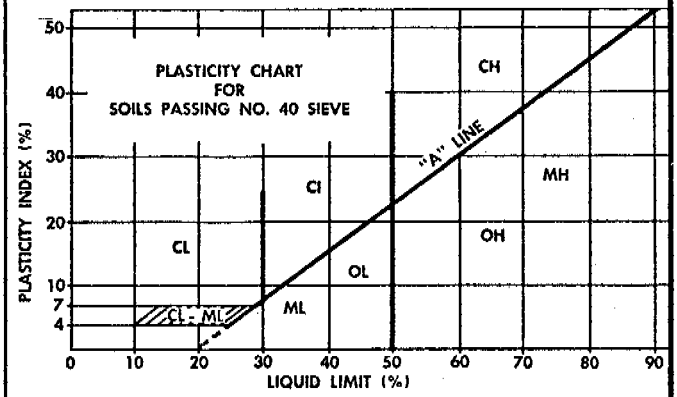
Composite Sand-Gravel Soils		Composite Sand-Silt Soils	
Percentages	Identification	Percentages	Identification
	Gravel; trace Sand		Sand; trace - Silt
90 to 10		95 to 5	
	Gravel; little Sand		Sand; trace + Silt
80 to 20		90 to 10	
	Gravel; some Sand		Sand; little Silt
65 to 35		80 to 20	
	Gravel and Sand		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	Nb	Nbn	
	Excess ice		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

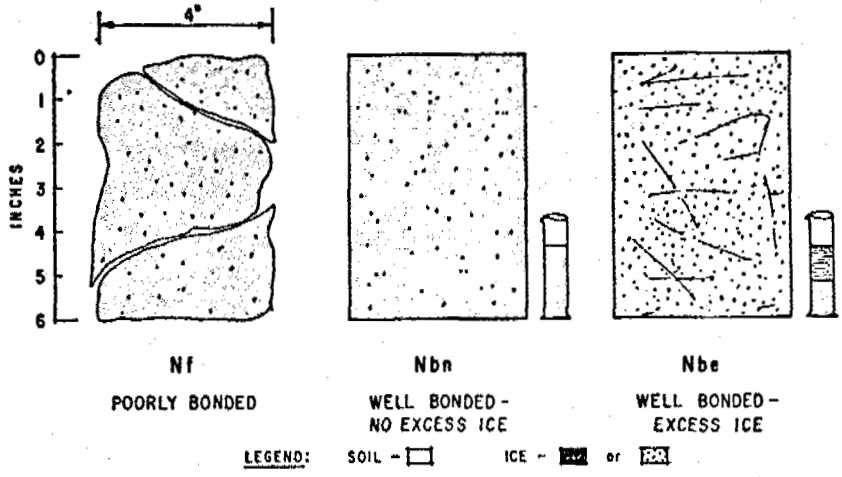


TABLE I (cont'd)

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 8. VISIBLE ICE LESS THAN ONE INCH THICK

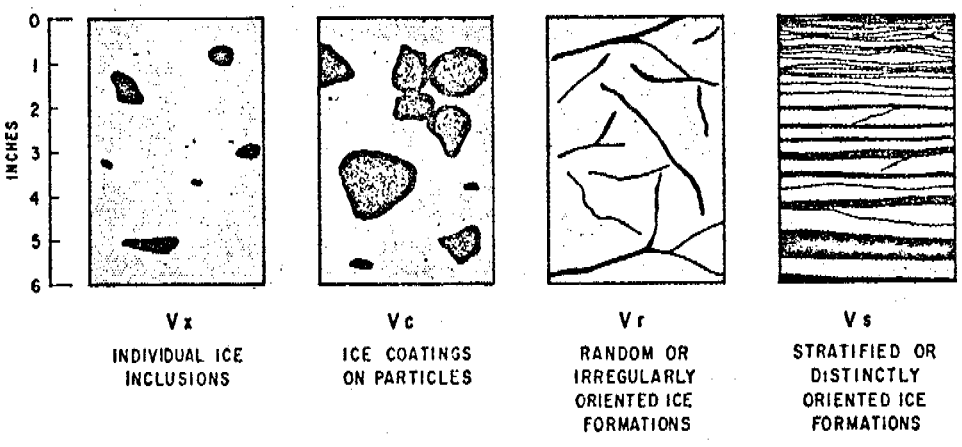


TABLE I (cont'd)

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

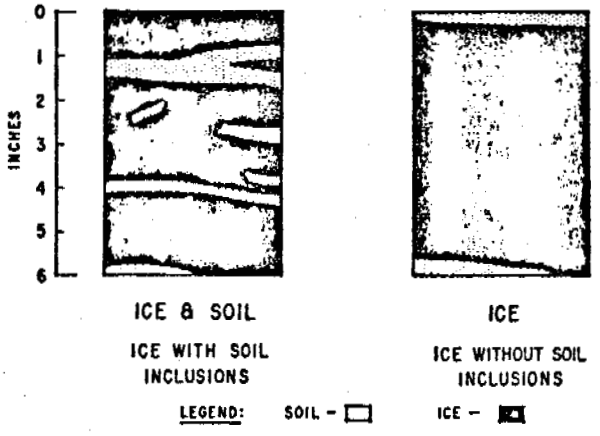


TABLE II

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.

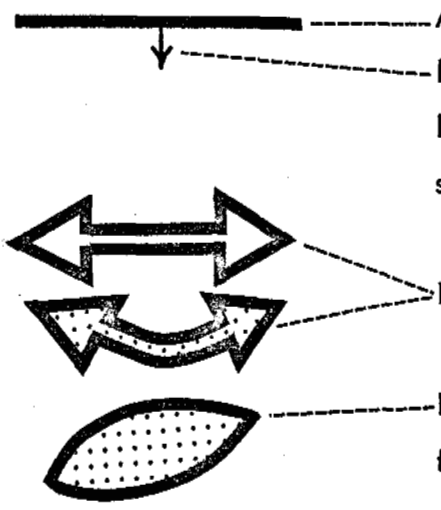
- Fishery resource areas are outlined in blue.

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.

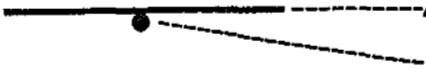
Indicates known or potential spawning areas or domestic fishing locales.

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.

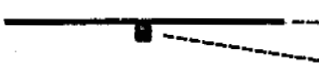
Symbols used on the maps are illustrated and explained as follows:



Approximate boundary of wildlife area.

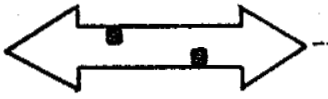
Indicates which side of boundary line is area defined. In otherwords, the area below the boundary line is of signifi-

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.

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