DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

NORMAN WELLS, N.W.T.

COMMUNITY STUDY AREA

PEMCAN SERVICES "72"

PEMCAN SERVICES Copy #32

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

Airphoto interpretation of prospective granular material sites was undertaken prior to the field work with J.D. Mollard and Associates Ltd. Recent airphotos, scaled at 1":3,000', provided by The Department of Indian Affairs and Northern Development, were utilized to outline sites, estimate the areal extent of sources and note locations of test holes and required access roads. Pertinent parts of these airphotos have been reproduced and used as location plans for catalogued sites. Air mosaics showing revised route location for the Mackenzie 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 eight feet below the ground surface. Natural outcrops were also catalogued and respective samples secured. On the basis of the airphoto interpretation and preliminary field reconnaissance, Sites NW 1, NW 12, NW 14, NW 15, NW 16, NW 18, NW 19 and NW 20 were slected for further detailed studies during the winter drilling program which was undertaken during December, 1972, and January and February, 1973. Additional field test drilling of Sites NW 12, NW 14 and NW 18 was conducted by the engineering consultant for 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 into this report.

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

A total of 21 sites were catalogued in the ten mile radius of Norman Wells (Figure 2). Of these, fourteen sites were investigated to a greater detail by means of test pits and eight sites 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. Seven sites that are not recommended for development are identified in Figure 2 by the suffix "X" behind the site number.

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

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

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

GEOMORPHOLOGY

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

- Mackenzie Plain - which covers both river banks and extends far beyond the Study Area following the river channel.

- Franklin Mountains - which borders the Mackenzie Plain on its northeast side.

The Mackenzie Plain is primarily covered by glacial, glaciofluvial and glaciolacustrine deposits. The glaciation has resulted in a generally flat to gently rolling topography. The bedrock, predominantly sandstones, shales and carbonates, is exposed in individual escarpments at the northeast margin of the Plain, and in deeply incised tributary streams of the Mackenzie River. Main landforms and geologic features are illustrated by Figure 1.

Glaciation has produced morainal till deposits which were surficially reworked by melt waters; these deposits were subsequently covered with glaciofluvial and glaciolacustrine silts, clays and sands. These deposits, covering the entire southwest Mackenzie River bank, are also locally encountered along the northeast side of the river. Remnants of beach ridges indicate individual stagnant stages of a former glacial lake basin. The beach ridges on the northwest side of the Mackenzie River are relatively shallow and consist of coarse granular deposits. Fine grained glaciolacustrine sediments, strand lines and beach ridges on the southwest side of the Mackenzie River were reworked by wind action which resulted in the development of longitudinal dunes.

The transitional zone between the former lake basin and Franklin Mountains exhibits a greater relief as the terrain gradually ascends to the foot of Discovery Ridge. Devonian crystalline and fossiliferous limestones are exposed in localized escarpments while less

competent shales usually outcrop only in deeply incised stream channels. In general, the bedrock is covered by a relatively shallow layer of glacial and glaciofluvial material which was reworked to variable depths by surficial erosion. Glaciofluvial outwashes, channel deposits and eskers consist predominantly of sandy materials that form thicker layers in a few localized areas.

The Franklin Mountains unit is represented by the rugged Discovery Ridge of the Norman Range. Numerous exposures of Devonian limestone form steep walls with talus accumulations of broken and eroded material at the base. The talus generally consists of various sized limestone fragments and blocks. Relatively large fluvial fans, containing coarse grained material, are frequently formed at the mouth of individual erosional gorges.

Current erosional processes affect both the rock faces in the Discovery Ridge area and the slopes along active stream channels. Stream beds contain granular deposits, the grain size of which is inversely proportional to the distance of transport. With the source of the material being in the Discovery Ridge area, the coarse deposits are generally encountered close to the mountain side while the finer materials are carried further downstream towards the Mackenzie River. Fluvial fans exist where stream courses have an abrupt break in slope and at their confluences with the Mackenzie River. The latter fans are generally below high water mark and contain fine grained material.

A shallow organic soil layer, topped with several inches of peat and moss is usually encountered outside of rugged or recently eroded areas. Low and poorly drained terrain is occasionally covered with a thicker organic section.

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

- Eskers (locally associated with kames) which contain both sand and

gravel, with occasional silt and clay pockets. They are widely scattered on the northern side of the Mackenzie River.

- Beach ridges, consisting of silty sands and gravels and located east of Norman Wells.

- Dunes and strand lines containing poor graded, fine silty sand. They are frequently noted on the south side of the Mackenzie River.

- Fluvial fans and stream channels. Upstream portions of water courses and associated fans on the northern side of the Mackenzie River contain coarse material, while their downstream parts and all channels within the southern section of the Study Area are predominantly formed by fine grained deposits. These materials are usually heterogeneous and irregularly stratified.

- Talus, found northeast of Norman Wells, consists of various sized limestone fragments and blocks with silt particles.

The bedrock exposed in the Kee Escarpment and in the front ranges of the Discovery Ridge is suitable for manufactured aggregates. An active quarry is located on the south side of the Kee Escarpment and quarried limestone has been widely used for construction purposes in the townsite.

The Study Area lies within the discontinuous permafrost zone. Excess ice is common in fine grained soils and its content usually ranges from thirty to sixty percent. Little or no excess ice exists in coarse and well drained deposits. The average depth of the seasonal freezing and thawing cycles is some three feet, but is apparently as much as twenty feet in clean and well drained sands and gravels.

TERRAIN PHOTOGRAPHS

Southeast face of Kee Escarpment with the Norman Range in the background. Note active quarry operations (Ref. Site NW 4).

Large sand dune located near Canol Camp on the south side of the Mackenzie River (Ref. Site NW 5).

ENVIRONMENT

The ten mile radius of the Study Area corresponds to the boundary of the Norman Wells "Development Area" as enacted by the Commissioner of the Northwest Territories. Within this "Development Area" the Territorial Government, in the interests of the public, regulates and controls the orderly development of the area. Also within the Study Area is the "Proposed Development Control Zone" as shown in Figure 2. It is proposed by the respective Federal and Territorial Governments, that management of lands within this Zone will be transferred from Federal to Territorial Government control. Federal projects such as buildings, highways and airports would be excluded from this transfer.

The Study Area is geographically located in an area that offers optimum use and development of both water and land environments. Based upon various components including those of landforms, water, natural vegetation and aesthetics, the Study Area is rated relatively high in terms of recreation and terrain values. This is particularly true on the north side of the Mackenzie River where variable relief and vegetation are enhanced by terrain types that range from river deposits to upland mountains.

The sensitivity and reaction of terrain to natural or artificially induced modifications is generally related to the type of terrain which in turn reflects to a great extent the physical nature of the terrain in terms of material type and ground ice conditions. 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. Thermokarst subsidence, undercutting and channel shifting can also be expected, especially in fine river deposit terrain.

Hummocky and rolling terrain as characterized by the till plains in the area contain

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

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

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

Vegetation

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

The dominant tree species in the Study Area are black and white spruce, tamarack,

birch, willows and alder. The ground cover is predominantly mosses, lichens, sedges, herbs and shrubs. The vegetation ranges from commercial growths on river islands and alluvial flats to scrubby growth and treeless muskeg.

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

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

Vegetation on the mountain slopes range from spruce growth near the base to spruce and some birch on the overburden-covered flanks.

In the Norman Wells Study Area, natural regrowth of vegetation on existing cutlines suggests that in general, regeneration of disturbed areas will occur, especially if the nutrient zones within the topsoil layer are left undisturbed. In some 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 re-establishment of natural vegetation.

Wildlife

Wildlife species of both Arctic tundra and Boreal forest utilize the Norman Wells Study Area and adjacent regions. For the most part, this utilization by waterfowl, wildlife, and fishery resources is based upon seasonal migration patterns that generally follow the Mackenzie River Valley. There are no known critical wildlife areas in the Norman

Wells Study Area; however, the entire Study Area is classified as an important wildlife region by the Canadian Wildlife Service.

The entire Study Area lies within a broad waterfowl migration and staging flyway that generally parallels the Mackenzie River Valley throughout this region of the north. From May through August this area is used by ducks for molting and nesting. Canada geese, white-fronted geese, snow geese and swans use this area for fall migration and staging. The central portion of the Study Area which includes the Mackenzie River, the sandy islands, and both bank areas, is utilized during May by the various geese and duck populations as a spring staging area (Figure 2).

Wildlife resources are trapped and hunted in the southern two-thirds of the Study Area. Fall moose hunting along both banks and on the islands of the Mackenzie is prevalent. Beaver, mink and lynx are trapped in this area, especially in the vicinity of Canol Lake and Three Day Lake. The extreme northern part of the Study Area in the drainage basin of Oscar Creek and Oscar Lake is trapped during fall and spring for beaver, marten, mink and muskrat. Both of these trapping areas are utilized for the most part by natives of Norman Wells.

Fishery resources in the Study Area are those predominantly found in the Mackenzie River, and include both resident species to the river and those that seasonally migrate along and through the Mackenzie system. The southeastern portion of the Study Area contains a drainage system that is of importance to both the fishery resources and the natives of the area (Figure 2). At the mouth of Stewart Creek, gillnet fishing operations are carried out on a seasonal basis. Natives in the area indicate that Stewart Creek is used by grayling in migrating to and from Three Day Lake. This migration route along Stewart Creek from the Mackenzie River to Three Day Lake is approximately four miles in length.

RECOMMENDATIONS AND CONCLUSIONS

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

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

Fine grained aggregates (Sand) ..... 40,000 cubic yards
Coarse grained aggregates (Gravel) ..... 60,000 cubic yards
Material suitable for building pads, roads,
airstrips, etc. .....800,000 cubic yards

The results of the completed study indicate that the availability of easily accessible quality granular materials for exploitation in the Norman Wells Study Area is relatively limited. The following sites are recommended for development and/or continued development of granular materials for the requirements of the Norman Wells community.

Site NW 4: Located approximately four miles northeast of Norman Wells in the prominent ridge known as Kee Escarpment, this site has virtually an unlimited quantity of limestone bedrock which can be utilized in the production of various categories of granular materials for most construction requirements. Production of granular materials from this site will entail a quarry operation with related blasting and crushing procedures. This site should be considered as a primary source of granular materials because of the following reasons:

- An existing quarry is currently in operation for the exploitation of granular materials for Norman Wells.

- An all weather road has been constructed to the existing quarry site and provides excellent access to Norman Wells.

- The availability of granular materials at other sites in the Study Area is relatively limited. The other sites also require the preparation of additional access from the townsite.

The detailed assessment and recommendations for the proposed development and exploitation of granular materials from Site NW 4 is outlined in the Site Description section of the report.

Site NW 15: Located approximately four miles north of Norman Wells, Site NW 15 consists of a series of eskers, kames and other ice contact deposits encompassing an area on both sides of the Bosworth Creek stream channel.

This site has an estimated quantity of 1,000,000 cubic yards of fine grained gravels which may be suitable for the production of base course, surface course and general utility fill requirements.

Development of this site should provide for a buffer zone of adequate width and breadth between the final limits of the borrow pit and the existing stream channel, waterfall and hiking trail.

The detailed assessment and recommendations for the proposed development and exploitation of granular materials from Site NW 15 is outlined in the Site Description section of this report.

Site NW 8: Located approximately eight miles northeast of Norman Wells, Site NW 8 consists of a large alluvial cone which has an estimated quantity of 1,000,000 cubic yards of well graded, coarse grained gravels which are suitable for utilization as base course, surface course and general fill aggregates in the

construction of roads, airstrips, building pads and utility backfill operations.

Proposed development and exploitation of granular materials from this site will involve the construction of new access roads and the upgrading of the existing trail to Fish Lake.

The detailed assessment and recommendations for the proposed development and exploitation of granular materials from Site NW 8 is outlined in the Site Description section of the report.

Site NW 19: Located approximately ten miles northeast of Norman Wells, Site NW 19 consists of a small kame-esker complex which has an estimated quantity of 1,000,000 cubic yards of medium grained clean sands with interbedded strata of fine to medium grained gravels. This material is of excellent quality for utilization as fill for most construction requirements and the production of good quality concrete sand is feasible with minor screening of the pit run aggregate.

Currently, the access to the site is very difficult. However, if the proposed Mackenzie Highway is constructed in its latest alignment, then good future access to Site NW 19 from the community of Norman Wells is possible.

Therefore, in view of the general scarcity of naturally occurring good quality granular materials in the Norman Wells Community Study Area, Site NW 19 may be of significance for future granular material requirements.

The detailed assessment and recommendations for the proposed development and exploitation of granular materials from Site NW 19 is outlined in the Site Description section of the report.

In addition, small volumes of marginal quality granular materials which may be utilized for the construction requirements of local utilities, are exploitable from Sites NW 12, NW 14 and NW 18. The detailed assessment, and recommendations for the proposed development and exploitation of granular materials from these sites is outlined in the Site Description section of the report.

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

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

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

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

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

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

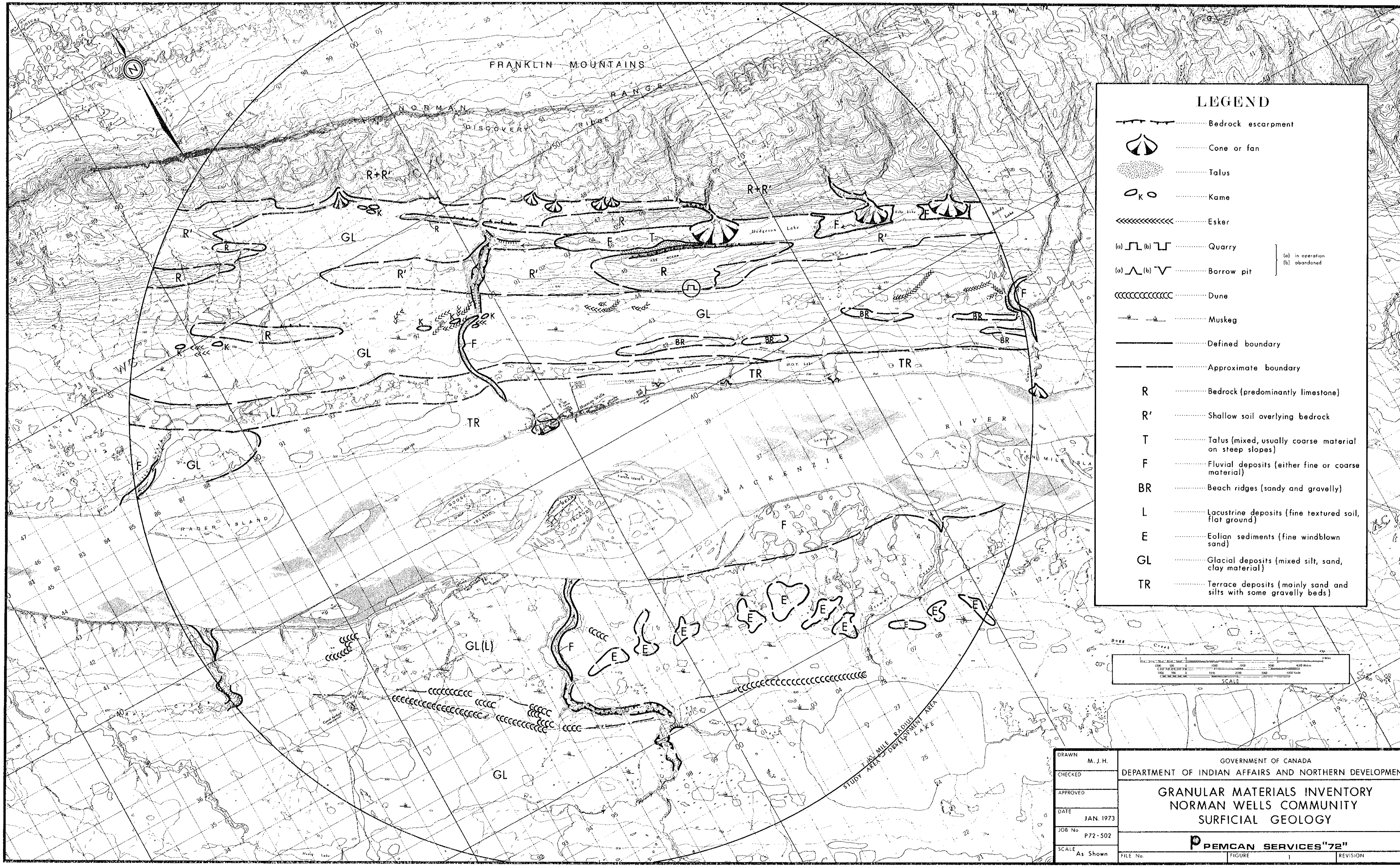
HAUL DISTANCE is the distance along existing and/or proposed access from the site to the community centre.

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

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

These recommendations are based upon an assessment of all known data on each respective site including location, access, physical characteristics, environmental considerations, development procedures and quantity, quality and suitability of material as related to projected granular material requirements for the community.

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


FRANKLIN MOUNTAINS
NORMAN RANGE
DISCOVERY RIDGE
MACKENZIE RIVER
RADER ISLAND
GOOSE ISLAND
BEAR ISLAND
Hodgeson Lake
Norman Wells
STUDY AREA 10 MILE RADIUS DEVELOPMENT AREA
LEGEND
Bedrock escarpment
Cone or fan
Talus
Kame
Esker
(a) (b) Quarry
(a) (b) Borrow pit
(a) in operation
(b) abandoned
Dune
Muskeg
Defined boundary
Approximate boundary
R Bedrock (predominantly limestone)
R' Shallow soil overlying bedrock
T Talus (mixed, usually coarse material on steep slopes)
F Fluvial deposits (either fine or coarse material)
BR Beach ridges (sandy and gravelly)
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)
SCALE
DRAWN M. J. H.
CHECKED
APPROVED
DATE JAN. 1973
JOB No P72-502
SCALE As Shown
GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT
GRANULAR MATERIALS INVENTORY
NORMAN WELLS COMMUNITY
SURFICIAL GEOLOGY
PEMCAN SERVICES "72"
FILE No.
FIGURE 1
REVISION

SITE NO.	MATERIAL TYPE		SUITABILITY OF MATERIAL	ESTIMATED VOLUME (cu. yds.)	EST'D. RECOV. DEPTH (feet)	OVERBURDEN			GROUND ICE (Content)	DRAINAGE	METHOD OF EXTRACTION	HAUL DIST. (miles)	ENVIRONMENTAL CONSIDERATIONS	ASSESSMENT OF SITE
	DESCRIPTION	SYM.				TYPE	DEPTH (feet)	DISPOSAL						
NW 1	Gravel; sandy	GW	General Fill	200,000	10	Topsoil & Silt	6	Strip, Waste & Stockpile	Medium	Fair to Southeast	Conventional with Thawing	31½	No Critical Wildlife Areas	Active; Continue Development
NW 2X	Sand & Gravel	GM	General Fill	100,000	4	Silt, organic	1	—	None	Into Stream Channel	Conventional	½	Severe; In Active Stream Channel	Not Recommended
NW 3X	Gravel; sandy	GW-GM	Base & Surface Courses; General Fill	150,000	4	Silt, organic	1	—	None	Into Stream Channel	Conventional	2	Severe; In Active Stream Channel	Not Recommended
NW 4	Bedrock; Limestone	—	All Construction Aggregates	Unlimited	+100	Colluvium	2	Strip & Waste	Very Low	Good to West	Quarry; Blasting & Crushing	4	No Critical Wildlife Areas	Active; Continue Development
NW 5	Sand; silty	SP	Marginal General Fill	1,500,000	+35	Topsoil	½	Strip & Stockpile	None	Good to Northeast	Conventional	8	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
NW 6	Sand; silty	SP	Marginal General Fill	1,500,000	+20	Topsoil	½	Strip & Stockpile	None	Good to Northeast	Conventional	10	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
NW 7	Sand; silty	SP	Marginal	500,000	15	Topsoil	½	Strip & Stockpile	None	Fair to Northeast	Conventional	8½	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
NW 8	Gravel	GW	Base & Surface Courses; General Fill	1,000,000	10	None	—	—	None	Good to West	Conventional	8	No Critical Wildlife Areas	Recommended for Development; Seasonal
NW 9	Gravel; sandy	GW	Base & Surface Courses; General Fill	700,000	10	None	—	—	None	Good to West	Conventional	9½	No Critical Wildlife Areas	Recommended for Development; Seasonal
NW 10X	Gravel	GW	Base & Surface Courses; General Fill	1,000,000	10	None	—	—	None	Good to West	Conventional	9	Recreational Area	Not Recommended
NW 11	Sand; silty	SP	Marginal General Fill	750,000	+10	Topsoil	½	Strip & Stockpile	None	Good to North	Conventional	7	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
NW 12	Sand; silty	SW-SM	General Fill	200,000	+20	Topsoil	1	Strip & Stockpile	None	Good to Southeast	Conventional	10	No Critical Wildlife Areas; Sensitive Terrain	Possible Future Development
NW 13X	Sand & Gravel	GW	General Fill	500,000	5	Silt, organic	½	Strip, Waste & Stockpile	None	Into Stream Channel	Conventional	10	Fishery Resource Area	Not Recommended
NW 14	Sand; silty	SW-SM	General Fill	1,500,000	+20	Topsoil	½	Strip & Stockpile	None	Fair to South	Conventional	2	No Critical Wildlife Areas	Possible Future Development
NW 15	Gravel; sandy	GW-GM	General Fill	1,000,000	+10	Topsoil	½	Strip & Stockpile	Low to Medium	Fair	Conventional	4	Recreation Area; Adjacent to Stream Channel; Sensitive Terrain	Possible Future Development
NW 16X	Bedrock; Limestone & Siltstone	—	General Fill	Unlimited	+50	Till	+3	Strip & Waste	Very Low	Fair	Quarry; Blasting & Crushing	7	No Critical Wildlife Areas	Not Recommended
NW 17X	Sand; silty	SP	Marginal General Fill	3,000,000	+10	Topsoil	1	Strip & Stockpile	N.D.	Good to North	Conventional	17	Fishery Resource Area; Sensitive Terrain	Not Recommended
NW 18	Sand	SW	General Fill	100,000	20	Topsoil	1	Strip & Stockpile	Low	Good to Southwest	Conventional	9	No Critical Wildlife Areas	Possible Future Development
NW 19	Sand & Gravel	SW-GW	General Fill; Concrete Sand	1,000,000	+20	Topsoil & Silt	2	Strip, Waste & Stockpile	Low	Fair to South	Conventional	10	No Critical Wildlife Areas Sensitive Terrain	Possible Future Development
NW 20	Gravel; silty	GM	General Fill	5,000	+5	Topsoil	+3	Strip, Waste & Stockpile	Low	Good to South	Conventional	4	No Critical Wildlife Areas; Adjacent to River	Active; Continue Seasonal Development
NW 21X	Limestone Fragments	—	General Fill	2,000,000	+40	Colluvium	½	Strip & Waste	N.D.	Good to North	Conventional with Crushing	6	No Critical Wildlife Areas	Not Recommended

Notes:

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

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

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

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

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

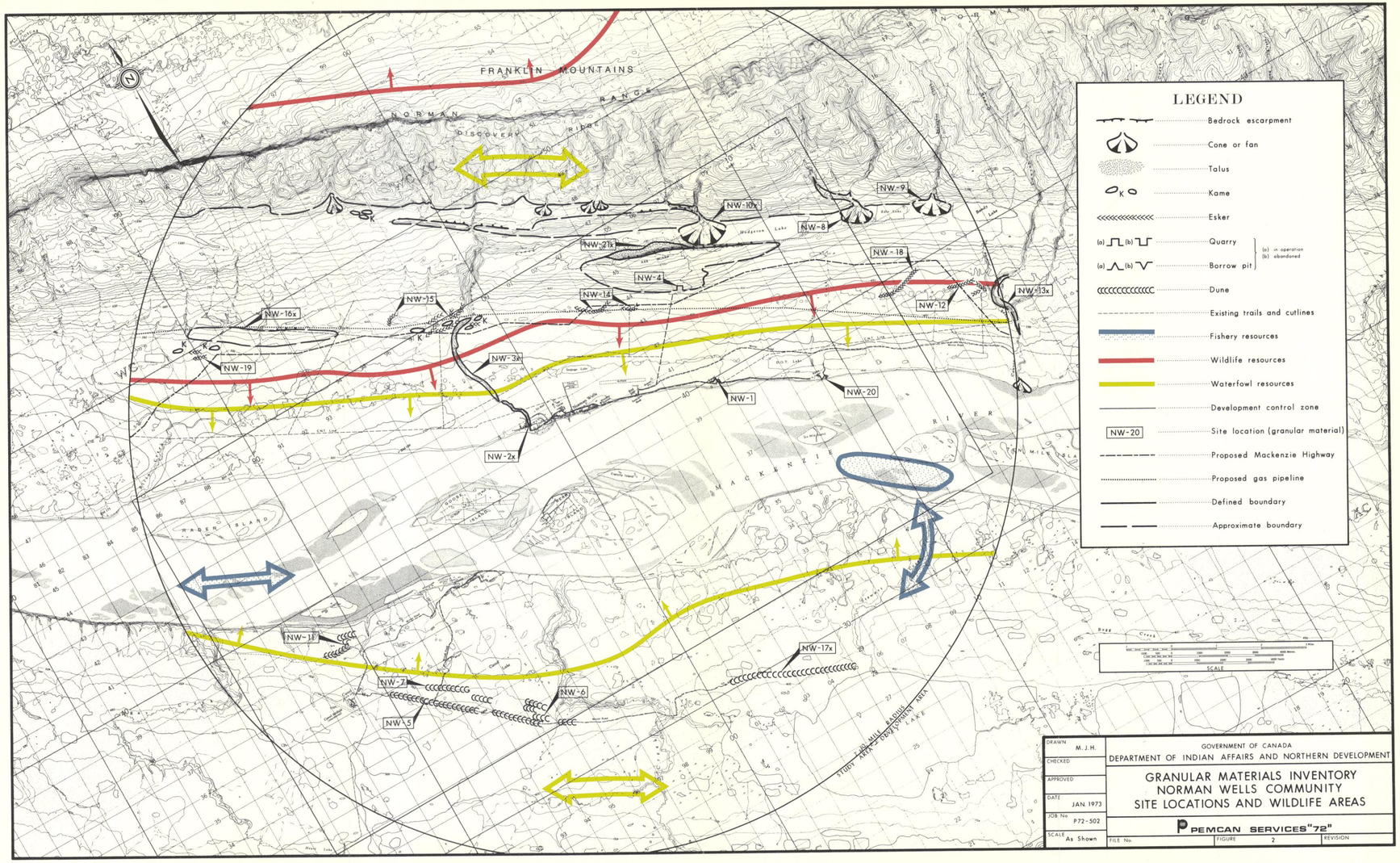
— SITE ASSESSMENT: "Active" indicates site is currently or periodically being used.

— N.D.: Not determined.

SITE NO.	MATERIAL TYPE: DESCRIPTION	MATERIAL TYPE: SYM.	SUITABILITY OF MATERIAL	ESTIMATED VOLUME (cu. yds.)	ESTD. RECOV. DEPTH (feet)	OVERBURDEN: TYPE	OVERBURDEN: DEPTH (feet)	OVERBURDEN: DISPOSAL	GROUND ICE (Content)	DRAINAGE	METHOD OF EXTRACTION	HAUL DIST. (miles)	ENVIRONMENTAL CONSIDERATIONS	ASSESSMENT OF SITE
NW 1	Gravel; sandy	GW	General Fill	30,000	10	Topsoil & Silt	7	Strip & Stockpile	Moderate at 3' to 5'	Fair; to South-east	Conventional	3½	No Detrimental Effects To Wildlife	Active; Continue Development
NW 2X	Sand & Gravel	GM	General Fill	100,000	4	Silt, organic	1	-	None	Into Stream Channel	Conventional	-	Very Severe; In Active Stream Channel	Not Recommended
NW 3X	Gravel; sandy	GW-GM	Base & Surface Courses; General Fill	150,000	4	Silt, organic	1	-	None	Into Stream Channel	Conventional	2	Very Severe; In Active Stream Channel	Not Recommended
NW 4	Bedrock; Limestone	-	All Construction Aggregates	Unlimited	+100	Colluvium	2	Strip & Waste	Low	Westerly	Quarry; Blasting & Crushing	4	Not Critical	Active; Continue Development
NW 5	Sand; silty	SP	General Fill	1,500,000	+35	Topsoil	½	Strip & Stockpile	None	Well Drained	Conventional	8	Waterfowl Migration & Staging Area	Active; Future Development
NW 6	Sand; silty	SP	General Fill	1,500,000	+20	Topsoil	½	Strip & Stockpile	None	Well Drained	Conventional	10	Waterfowl Migration & Staging Area	Future Development
NW 7	Sand; silty	SP	General Fill	750,000	+20	Topsoil	½	Strip & Stockpile	None	Well Drained	Conventional	8½	Waterfowl Migration & Staging Area	Future Development
NW 8	Gravel	GW	Base & Surface Courses; General Fill	1,000,000	-	None	-	-	None	Good, Westerly	Conventional	8	No Critical Wildlife Areas	Recommended For Development
NW 9	Gravel; sandy	GW	Base & Surface Courses; General Fill	700,000	-	None	-	-	None	Good, Westerly	Conventional	9½	No Critical Wildlife Areas	Recommended For Development
NW 10	Gravel; well graded, coarse	GW	Base & Surface Courses; General Fill	1,000,000	-	None	-	-	None	Good, Westerly	Conventional	4	Recreational Area	Not Recommended
NW 11	Sand; silty	SP	General Fill	750,000	+10	Topsoil	½	Strip & Stockpile	None	Well Drained	Conventional	7	Waterfowl Migration & Staging Area	Future Development
NW 12	Sand; silty	SW-SM	General Fill	200,000	+20	Topsoil	1	Strip & Stockpile	None	Good, Southerly	Conventional	9	No Critical Wildlife Areas	Future Development
NW 13X	Sand & Gravel	GW	General Fill	500,000	5	Silt, organic	½	Strip & Stockpile	None	Poor	Conventional	10	Fishery Resource Area	Not Recommended
NW 14	Sand; silty	SW-SM	General Fill	1,500,000	+20	Topsoil	½	Strip & Stockpile	None	Poor	Conventional	2	No Critical Wildlife Areas	Future Development
NW 15	Gravel; sandy	GW-GM	General Fill	1,000,000	+10	Topsoil	½	Strip & Stockpile	None	Poor; Southwest	Conventional	4	Recreation Area; Active Stream Channel	Future Development
NW 16X	Bedrock; Limestone	-	All Types of Construction Aggregate	Unlimited	+50	Till	+3	Strip & Waste	None	Fair; Southwest	Quarry; Blasting & Crushing	7	No Critical Wildlife Areas	Not Recommended
NW 17X	Sand; silty	SP	General Fill	3,000,000	+10	Topsoil	1	Strip	None	Well Drained	Conventional	17	Waterfowl Migration & Staging Area; Fishery Resource Area	Not Recommended
NW 18	Sand;	SW	General Fill	30,000	20	Topsoil	1	Strip	None	Poor	Conventional	9	No Critical Wildlife Areas	Future Development
NW 19	Sand;	SM	General Fill	100,000	+30	Topsoil	1	Strip	None	Fair; Southerly	Conventional	10	No Critical Wildlife Areas	Future Development
NW 20	Gravel; coarse, very silty	GM	General Fill	5,000	+5	Topsoil organic	3	Strip	None	Good; Westerly	Conventional	4	Waterfowl Staging & Migration Area	Active; Continue Periodic Development
NW 21X	Limestone Fragments	-	General Fill	2,000,000	+40	Colluvium	½	Strip & Waste	High at +3'	Good; Northerly	Conventional With Crushing	6	No Critical Wildlife Areas	Not Recommended

Notes:

- GROUND ICE (content): Rating and depth figures are based upon depths of specific test pits.
- DRAINAGE: Rating as shown generally refers to drainage conditions within the site.
- METHOD OF EXTRACTION: a) Generally indicates type of equipment needed for exploitation.
  b) "Conventional" indicates use of standard excavation equipment such as dozers, overhead loaders, backhoes, light rippers.
- HAUL DISTANCE: is distance from site to center of community.
- SITE ASSESSMENT: "Active" indicates site is currently or periodically being used.



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

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY NORMAN WELLS COMMUNITY SITE LOCATIONS AND WILDLIFE AREAS

PEMCAN SERVICES "72"

FILE No. | FIGURE 2 | REVISION

SITE DESCRIPTIONS - NORMAN WELLS STUDY AREA

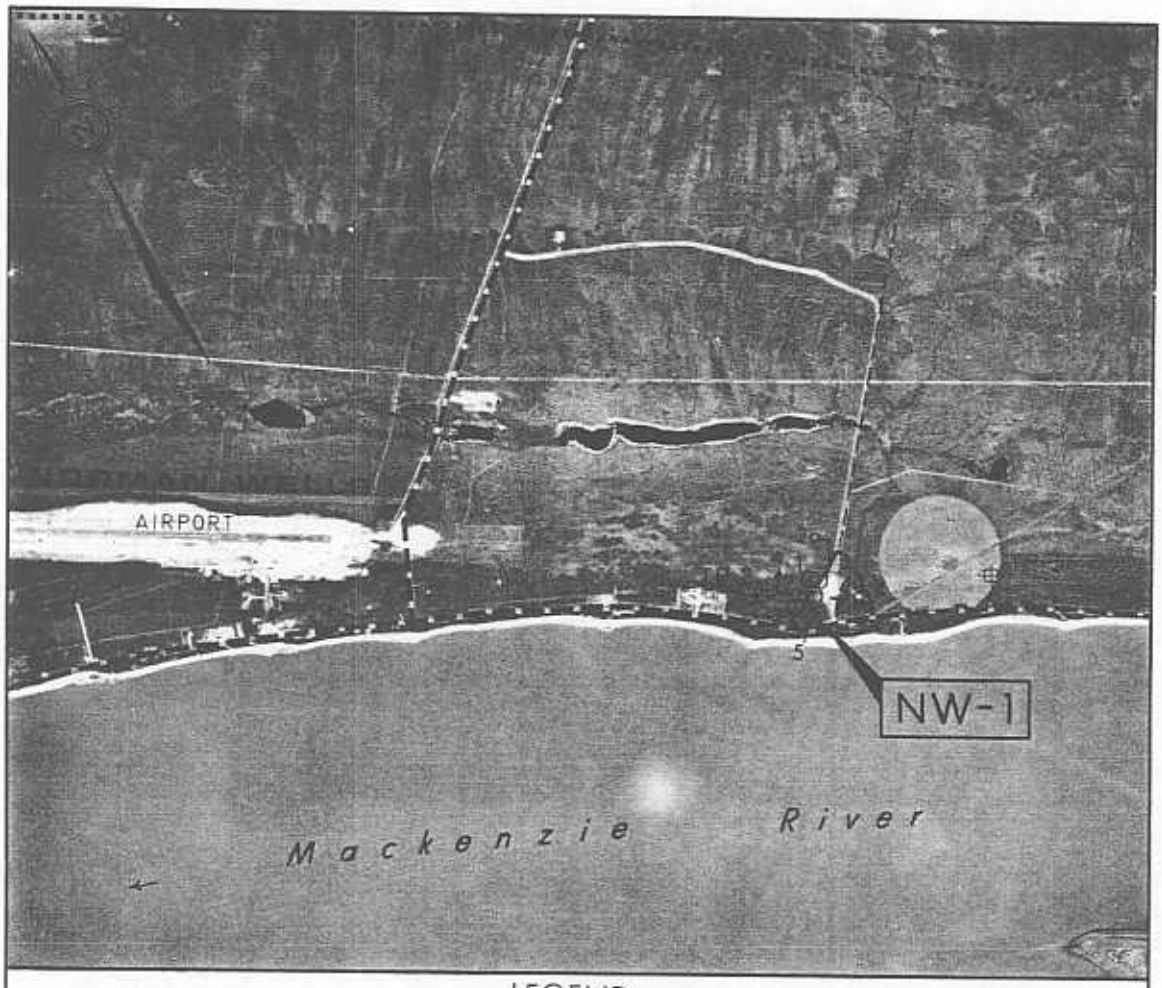
SITE NO. NW 1

Located approximately $3\frac{1}{2}$ miles east of Norman Wells adjacent to the existing all-weather road, Site NW 1 consists of an occasionally operated community borrow pit.

Type of Material: Gravel; some sand, little silt

Estimated Volume: 200,000 cubic yards

Assessment: Fair quality material for general fill. This site is recommended for granular materials exploitation for the periodic requirements of the community.



LEGEND

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

Airphoto No. A22934/139

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 1 is located approximately $3\frac{1}{2}$ miles east of Norman Wells adjacent to the existing all-weather road and consists of a long, narrow, high terrace which parallels the north bank of the Mackenzie River. The relatively flat site area is approximately 1000 feet from the north bank of the Mackenzie River where an existing borrow pit is currently located and operated. Advanced clearing and stripping for the current borrow pit operations has resulted in the lowering of the ground ice table. The permafrost depth varies from 3 to 5 feet below the existing ground surface in the adjacent undisturbed terrain.

The terrace material is predominantly fine grained soils whereas the coarser granular material, consisting of well graded gravels, with some silt, are encountered in scattered pockets. The horizontally layered silt, sand and gravel beds are of fluvial origin and overlie shale and siltstone bedrock. The gravel stratum is covered by a silty overburden layer approximately 6 feet thick.

An unnamed stream has eroded a relatively deep gully through the overburden into the underlying shale bedrock and forms the natural southeast boundary of the existing borrow pit.

The adjacent terrain is predominantly moss-covered and is underlain by a $\frac{1}{2}$ to 1 foot thick organic topsoil layer which supports stands of spruce ranging to 14 inches in trunk diameter. The underbrush is dense and is comprised of willow with occasional alder.

The proximity of the borrow site to Norman Wells negates any major detrimental effects to wildlife and waterfowl of the region.

The existing all weather road, immediately adjacent to the site area, provides excellent access to the community of Norman Wells.

DEVELOPMENT

The data obtained from the drill holes conducted on Site NW 1 during the winter field drilling program has, generally, confirmed the initial findings of the preliminary field reconnaissance. On the basis of the drill hole information the areal extent and depth of recoverable granular materials has been delineated more accurately and the quality and quantity of material available at Site NW 1 has been established as follows:

- The depth of overburden consisting of topsoil and silt with some clay ranges from $5\frac{1}{2}$ feet to $6\frac{1}{2}$ feet.

- The layer of exploitable and recoverable gravel averages approximately 10 feet in thickness.

- The areal extent of exploitable gravels, measures approximately 700 feet in width by 1100 feet in length, and is generally represented by drill holes DH 2, DH 2A and DH 4.

- In general, the gravels, which are encountered at Site NW 1, have moderate silt content and are primarily suitable as good quality fill material in the "Pit Run" condition for building pads, road bases, and general utility backfill.

Site NW 1 is recommended for continued development as an existing borrow pit and the following guidelines for borrow pit operations should be followed:

- Advanced clearing and stripping has resulted in the lowering of the ground ice table which in turn has facilitated the harvesting of the material. Therefore, similar procedures should be considered in areas where the existing borrow pit limits may be extended.

- Currently, only the topsoil and 1 to 2 feet of the surficial silt layer are stripped from the borrow area. The remaining portion of the silt stratum is then excavated, together with the gravel and the underlying badly fragmented and weathered siltstone and shale bedrock which has resulted in a relatively poor quality material exhibiting high silt contents. The quality of the extracted granular material can be improved if a thicker layer of silt is stripped and wasted prior to the excavation of the gravel stratum.

- Operating procedures should be maintained whereby the waste surficial materials do not drain southeastwards to the gully and existing watercourse.

- On the basis of the drill hole information, future expansion of the borrow pit operations are generally restricted in the northwesterly direction; however, it is considered that the borrow pit can be extended eastwards (i.e. across the stream channel), for an additional 400 to 500 feet.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following:

- Recontouring of the pit area as has been accomplished at the north end of the borrow pit to maintain good drainage to the adjacent terrain. Similar recontouring procedures should be maintained during the continued operation of the borrow pit.

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

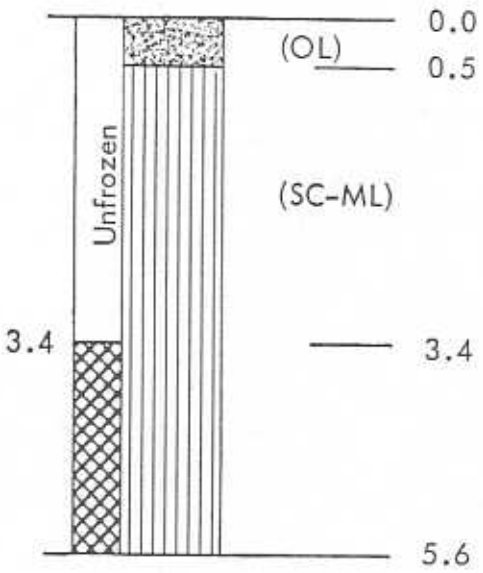
- Revegetation of the restored borrow pit areas should be considered although existing cutlines in the area indicate that understory growth and eventually spruce will be naturally reestablished.

- Maintain the stand of spruce which presently obscures much of the pit area from the all weather road.

- This area should also be considered as a possible future building development site.

DETAILED TEST PIT LOG

NW 1/TP 2

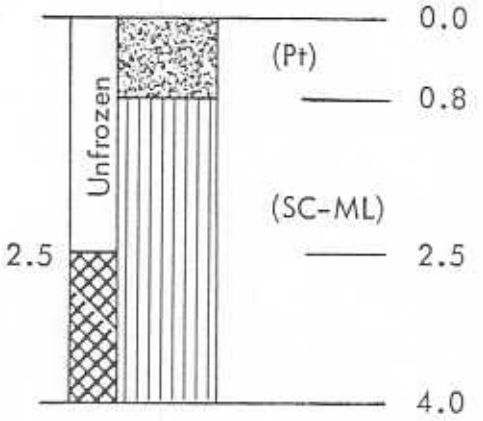


Topsoil; organic, black, roots, damp

Silt; little clay, occasional thick sand lenses, infrequent pebbles to 1/2 inches, slightly laminated, brown, wet.

Frozen below 3.4 feet, ice crystals and ice lenses to 1/4 inches thick. Infrequent boulders 6 - 10 inches in diameter.

NW 1/TP 3

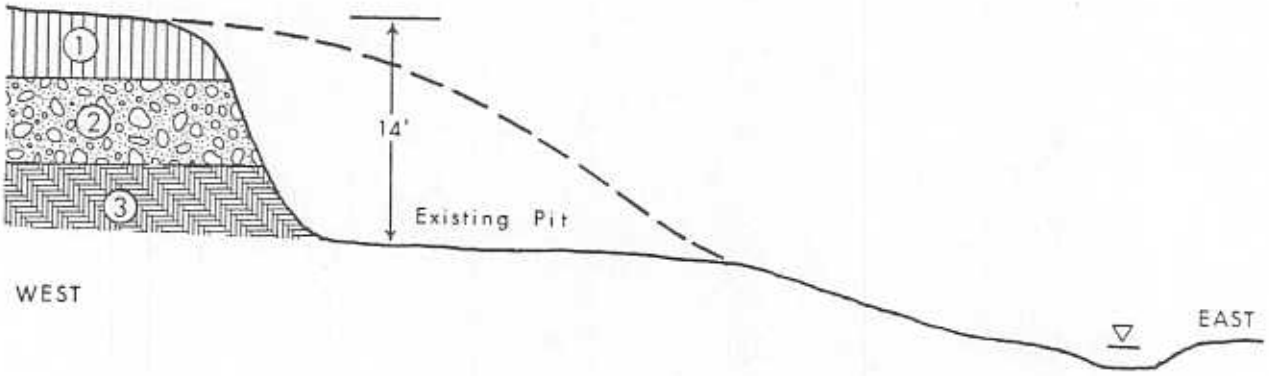


Topsoil; lightly organic, black, very soft, wet

Silt; some sand, little clay, brown, very soft, wet to saturated. Frozen below 2.5 feet, ice crystals and occasional ice lenses.

SECTION A-A'

(NOT TO SCALE)



Soil profile as exposed in the pit wall:

1. Silt; some clay and sand, few pebbles, slightly stratified.

2. Gravel; some sand, horizontally stratified, occasional silt lenses, scattered boulders.

3. Bedrock; badly fragmented, horizontally laminated siltstone and shale, frozen, scattered ice lenses.

DETAILED DRILL HOLE LOG

SITE NO. NW 1

HOLE NO. DH-1

DATE: DEC. 8, 1972 | 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	0.4 TOPSOIL: some silt, organic, fibrous		Vx	L-M		0
		ML	SILT: some clay, little sand, light brown		Nbn	L		
2			2.0					2
		SM-SP	SAND: little silt, fine grained, poorly graded, medium brown		Nbe			
4								4
6				UF				6
8			8.0					8
		CI	CLAY: some silt, medium plastic, dark brown	UF				
10								10
			11.5					
12			TOTAL DEPTH 11.5'					12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

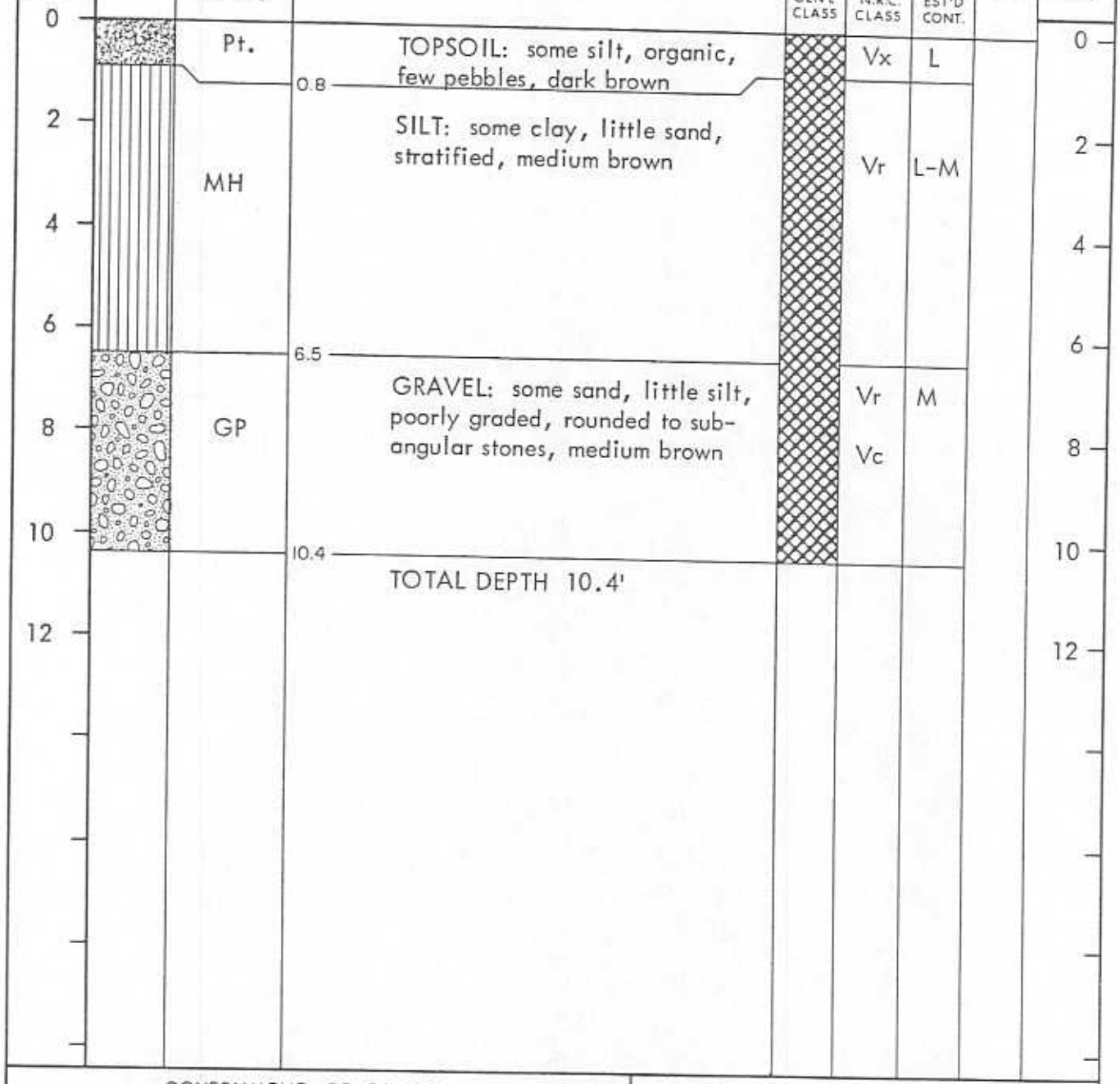
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 1 HOLE NO. DH-2

DATE: DEC. 8, 1972 LOGGED BY: ☒ PEMCAN ☐

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



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 1 HOLE NO. DH-2A

DATE: DEC. 8, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, pebbles to ½" size medium to dark brown		Nbe	L		0
1.0								
2		MH	SILT: some clay, trace sand, stratified, medium to light brown		VsVr	M		2
4								4
5.5								
6		GM-GP	GRAVEL: some sand, thin silt layers, medium grained, poorly graded, medium brown - large boulders at 7.5'		Vs	M		6
8								8
10								10
11.0			TOTAL DEPTH 11.0'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 1 HOLE NO. DH-3

DATE: DEC. 9, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	0.5 PEAT: fibrous		Vx	L		0
2		MH-ML	SILT: some clay, trace sand, light brown - becoming medium brown at 5.5'		Vs	M		2
4								4
6		CL-CI	5.5 CLAY, SILT, SAND MIXTURE: - low to medium plastic, thin layers of sand, light to medium brown (TILL-LIKE)		Nbe	L		6
8								8
10			9.0 TOTAL DEPTH 9.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 1 HOLE NO. DH-4

DATE: DEC. 9, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt-OL	TOPSOIL: some clay & silt, organic, dark brown		Vx	L		0
0.8								
2		MH	SILT: some clay, low plastic, medium brown		Vx	L		2
3.5								
4		GW	GRAVEL: rounded to subangular, some silt, few cobbles, medium grained		Vx Vc	L	M.C. G.S.	4
5.5								
6		ML-MH	SILT: some sand & clay, low to medium plastic, brown	UF				6
6.5								
8		GW-GM	GRAVEL: well graded, medium grained, some sand & silt, rounded to sub angular, medium brown					8
10			- boulders at 9.5'	UF				10
10.0								
12		GW	GRAVEL: well graded, medium grained, clean, little silt, sub angular, medium brown				M.C. G.S.	12
14			- few cobbles at 13.5'	UF				14
15.5								
16		SM	SAND: some silt, fine to medium grained, dark brown	UF				16
16.4								
18			TOTAL DEPTH 16.4' NOTE: DRILLING TERMINATED DUE TO REFUSAL ON BOULDER AT 16.4'					18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 1 HOLE NO. DH-5

DATE: DEC. 10, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt		Vx	M		0
0.9								
2		MH	SILT: some clay, trace fine sand, distinctly stratified, low plastic - layer of sand at 1.5' & 3.8'		Vs	M		2
4				UF				4
6								6
6.0								
8		CI	CLAY: some silt, medium plastic, greyish brown	UF				8
10								10
10.0			TOTAL DEPTH 10.0'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

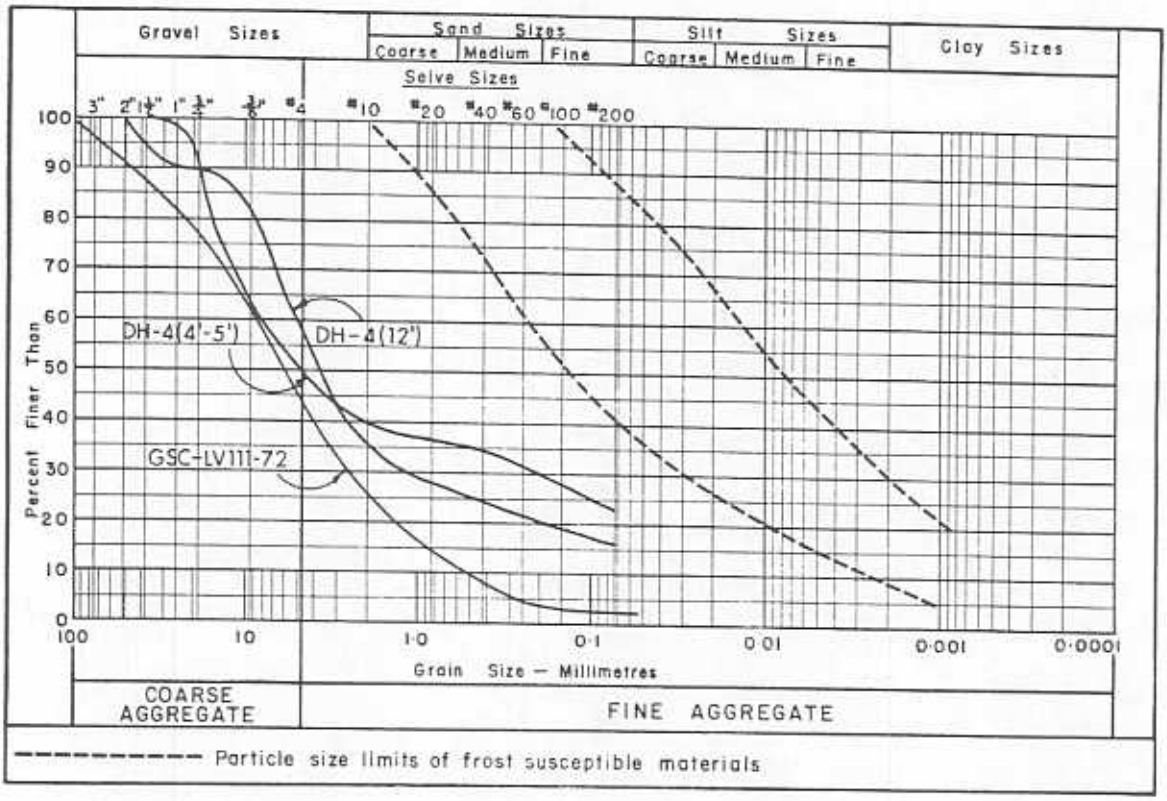
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 1/DH 4	NW 1/DH 4	GSC LV 111 - 72
Sample Depth (Feet):	12	4 - 5	-
Moisture Content (%):	5.3	7.6	2.8
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



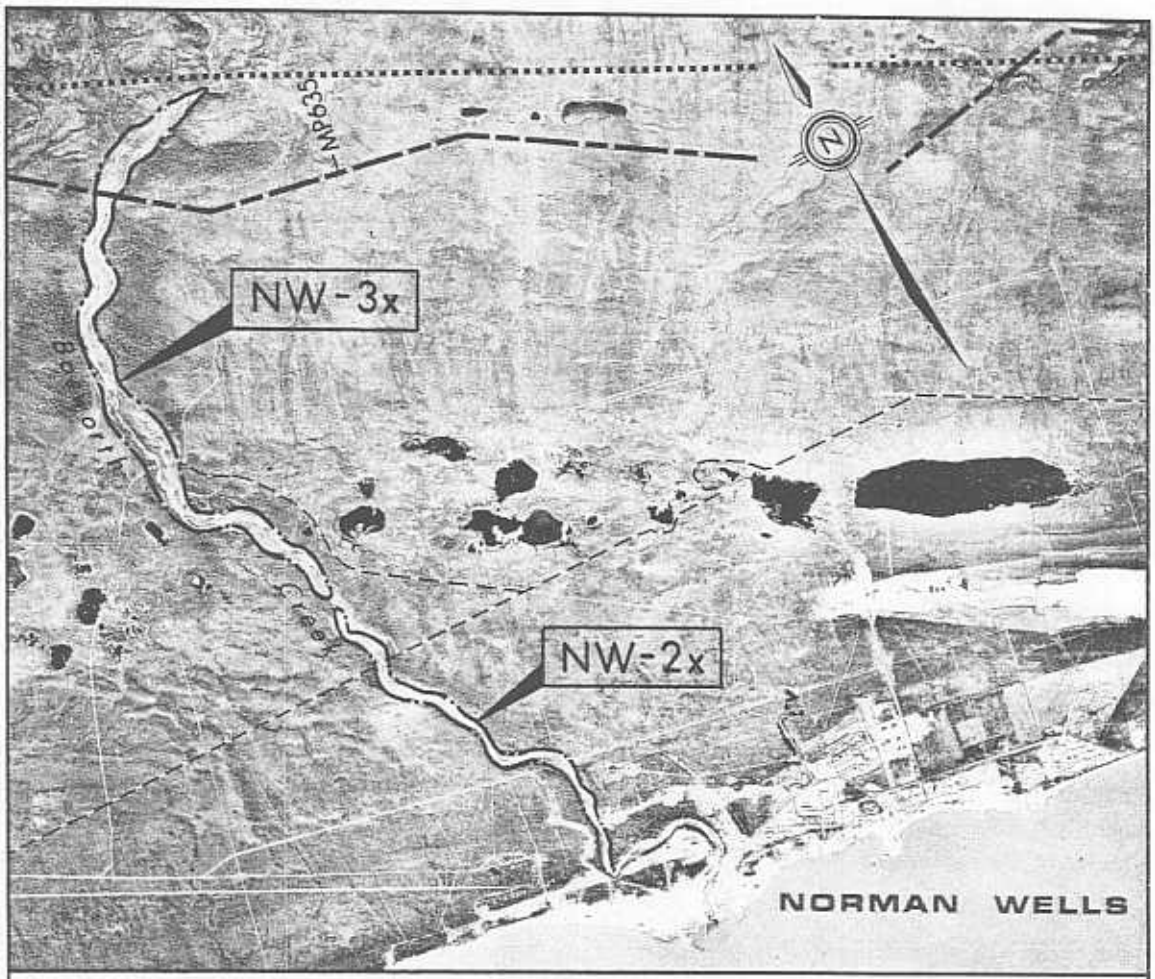
PETROGRAPHIC ANALYSIS: (NW 1/DH 4 at 4' - 5')

Quartzite	56.1%
Limestone & dolomite	14.7%
Igneous materials	4.8%
Cherts	16.4%
Siltstone (hard)	3.2%
Deleterious material: Friable, calcareous and ferrugenous siltstone and sandstone	4.8%

SITE NO. NW 2X

Located immediately west of Norman Wells, Site NW 2X is about 2 miles in length and consists of sand and gravel bars in the downstream portion of Bosworth Creek.

Type of Material:	Sand with gravel bars, some silt.
Estimated Volume:	100,000 cubic yards
Assessment:	Fair quality material for general fill. The source is not recommended for development because the stream is used as a water supply for Norman Wells. Also, development of borrow pits near the mouth would be difficult since the area contains producing high pressure oil wells.



LEGEND

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

Airphoto No. A22934/137

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 2X is located in the downstream portion of Bosworth Creek immediately west of Norman Wells, and is approximately 2 miles in length. The downstream portion of Bosworth Creek is slightly incised below the adjacent flat terrain with a large alluvial fan at its mouth. Because of irregular discharge, the stream flows in a meandering pattern and has occasionally shifted its channel.

Sands and gravels are exposed within the active stream floodplain as individual bars. They are predominantly fine grained, and are frequently covered and interspersed with alluvial silt. The material is of variable composition which, in general, becomes finer toward the stream mouth. The deposits lie below the high water level mark.

Terrain adjacent to the site is generally moss covered and is underlain with an organic layer approximately 1 foot thick. Wet boggy areas are common and are characterized by growths of willow, dwarfed spruce, and some tamarack.

The downstream area near the mouth of Bosworth Creek has been considerably altered by lease access roads, tank farms, gathering system pipelines and building development in conjunction with the exploration and production of the Norman Wells oil field.

The site is within the broad migration and staging area as outlined in Figure 2. The historic use of this area by the oil industry and the proximity of this site to the community of Norman Wells, negates any severe implications upon wildlife and waterfowl.

DEVELOPMENT

Site NW 2X is not recommended for immediate development because of the following:

- The site is located in the active floodplain of Bosworth Creek; therefore, most granular material deposits are below the high water level of the creek.

- Development logistics in the lower part of the site would be difficult since this area is already undergoing major industrial development by virtue of the production operations in the Norman Wells oil field. Several high pressure oil wells and their attendant facilities are in operation in this area.

- The community of Norman Wells is dependent upon Bosworth Creek for their water supply.

- Granular materials of equal or better quality can be secured from other sites within the designated community area.

If exploitation of this site is anticipated at a future date, development guidelines should be established to ensure the compatibility between development and the current

physical status of the area. These development guidelines might include:

- Establishment of procedures whereby the existing water supply and its attendant facilities are assured of protection for the community of Norman Wells.

- Establishment of borrow site locations in a manner that would be compatible with the current and future industrial plans as related to the oil field and commercial operations in the area.

- Guidelines whereby the areas to be exploited would be confined to dry sand and gravel bars as far removed as possible from the existing stream channel.

ABANDONMENT AND REHABILITATION

Further development of this site should be preceded with the formulation of guidelines that establish both development, abandonment and rehabilitation procedures as related to the physical framework of the site at the time. These guidelines might include:

- A current assessment of the physical nature of the site as related to oil field development and granular material exploitation.

- Development of restoration guidelines such as vegetation buffer zones and isolated sediment settling ponds.

- Development of guidelines that incorporate procedures such as revegetation and recontouring of abandoned sites.

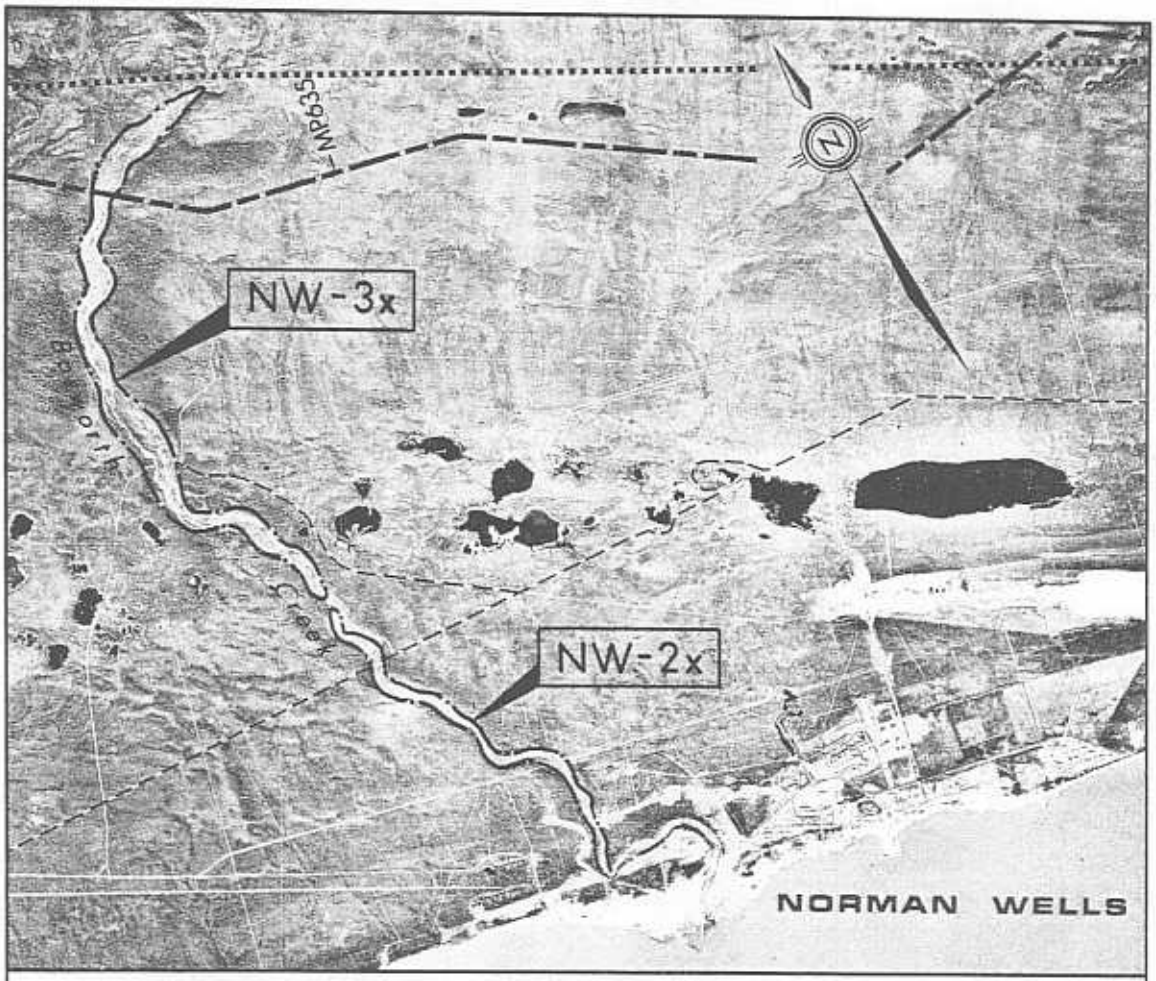
SITE NO. NW 3X

Located northwest of Norman Wells, Site NW 3X is a gravel bar deposit that extends about 2 miles upstream from the north end of Site No. 2X along Bosworth Creek.

Type of Material: Gravel; some sand.

Estimated Volume: 150,000 cubic yards

Assessment: Fair to good quality material for base and surface courses; screened and blended may fit the requirements for concrete aggregate. The extraction of materials is, however, not recommended because the granular materials are, for the most part, within the active stream channel of Bosworth Creek.



LEGEND

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

Airphoto No. A22934/137

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 3X is located northwest of Norman Wells in the active stream channel of Bosworth Creek and extends about two miles upstream from the north end of Site NW 2X. Bosworth Creek in the catalogued section forms a relatively wide braided stream that becomes deeply incised below the adjacent rolling terrain in the northern end of the site area. Exposed granular deposits, predominantly sandy gravel of variable gradation, cover the gully bottom as numerous bars. Some bars are covered with silty sand supporting growths of small shrub. The sediment concentration and gradation of material varies considerably throughout the stream channel and discontinuous horizontal stratification is common.

The granular deposits, in general, lie below the active high water mark of the stream.

Exposed bars, within the channel banks, that contain fine grained granular materials occasionally support dwarfed growths of willow. Areas adjacent to the banks of Bosworth Creek support growths of spruce that occasionally reach trunk diameters of 10 to 12 inches. Tamarack is common in the localized wet, poorly drained areas.

Norman Wells obtains its water supply from Bosworth Creek.

A waterfall, located on Bosworth Creek near the north end of the site, is noted for its natural beauty and is considered as a tourist attraction. Access to the waterfall is by means of a hiking trail that generally parallels the east bank of the stream.

The site is currently accessible only during the winter season along the winter road and the hiking trail.

DEVELOPMENT

Site NW 3X is not recommended for immediate development because of the following primary reasons:

- Bosworth Creek is the primary water supply for Norman Wells.
- Much of the available granular materials are found within the braided channel and below the high water mark of the stream.
- The northern area of the site is of aesthetic value to the region.

If local needs require the exploitation of granular materials from this site at a future date, then guidelines that are based upon the physical status of the site should be established at that time. Some of these guidelines should include:

- Procedures should be established whereby only dry bars and other areas removed from the stream channel are developed.

- Procedures should be established whereby the exploitation of borrow areas can be geographically flexible within the site in order to allow for periodic shifting of the stream channel.

- Procedures should be established relating to the periodic stripping of granular materials so that excavation does not occur more than 2 or 3 feet below the ground water table. In such cases, wet material should remain isolated from the active stream channels.

- Procedures should be established to maintain buffer zones and sediment settling ponds that separate the working areas from the active stream channel.

- Procedures should be established for adequate aesthetic buffer zones along the stream banks.

ABANDONMENT AND REHABILITATION

If Site NW 3X is developed at a future date an assessment should be made that relates to the current status of the area and the proposed development of borrow pits. This assessment should result in guidelines on abandonment and rehabilitation procedures that would include:

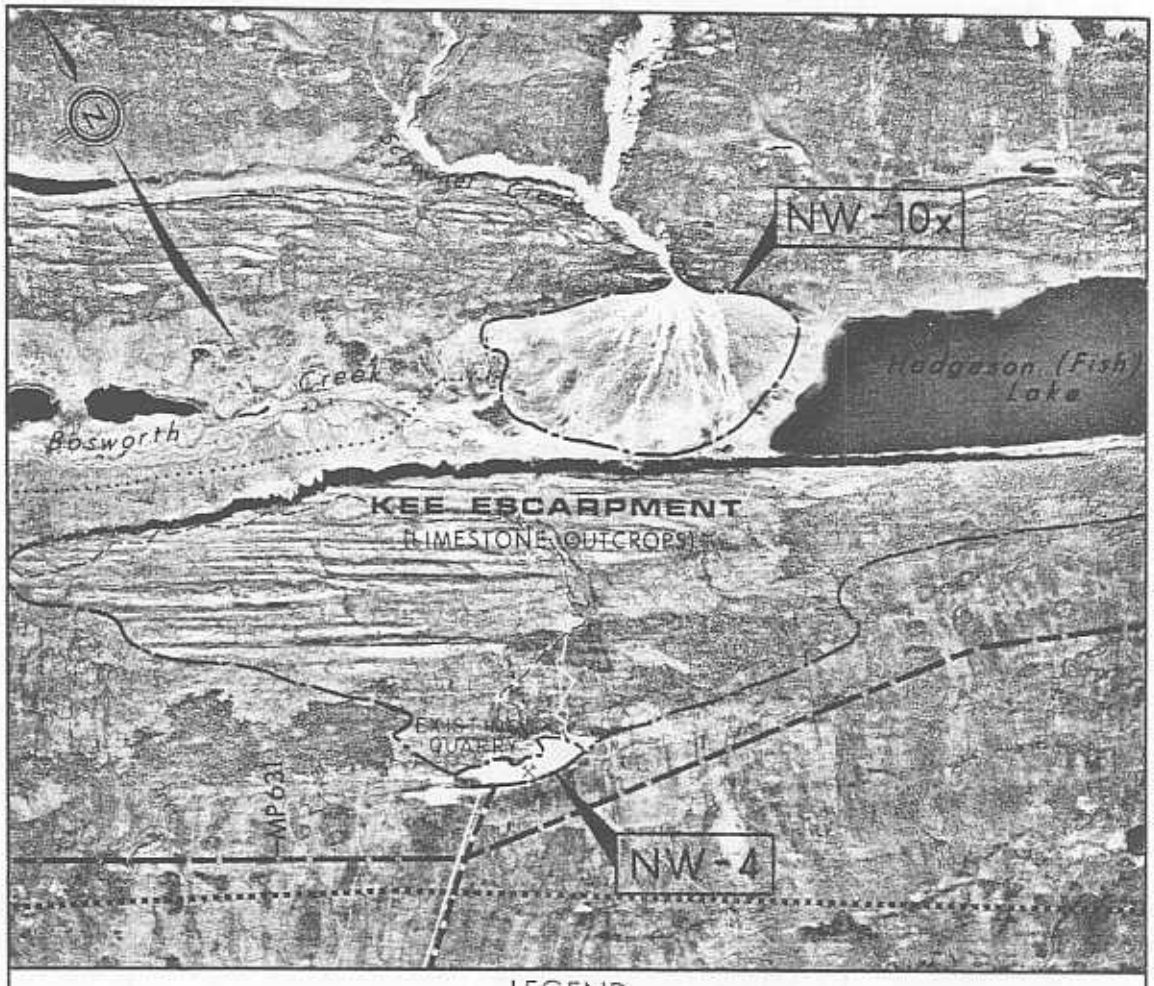
- Terracing and recontouring procedures for pit areas should be established.

- Procedures should be established whereby restored pit areas are breached into existing channels so that high water flows will naturally cleanse and restore such areas.

SITE NO. NW 4

Located approximately 4 miles northeast of Norman Wells, Site NW 4 encompasses a prominent ridge known as Kee Escarpment. A quarry is currently in operation at the south side of Kee Escarpment and an all weather road provides access to Norman Wells.

Type of Material:	Limestone, weathered and fragmented at surface; massive and competent at depth.
Estimated Volume:	Unlimited in terms of requirements for Norman Wells.
Assessment:	Material from the surficial zone is of excellent quality for general pit run fill; crushed limestone from Zone II is suitable for sub-base, base and surface courses; crushed, screened and possibly washed limestone can be utilized for quality concrete aggregates from Zone III.



LEGEND

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

Airphoto No. A22934/101

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 4 is located 4 miles northeast of Norman Wells community and consists of a prominent ridge known as Kee Escarpment at the southern base of the Norman Range. The ridge has a very rugged relief with numerous bedrock exposures and encompasses an area approximately $2\frac{1}{2}$ miles in length and $\frac{1}{2}$ mile in width.

The ridge is basically comprised of Devonian dolomitic limestone. The initial 10 to 15 feet of the surficial limestone layer is badly fractured and weathered. The limestone bedrock becomes more massive at increasing depths from the surface. The more competent beds of limestone form the predominent ridges which constitute the rugged appearance of the site.

Residual soil and colluvium form a predominantly shallow layer, 1 to 2 feet in thickness, and support sparse growths of black spruce and small shrub. Thicker overburden, in the order of 5 feet in depth, exists in localized depressions.

An existing quarry operation has removed material from the southeast face of Kee Escarpment resulting in the exposure of a vertical wall of limestone that is approximately 70 feet high. The exposed limestone in the wall indicates a dip of 15 degrees to the south. The northwest portion of the existing quarry is covered with a surficial layer of limy shales.

The upslope flanks of the site along the northern and western periphery support light stands of spruce with occasional growths of tamarack. Along the southern and eastern edges of the site the vegetation ranges, in a southerly direction, from dwarfed spruce and shrubs to well developed stands of spruce with an increased growth in tamarack. The presence of tamarack generally indicates a wetter growth environment than the flank areas.

There are no known critical wildlife areas in the vicinity of the quarry. Past exploitation of the quarry and the proximity to the townsite suggests that wildlife should not be extensively affected by continued operation of the quarry.

An all weather road with excellent access has been constructed from the existing quarry to the community of Norman Wells. In addition, a temporary access road traversing the width of Site NW 4 has been extended from the existing quarry to the southern shoreline of Fish Lake.

DEVELOPMENT

Site NW 4 is considered to be a major source of the granular materials to supply the requirements for the community of Norman Wells. The development of this site would entail a quarry operation and with the utilization of selective development and processing

techniques would produce granular materials of various categories for most construction needs.

The quality of material in the Kee Escarpment's limestone formation has been established, to a degree, upon the intensity of weathering which has resulted in the following three basic types:

Zone I: Extensively weathered, badly fractured and fragmented limestone forming the initial 10 to 15 foot thick surficial bedrock zone. This material can be easily ripped and may be utilized in the pit run condition for good quality general fill material.

Zone II: Slightly weathered, moderately fractured to blocky limestone forming a 15 to 20 foot thick lower stratum in the exposed quarry wall. It is considered that blasting will be required to remove the material in this zone. The limestone from this zone can be utilized for base and surface course aggregates if the extracted material is crushed to the specified gradation limits.

Zone III: Competent, generally massive limestone is encountered at depths in excess of 30 feet in the existing quarry. Fractures in the massive limestone were noted at intervals in excess of several feet. The massive limestone from this zone would have to be extracted by blasting. Good quality aggregates for surface courses and concrete aggregates can be produced by processing this limestone section through crushers.

A stratigraphic section of the Kee Escarpment limestone formation, based on field reconnaissance, is illustrated as a sketch on page 4-6. The three zones within the limestone formation are depicted on the sketch.

Currently, the limy shale mantle which overlies the limestone formation at the northwest end of the quarry is being extracted and utilized for use in general fill construction. This limy shale is very susceptible to deterioration by weathering and is considered a low quality material for general fill.

The development of the existing quarry has resulted in a 70 foot high vertical face which prevents selective excavation of material. Therefore, it is recommended that if this site is further developed to obtain granular materials, then the following operation guidelines should be considered:

- Quarry operations should be centered to already mined areas rather than continuously expanding the quarry wall in a westerly direction along the southern side of the escarpment.

- New mining stages within the existing quarry could be suitably established on the east quarry end while working faces would be gradually expanded in both the westerly and northerly (upslope) directions. The east side of the existing quarry is preferred because of better accessibility.

- Once the existing or otherwise arbitrary set up of the west quarry boundary is reached, the mining would start again from the east end.

- When the main quarry wall is set several hundred feet back from the original slope face, the mining of the western side could be resumed. This would allow for more than one working face and separate access to zones of individual rock types.

- The rock quarry would be mined in benches or terraces set at depths corresponding to the zones of individual types which are present in the limestone formation. These benches would facilitate the excavation of selective material based on current requirements for construction and would also ensure better access and safer quarry operations.

- The extensively fractured, weathered and fragmented limestone in Zone I could be easily extracted by conventional methods utilitizing dozers, overhead loaders and relatively light ripping equipment. However, in view of the extensively weathered condition of the limestone from this surficial zone, the use of this material should be restricted for general fill requirements.

- The massive, slightly weathered and moderately fractured limestone from Zone II may be partially extracted with heavy ripping equipment; however, it is generally considered that blasting would be required to expedite the extraction of material from this zone. The limestone in this stratum is quite competent and should produce good quality aggregates for surface courses in addition to quality pit run fill material. The use of this material as a source for surface courses would entail the processing of the shattered pit run limestone through a crusher to reduce the material to required specifications.

- The massive and competent limestone from Zone III could only be extracted by blasting. Blasting techniques should be employed to shatter the in situ limestone into fragments which could be processed by a crushing operation. The material from this stratum is very sound and could be utilized for concrete aggregates with the proper processing techniques. The production of coarse concrete aggregates from this source should be easily obtainable with normal crushing operations.

However, if the production of fine concrete aggregate is envisioned then a primary and secondary crushing technique as well as a washing operation may be required to produce fine aggregate within required A.S.T.M. specifications.

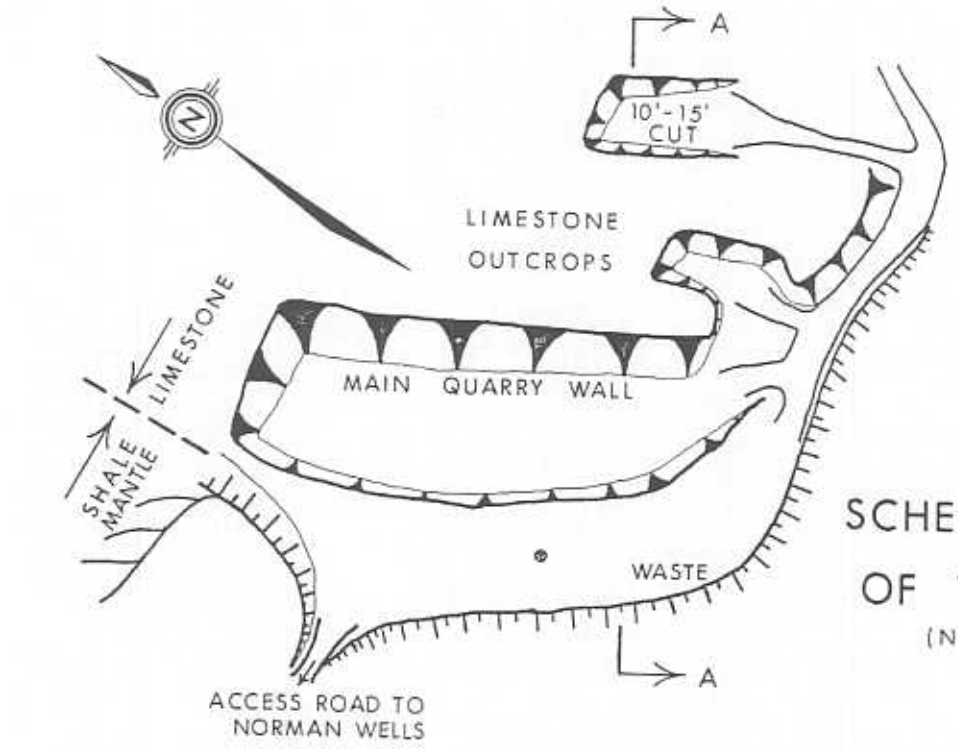
- Prior to any development of fine or coarse concrete aggregrates from this limestone quarry, additional laboratory tests should be conducted to evaluate specific physical properties of the material relevant to the manufacturing of quality concrete mixes. Some typical tests are outlined below:

  a) Autoclave expansion
  b) Specific gravity and absorption
  c) Chemical soundness
  d) Detailed trial design mixes for water-cement ratio and compressive strengths.

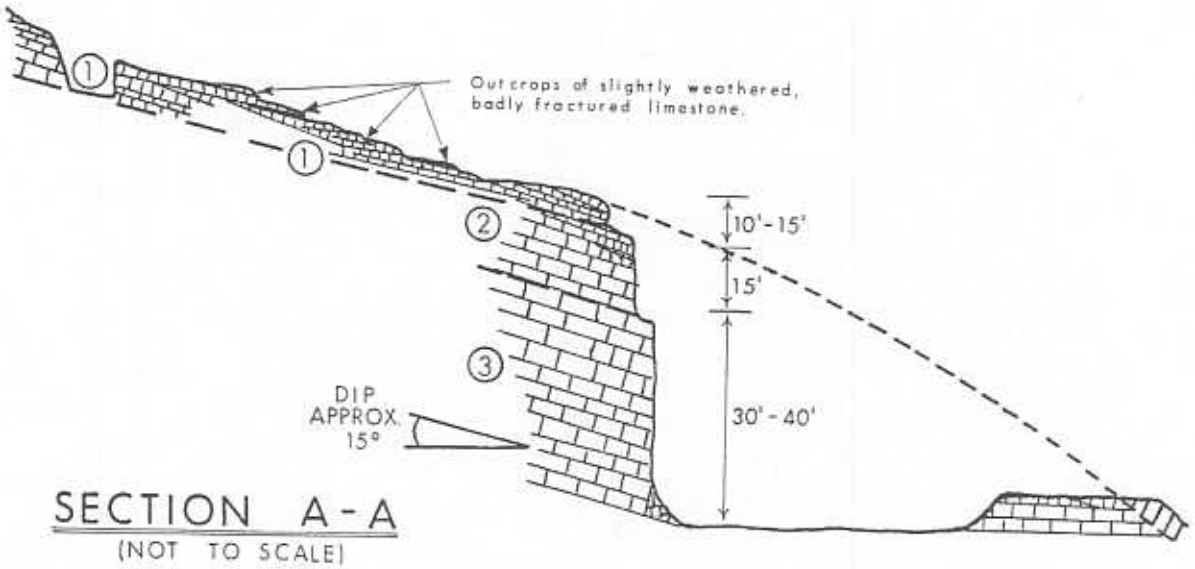
- The access to the hunting and fishing trail to the Fish Lake area should be maintained during the operation of the quarry.

ABANDONMENT AND REHABILITATION

In general if a well organized and controlled operation is maintained during the development and extraction of material from the quarry, the problems related to abandonment and rehabilitation would, inherently, be managed. Since the quarry is considered to be a long term operation, specific restoration procedures could only be considered if and when the quarry is ultimately slated for abandonment.



SCHEMATIC SKETCH
OF THE QUARRY
(NOT TO SCALE)



SECTION A-A
(NOT TO SCALE)

1) Limestone, weathered to slightly weathered, badly fragmented, some fractures opened, thinly laminated (lamina 1 to several inches thick).

2) Limestone, very slightly weathered to fresh fractured, thinly bedded - resulting in moderately sized blocks.

3) Limestone, fresh, fractures usually several feet apart, thickly ledged, generally massive.

SUMMARY OF LABORATORY TEST DATA

Sample Location: NW 4 (Limestone)

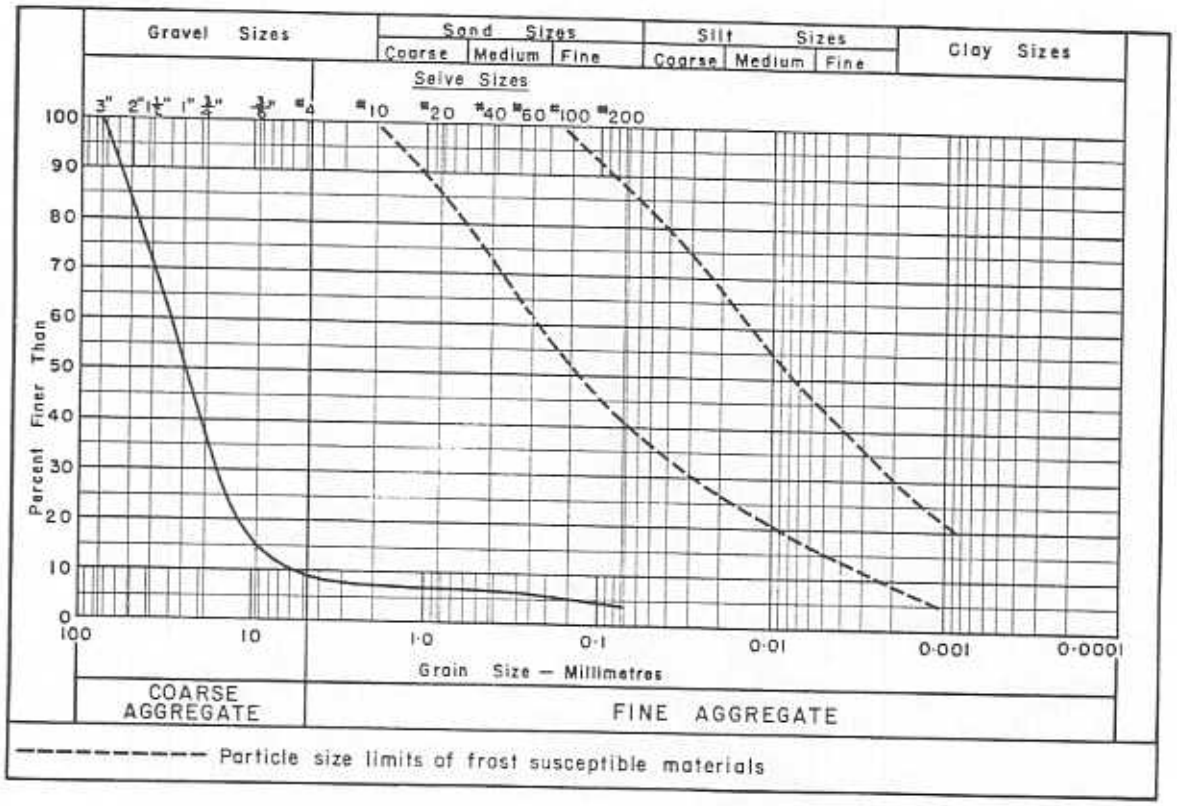
Sample Depth (Feet): Surface

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone and dolomite	99.92 %
Chert	.05 %
Granite	.03 %

No deterious material

L.A. ABRASION TEST:

Percent loss - 21.0

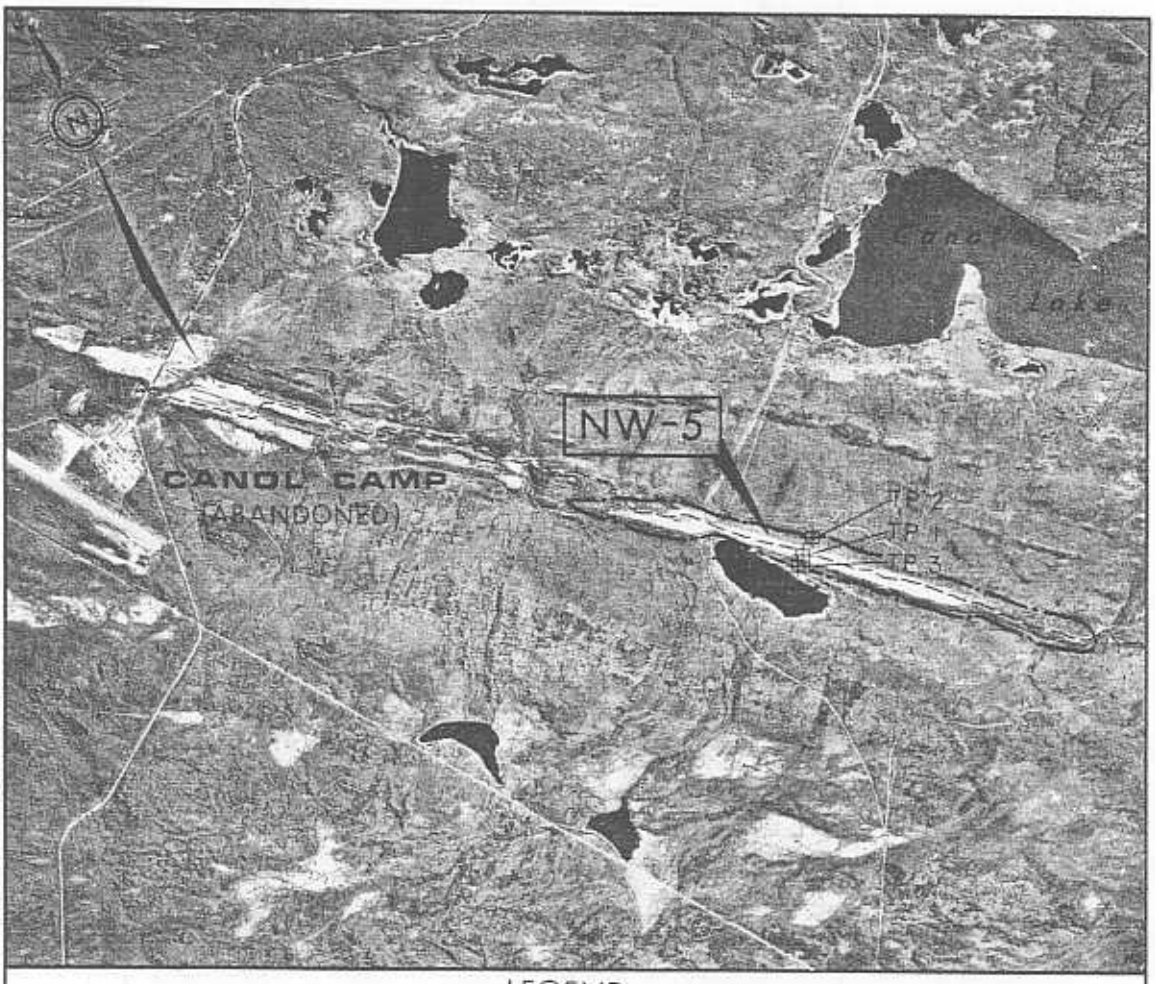
SITE NO. NW 5

Located approximately 8 miles southwest of Norman Wells on the south bank of the Mackenzie River, Site NW 5 consists of a large sand dune.

Type of Material: Sand; little silt, fine.

Estimated Volume: 1,500,000 cubic yards

Assessment: Low quality material for marginal general fill; better material and access at other sites suggests this source will not be developed in the near future.



LEGEND

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

Airphoto No. A22862/10

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 5 is located approximately 8 miles southwest of Norman Wells on a glacio-fluvial plain on the south bank of the Mackenzie River. The site consists of a large sand dune which is greater than $1\frac{1}{2}$ miles in length and rises 35 to 75 feet above the adjacent flat muskeg terrain. Canol Lake is approximately $\frac{1}{2}$ mile northeast of the dune area. The ground water table apparently lies deep within the dune, corresponding to the low terrain topography.

A winter road from the abandoned Canol camp traverses the partly stripped top of the dune. The stripping was probably carried out in conjunction with the borrowing of sand for the road construction when the Canol camp was established.

The dune slopes are covered with a shallow layer of organic topsoil which supports a growth of birch trees. Wet areas in the flat muskeg terrain adjacent to the dunes support growths of spruce and tamarack.

Site NW 5 is within the broad staging and migration route that is utilized by waterfowl, especially during the fall season. The site is also within the region of occasional trapping by natives of Norman Wells; this is particularly true of the areas around and between Canol Lake and Three Day Lake where beaver, mink and lynx are trapped.

Fall moose hunting by the natives of Norman Wells is common in this region on the islands and along the south bank of the Mackenzie River.

The existing winter road from the south bank of the Mackenzie River, through the abandoned Canol camp and across the top of the large dune provides the best access to this site.

DEVELOPMENT

The development of Site NW 5 is not recommended at this time because the sand at this site is of very poor quality and better sources of granular materials are available in the Study Area. If however, development of this site is anticipated at a future date, the following development guidelines should be considered:

- Procedures whereby either truck hauling in the winter or barge hauling in summer would be feasible. This would require stockpiling of materials because of seasonal access.

- Procedures whereby exploitation of granular materials would be initiated at the west end of the large sand dune.

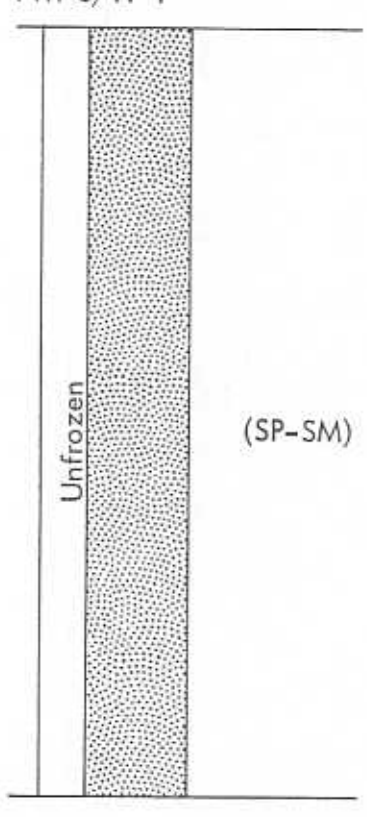
- Procedures whereby vertical excavation is adopted thus minimizing the extent of exposed borrow area to erosion by wind and water. Retention of vegetation buffer zones should also be considered.

ABANDONMENT AND REHABILITATION

If Site NW 5 is developed at a future date, then restoration procedures that are compatible with the development and legislative land use requirements that are current at that time should be developed. These might include procedures such as redistribution of stockpiled surficial materials, recontouring and reseeding of critical areas.

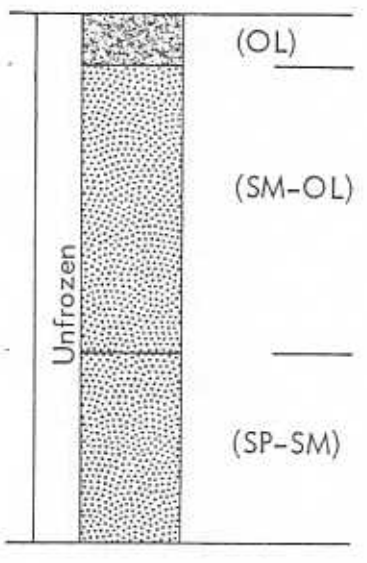
DETAILED TEST PIT LOG

NW 5/TP 1



Sand; little silt, fine grained, poorly graded, brown, damp.

NW 5/TP 2



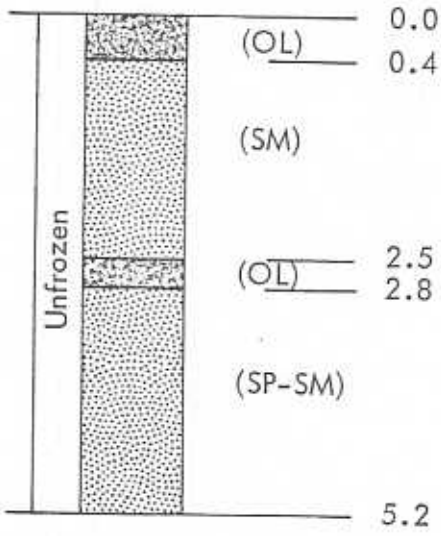
Topsoil; organic, black, roots

Sand; little silt, fine grown, roots, some clay lenses

Sand; little silt, fine grained, poorly graded, brown, damp.

DETAILED TEST PIT LOG

NW 5/TP 3



Topsoil; organic, black, roots

Sand; little silt with occasional clay lenses, greyish, fine grained, damp

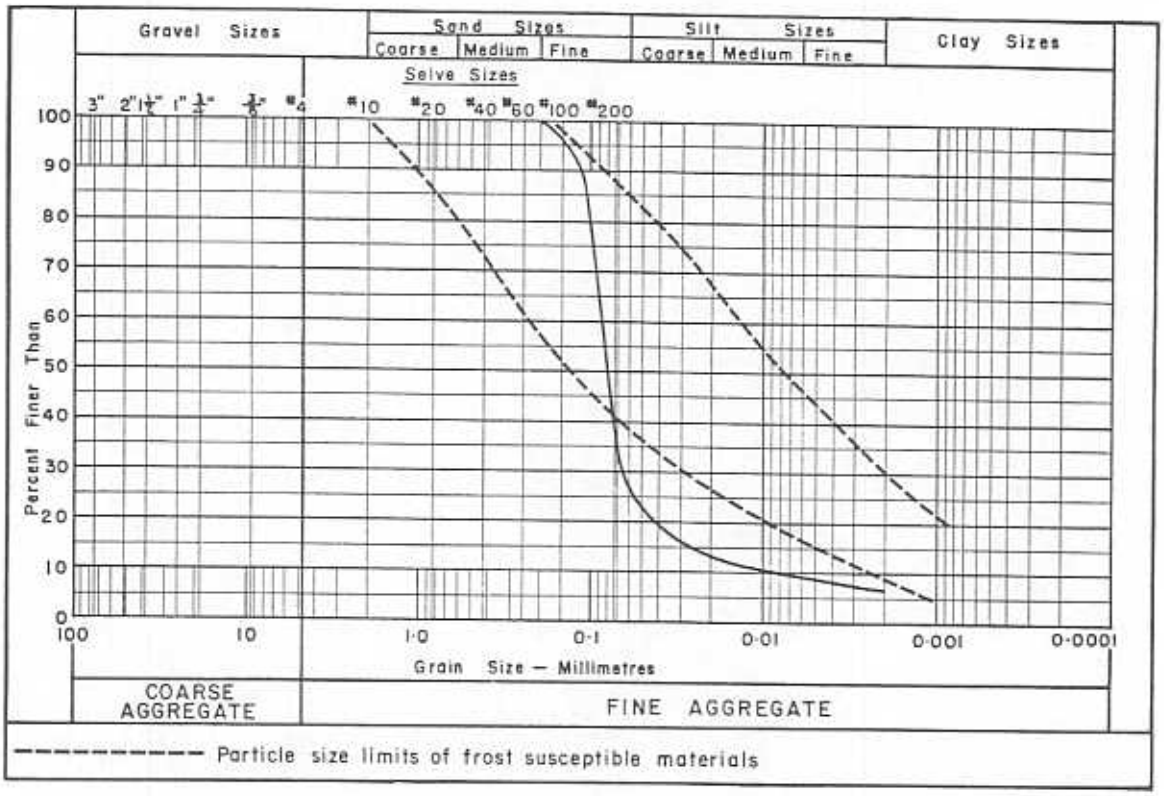
Silt; some clay, organic, black, wet

Sand; little silt, fine grained, poor graded, brown, damp.

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 5/TP 1
Sample Depth (Feet):	2.0 - 5.0
Moisture Content (%):	2.1
Ice Content (%):	-
Organic Content (%):	-

GRAIN SIZE DISTRIBUTION:

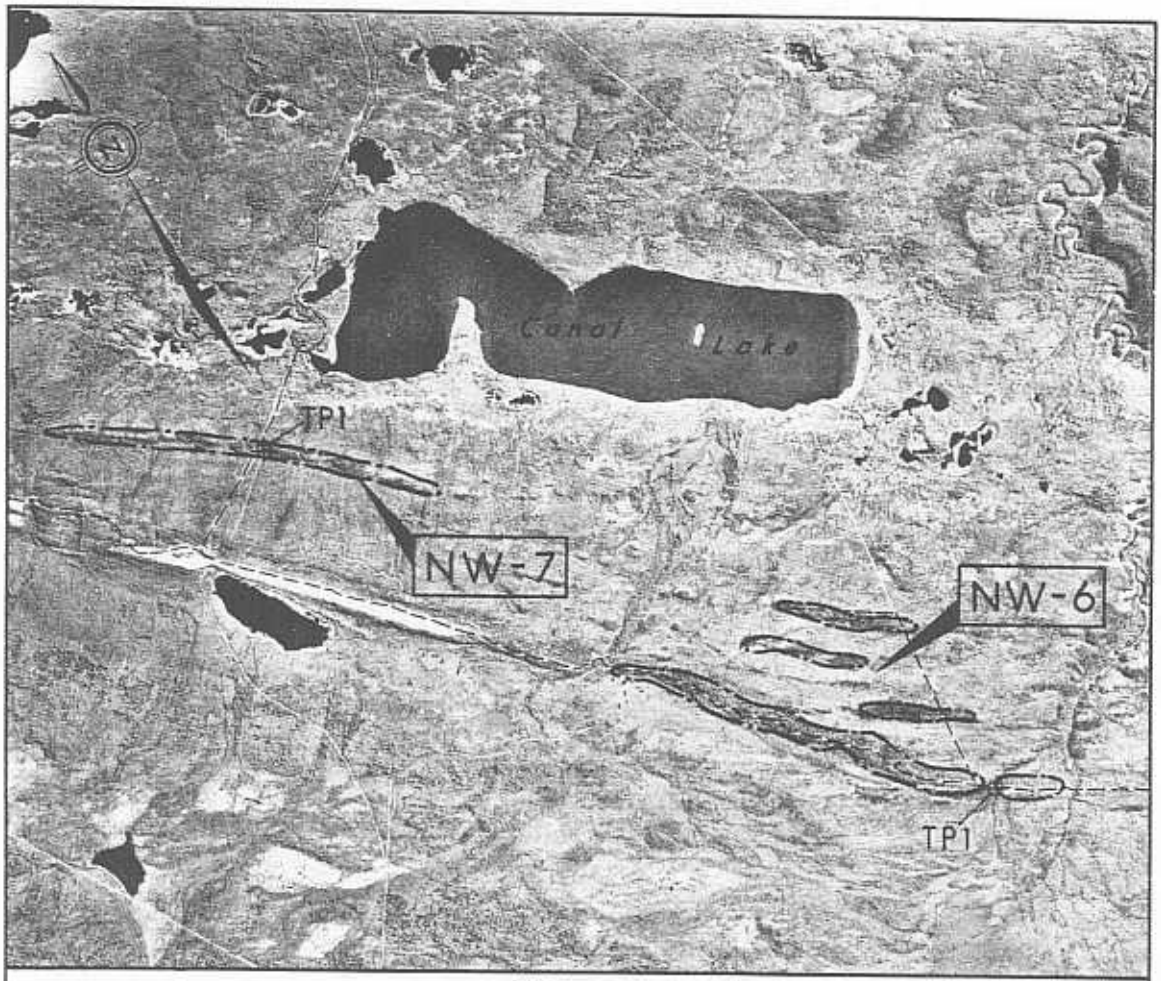


PETROGRAPHIC ANALYSIS:

SITE NO. NW 6

Located approximately 10 miles southwest of Norman Wells on the south bank of the Mackenzie River, Site NW 6 is a series of small sand dunes.

Type of Material:	Sand; little silt, fine.
Estimated Volume:	1,500,000 cubic yards
Assessment:	Low quality material for general fill; better material and access to other sites suggests this source will not be developed in the near future.



LEGEND

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

Airphoto No. A22862/11

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 6 consists of a series of small sand dunes located on a glaciofluvial plain on the south bank of the Mackenzie River. The site is approximately $2\frac{1}{2}$ miles east of the abandoned Canol camp. The major sand dune at this site is approximately $1\frac{1}{4}$ miles in length, 125 feet wide at the base, and an average height of 20 feet above the adjacent flat terrain. Three minor dunes, approximately 1500 feet in length are located north of the large dune. The dunes contain very fine, eolian sand and are unfrozen to depths investigated.

A winter road from the abandoned Canol camp traverses the top of the large dune. An incised gulley, located at the northwest side of the large dune, separates Site NW 6 from Sites NW 5 and NW 7. The eastern side of the large dune is partially eroded by an intermittent stream.

The dune slopes are covered with a shallow layer of organic topsoil which supports a growth of birch trees. Wet areas in the flat muskeg terrain adjacent to the dunes support growths of spruce and tamarack.

Site NW 6 is within the broad staging and migration route that is utilized by waterfowl, especially during the fall season. The site is also within the region of occasional trapping by natives of Norman Wells; this is particularly true of the areas around and between Canol Lake and Three Day Lake where beaver, mink and lynx are trapped.

Fall moose hunting by the natives of Norman Wells is common in this region on the islands and along the south bank of the Mackenzie River.

The existing winter road from the south bank of the Mackenzie River, through the abandoned Canol camp and across the top of the large dune provides the best access to this site.

DEVELOPMENT

The development of Site NW 6 for granular materials is not recommended at this time since the sand at this site is of very poor quality and better sources of granular materials are available in the Study Area. If however development of this site is anticipated at a future date, the following development guidelines should be considered:

- Procedures whereby either truck hauling in the winter or barge hauling in summer would be feasible. This would require stockpiling of materials because of seasonal access.

- Procedures whereby exploitation of granular materials would be initiated at the west end of the large sand dune.

- Procedures whereby vertical excavation is adopted thus minimizing the extent of exposed borrow area to erosion by wind and water. Retention of vegetation buffer zones should also be considered.

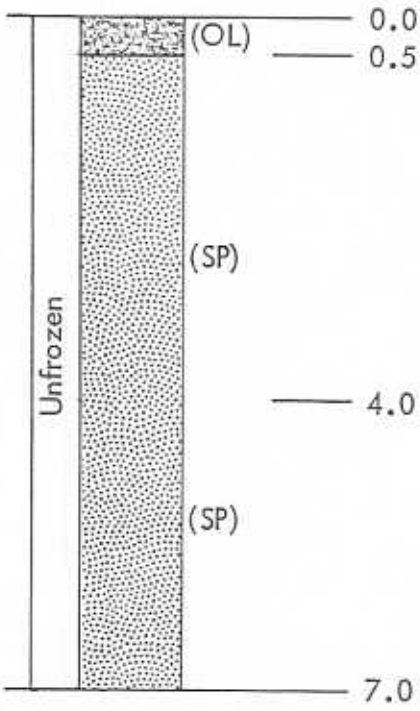
ABANDONMENT AND REHABILITATION

If Site NW 6 is developed at a future date, then restoration procedures that are compatible with the development and legislative land use requirements that are current at that time should be developed. These might include procedures such as redistribution of stockpiled surficial materials, recontouring and reseeding of critical areas.

DETAILED TEST PIT LOG

NW 6/TP 1

Road cut exposure



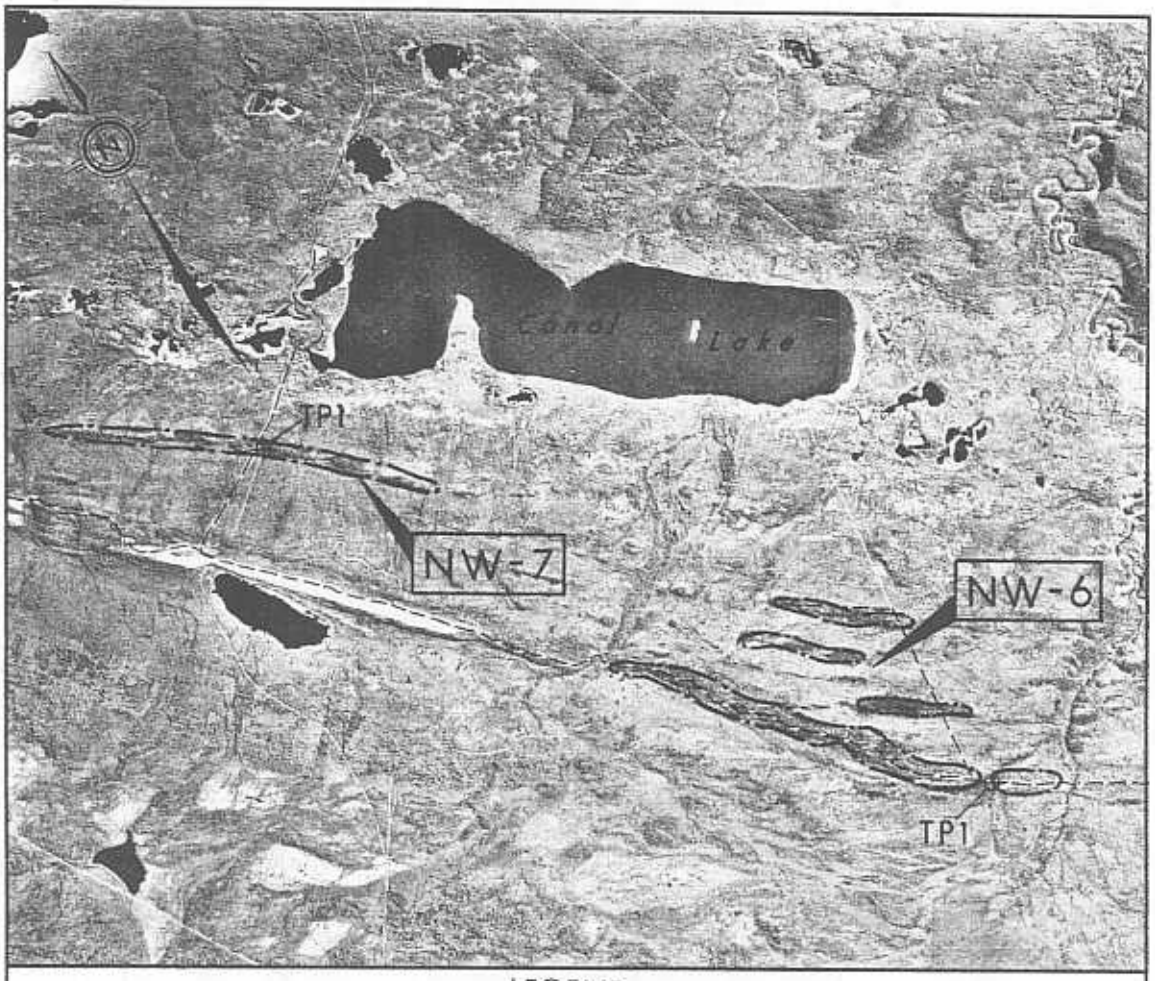
SITE NO. NW 7

Located approximately $8\frac{1}{2}$ miles southwest of Norman Wells on the south bank of the Mackenzie River, Site NW 7 consists of a large sand dune located on a glaciofluvial flood plain.

Type of Material: Sand; little silt, fine.

Estimated Volume: 500,000 cubic yards.

Assessment: Low quality material for general fill; better material and access to other sites suggests this source will not be developed in the near future.



LEGEND

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

Airphoto No. A22862/11

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 7 is located immediately north of Site NW 5 and approximately 1500 feet south of Canol Lake. This site represents one of the larger sand dunes comprising the duned beach ridges located on the glaciofluvial floodplain on the south bank of the Mackenzie River east of the abandoned Canol airstrip. The dune, which is approximately one mile in length and 200 feet in width at its base, rises to a maximum height of 20 to 30 feet above the adjacent flat muskeg terrain.

The dune contains very fine, silty eolian sand which is unfrozen to depths investigated. Probing with shallow test pits along the side slopes of the dune showed considerably higher silt content on the eastern flanks of the dune which may confirm that these dune structures are sandy beach ridges reworked by wind action.

The dune slopes are covered with a shallow layer of organic topsoil which supports birch growth that ranges from 6 to 10 inches in trunk diameter. The birch growth is also enhanced by the well drained nature of the sandy dune and the relatively extensive depth to permafrost. The ground water table apparently lies deep within the dune, possibly at depths corresponding to the elevation of water in adjacent lakes. The wet, adjacent muskeg terrain supports a growth of black spruce and tamarack.

The access to Site NW 7 consists of the winter road to Canol camp and the cutline which dissects the dune area. The site is approximately $8\frac{1}{2}$ miles from the community of Norman Wells.

Site NW 7 is within the extensive waterfowl migration and staging area which parallels the Mackenzie River in this area (Figure 2). The area around Canol Lake and Three Day Lake is also trapped for beaver, mink and lynx by the natives of Norman Wells. The river bank and islands in this area are hunted for moose in the fall.

DEVELOPMENT

The development of Site NW 7 for borrow material is not anticipated in the near future. Sources of granular materials of better quality and better access to the community of Norman Wells are available at other sites within the Study Area.

However, if extensive removal of material from this site is anticipated at a future date then the following development guidelines should be considered:

- Vertical excavation opposed to horizontal excavation should be considered to minimize the erosion of the exposed borrow areas by wind and rain action.
- Transportation of the material by truck haul during the winter or barge haul in the summer will be required if the material is to be utilized in the community of Norman Wells.

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

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

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site NW 7 is developed as a borrow pit:

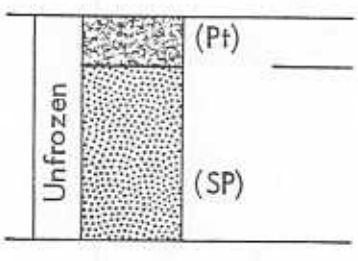
- Recontouring of borrow pit area to maintain good drainage to the adjacent terrain.

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

- Revegetation of the restored borrow pit areas.

DETAILED TEST PIT LOG

NW 7/TP 1



Topsoil with peat; black, organic

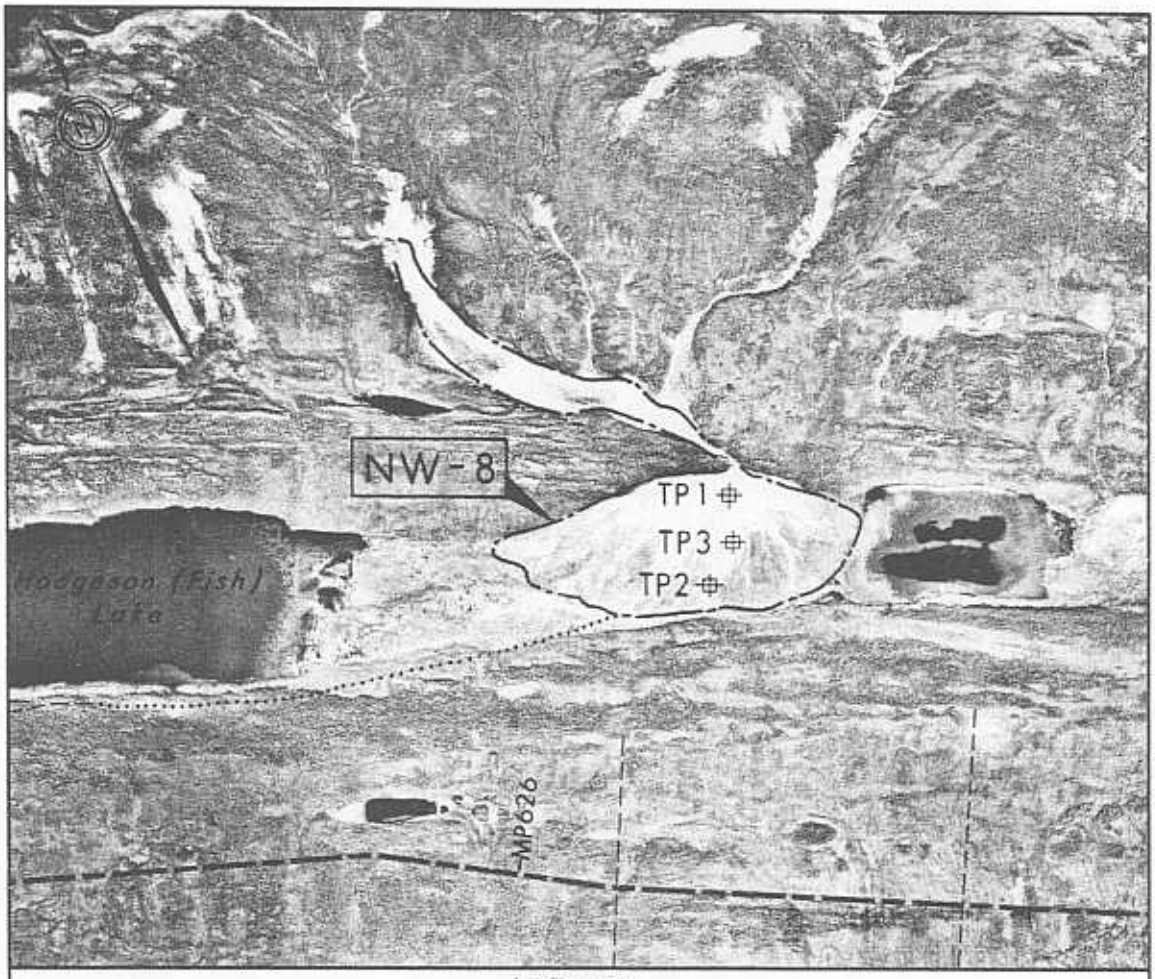
Sand; trace of silt, fine to very fine grained, light brown

SITE NO. NW 8

Located northeast of Kee Escarpment, approximately 8 miles from Norman Wells, Site NW 8 is a large alluvial cone.

Type of Material:	a) Primary:	Well graded coarse gravels.
	b) Secondary:	Silty medium gravels.
Estimated Volume:	a) Primary:	250,000 cubic yards.
	b) Secondary:	750,000 cubic yards.

Assessment: The primary material should be extracted first and may be utilized for general fill, surface and base coarse material. The secondary material is generally suitable for fill material.



LEGEND

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

Airphoto No. A 22934/99

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 8, located approximately 8 miles northeast of Norman Wells at the foot of the Norman Range, consists of a large alluvial cone at the mouth of a narrow valley which is deeply incised into the upslope limestone bluffs. The surface of the alluvial cone is braided with numerous dry stream channels developed during the spring seasonal discharge from the mountain valley.

The alluvial cone contains well graded coarse grained gravels with little sand and a trace of silt. Similar gravel deposits are evident within the relatively wide stream channel north of the cone. By midsummer the water flow in the stream is very low.

The active portion of alluvial cone is approximately 750 by 700 feet in size; whereas the entire cone area is approximately 1400 by 1700 feet. The upper active part of the cone is almost entirely devoid of vegetation cover while the lower part of the cone is covered with a thin veneer of organic topsoil and moss supporting sparse growths of small shrubs and tamarack.

Numerous limestone exposures are evident along the steep valley walls and ridges immediately north of the cone. These limestone outcrops are similar to the limestone exposures noted at Kee Escarpment which is located approximately 4 miles west of this site.

The northern edge of the site along the bedrock flanks of the Norman Range supports scattered growths of spruce. Wet muskeg terrain with occasional tamarack development predominates on the western and eastern edges of the site. This terrain flanks Fish Lake on the east and Edie Lake on the west. The southern periphery of the site supports both tamarack and spruce.

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

The eastern end of Fish Lake is accessible by road and is used by the residents of Norman Wells as a recreation area.

The access to this site consists of the all weather road to the existing quarry at Kee Escarpment; the fishing and hunting trail to Fish Lake and $1\frac{1}{2}$ miles of new access road. The proposed Mackenzie Highway route passes within 1 mile of this site and would provide excellent access to the community of Norman Wells.

DEVELOPMENT

The active upper portion of the alluvial cone, at the apex, should be considered as the primary source of borrow material from this site in view of the predominance of well graded gravels. The lower terraces of the cone consisting of lower quality gravels with

relatively high silt contents may be developed as a secondary consideration for gravel fill material. The following development procedures should be observed:

- The thin veneer of organic topsoil, sparse shrub and occasional tree growth will have to be stripped and cleared if the lower reaches of the cone are to be developed. The waste material should be stockpiled along the southern toe of the cone to maintain drainage of spring runoff water into the adjacent lakes.

- A channel should be cut into the cone from the mouth of the valley to the adjacent lake to prevent indiscriminant discharge of spring runoff water over the face of the cone. In view of the late spring and early summer runoff water condition, extraction of borrow material from this site will likely have to be restricted to a late summer, fall and winter operation. Buffer zones should be maintained so that working areas are isolated from active stream channels. Development procedures should also be adopted whereby excavated wet materials are not handled near flowing water courses.

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

- A new access road, approximately $1\frac{1}{2}$ miles in length, will have to be developed from the cone to the existing quarry at Kee Escarpment to transport material from this site. The proposed new access is noted on the air photo print of the source area.

ABANDONMENT AND REHABILITATION

Abandonment procedures should include:

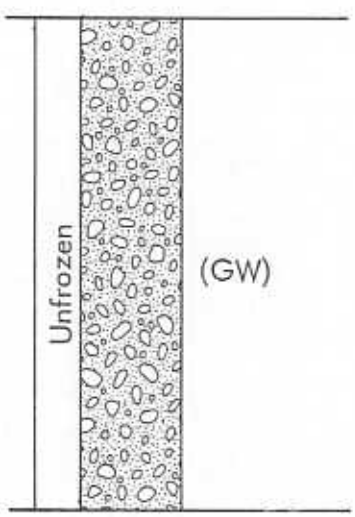
- Recontouring of the pit area to provide proper drainage of high discharges of spring runoff water into the adjacent drainage basin.

- Abandoned borrow areas should also be breached into active channels thus allowing natural dissipation of turbidity during spring melt and runoff.

- Since the cone is still in an active stage of growth, the reseeding of developed pit areas is not considered necessary. However, some reseeding of established access roads might be considered when the site has been abandoned. Specific abandonment and restoration procedures should be outlined during the final stages of development and these procedures should be compatible with good engineering practices and land use regulations as established at that time.

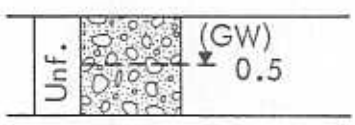
DETAILED TEST PIT LOG

NW 8/TP 1



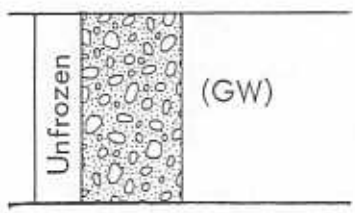
Gravel; little sand, coarse, well graded, occasional cobbles, trace of silt.

NW 8/TP 2



Gravel; little sand, coarse, well graded.

NW 8/TP 3



Gravel; some sand, coarse, occasional cobbles, well graded

SUMMARY OF LABORATORY TEST DATA

Sample Location: NW 8/TP 1

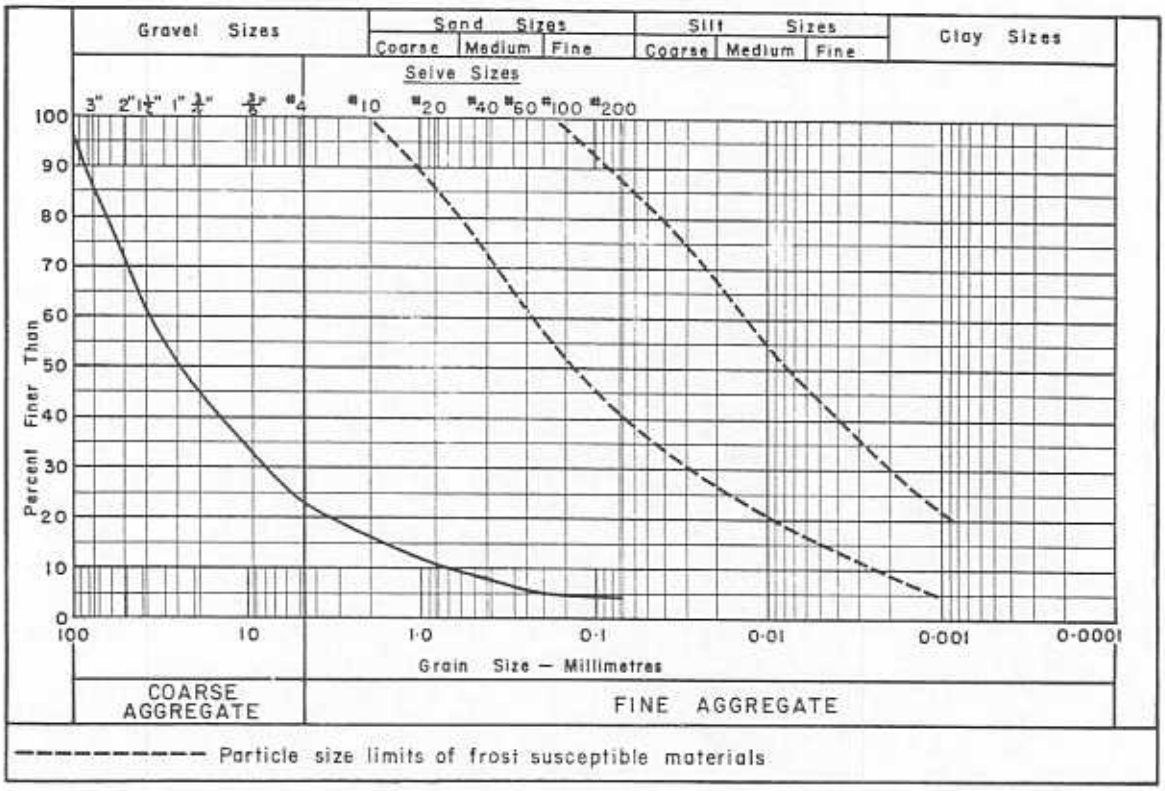
Sample Depth (Feet): 3.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone & dolomite	87.4 %	Igneous granite	.8 %
Quartzites	1.1 %	Cherts	1.1 %

Deleterious limestone and dolomite	7.9 %
Deleterious shale and slate	1.4 %

L.A. ABRASION TEST:

Percent loss - 33.1

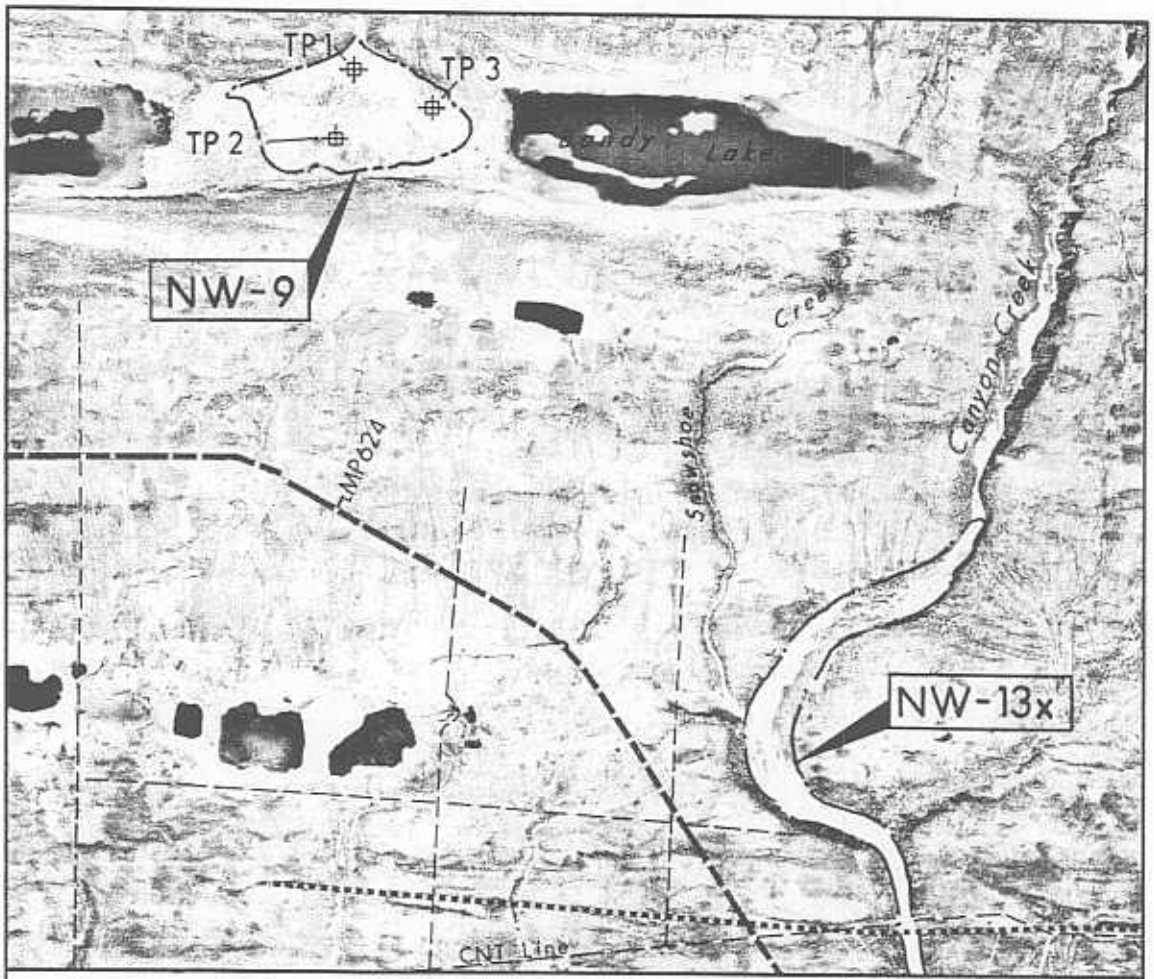
SITE NO. NW 9

Located approximately 9½ miles northeast of Norman Wells and situated between Edie Lake and Bandy Lake, Site NW 9 is a large alluvial cone.

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

Estimated Volume: 700,000 cubic yards.

Assessment: Good quality material suitable for general fill, surface and base courses. Current development restricted to local utilization because of requirement for construction of long new access roads.



LEGEND

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

Airphoto No. A22934/98

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 9, approximately 9½ miles northeast of Norman Wells, consists of a large alluvial fan located at the mouth of a deeply incised narrow valley on the southern edge of Discovery Ridge along the base of the Norman Range. The cone is located between Edie Lake and Bandy Lake. A narrow, partially braided stream channel is incised in the surface of the cone to provide drainage in an easterly direction from the valley into Bandy Lake. By mid to late summer the water flow in this stream is very low.

The material contained in the cone is relatively consistent and is composed of medium grained, sandy gravels. The areal extent of recoverable granular material in the cone is approximately 700 by 3000 feet.

A thin veneer of topsoil, varying from 0 to 12 inches in depth mantles the surface of the alluvial cone. Vegetation growth at the apex of the cone is very sparse and consists mainly of moss and very small bushes. Denser brush growth and sparse stands of black spruce with occasional tamarack were noted along the lower reaches of the cone.

The peripheral areas of the site along the north side and the upslope areas on the flanks of the Norman Range support growths of spruce. The western and eastern flanks of the site are predominately muskeg terrain which is characterized by growths of scrub brush and occasional tamarack. During spring runoff this terrain would be wet and unstable.

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

The access to this site consists of the all weather road to the Kee Escarpment quarry site; the fishing and hunting trail to Fish Lake and 4 miles of new cleared access road. If the proposed Mackenzie Highway is constructed then the base of the alluvial fan will be within one mile of a good access road to Norman Wells.

DEVELOPMENT

The material from this site is slightly inferior to the material from Site NW 8 and in addition is approximately 1½ to 2 miles further removed from the community. Therefore, development of borrow material from this site is not envisioned, until sources of better quality and closer access to the community have been depleted. However, if this site is developed at a future time to provide material for construction of utilities within economical reach of this site, then the following procedures should be observed:

- The existing stream channel should be deepened to ensure positive drainage of spring runoff water to the east into Bandy Lake and thus prevent the inundation of any active borrow pit operation.

- The layer of organic topsoil and vegetation should be stripped and cleared prior to borrow pit excavation operations.

- The waste material should be stockpiled along the southern toe of the cone to maintain drainage into the adjacent lakes.

- The use of dozers, overhead loaders and light ripping equipment can be utilized for extracting the material from this site.

ABANDONMENT AND REHABILITATION

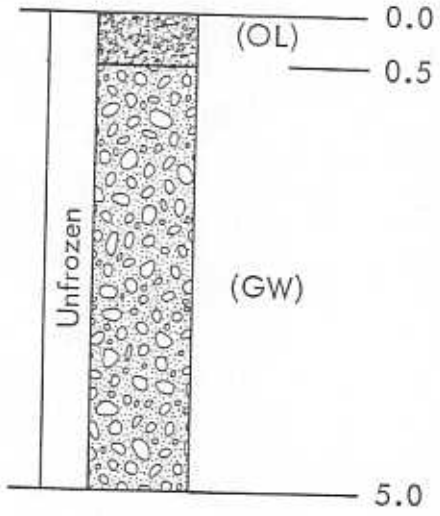
Generally, it is anticipated that any pit operation for removal of material from this site will be gradually masked by the influx of new material brought down by the high discharge of water from the mountain valley during spring runoff periods.

Abandonment procedures should, however, include:

- Breaching of abandoned borrow pits whereby the pits are connected to active stream channels thus facilitating restoration of the pits and their attendent sediment loads through dissipation during spring runoff.

DETAILED TEST PIT LOG

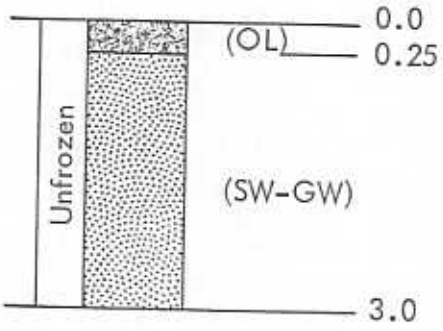
NW 9/TP 1



Topsoil; some sand, trace of gravel

Gravel; some sand, well graded, grey. Frequent cobbles and boulders, predominantly rounded and subangular.

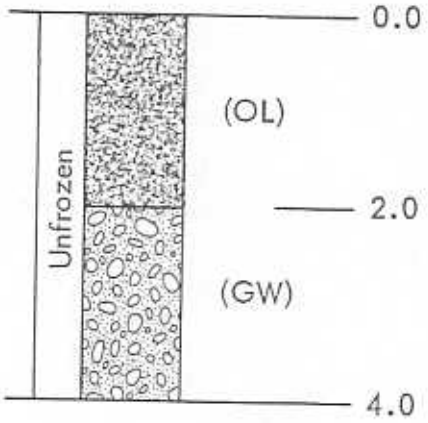
NW 9/TP 2



Topsoil; some sand

Sand and Gravel. Sand medium to coarse graded, trace of rounded gravel to 2 inch maximum size.

NW 9/TP 3



Topsoil; some silt and sand

Gravel; some sand, pebbles to 3 inch, medium to coarse grained.

SUMMARY OF LABORATORY TEST DATA

Sample Location: NW 9/TP 1

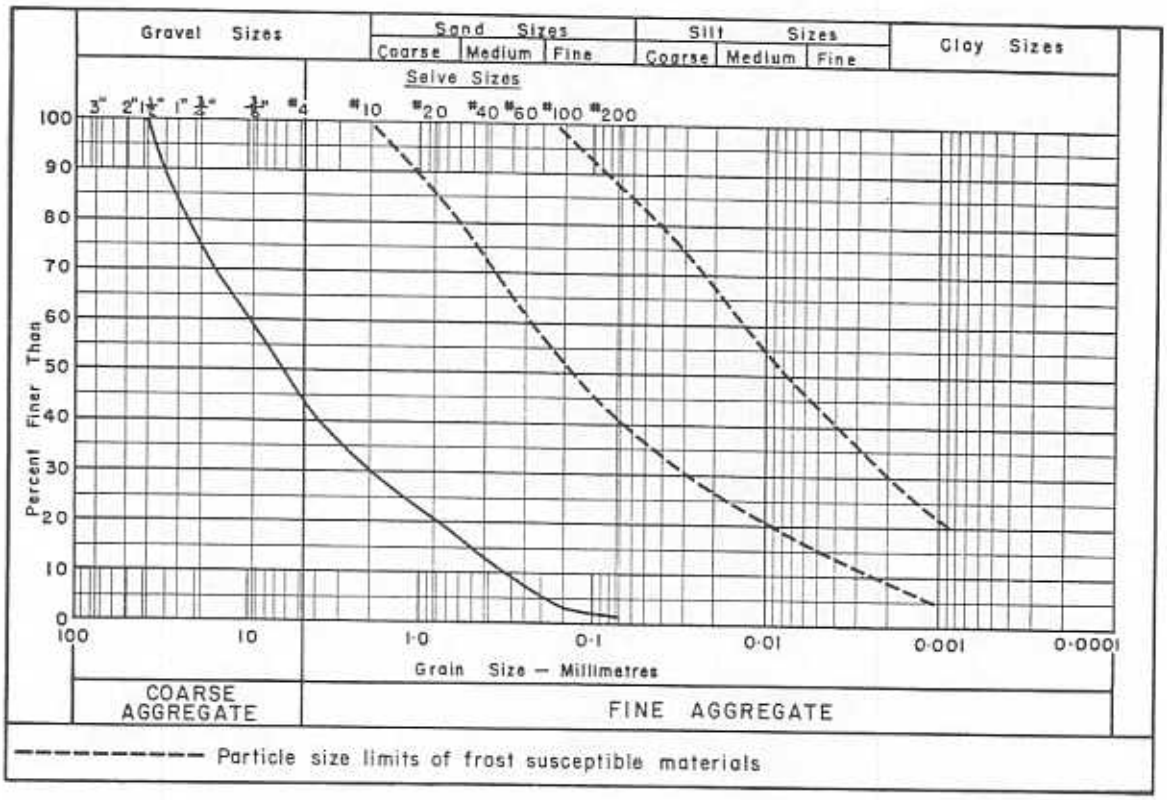
Sample Depth (Feet): 2.0 - 5.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone and dolomite	89.25 %	Quartzites	0.26 %
Igneous material	0.56 %	Cherts	0.66 %

Deleterious limestone and dolomite	8.92 %
Deleterious shale and slate	0.34 %

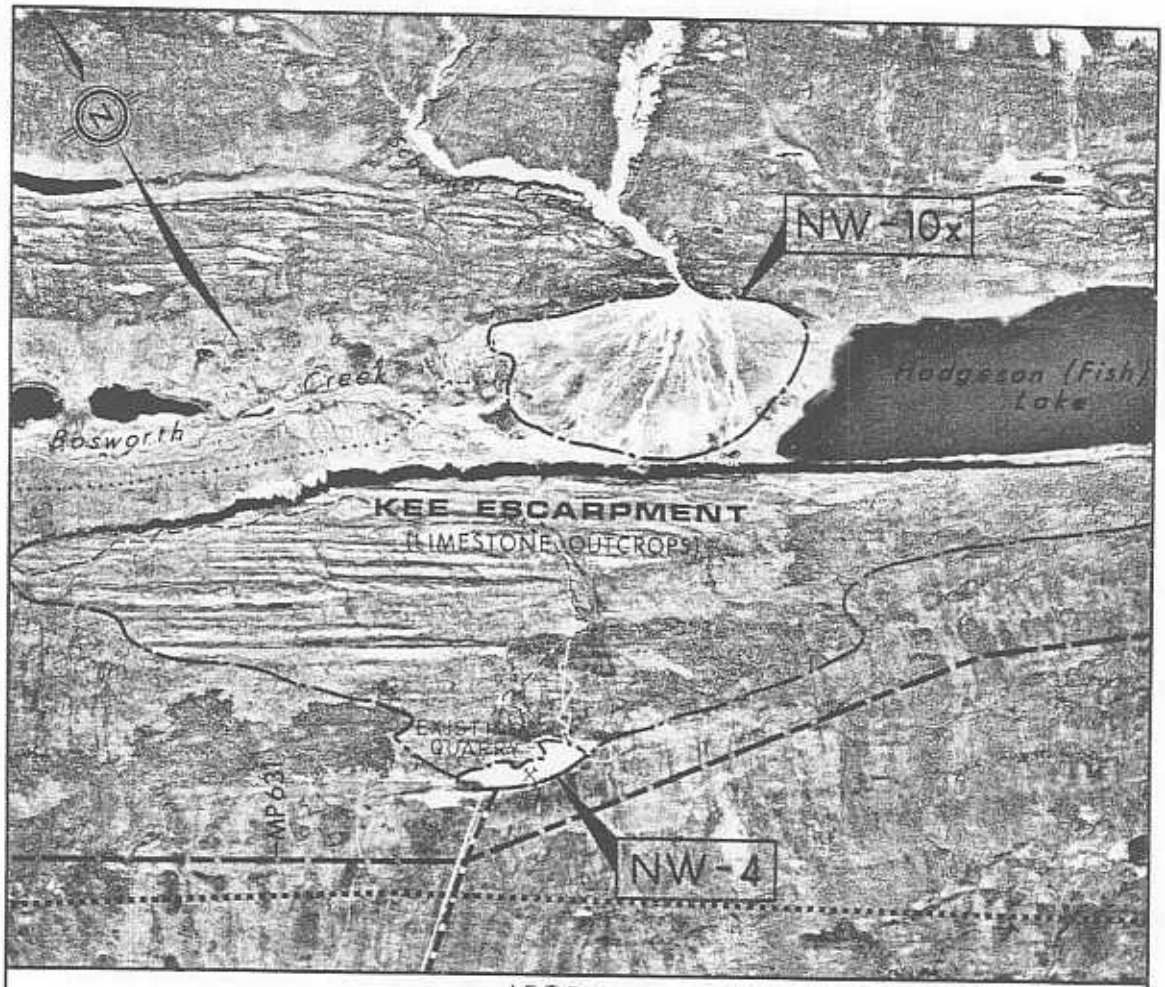
SITE NO. NW 10X

Approximately 4 miles due north of Norman Wells, Site NW 10X is a large alluvial cone located at the mouth of Schooner Creek, on the western lakeshore of Hodgeson (Fish) Lake. The total haul distance to the site is approximately 9 miles.

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

Estimated Volume: 1,000,000 cubic yards.

Assessment: Good quality gravels for surface and base coarses and general fill. Currently not recommended for development because of very difficult access across wet muskeg terrain.



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. A 22934/101

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 10X is located approximately 4 miles north of Norman Wells and consists of a large alluvial fan, approximately 700 by 4000 feet in area, which is located at the mouth of Schooner Creek immediately north of Kee Escarpment on the western shoreline of Hodgeson Lake (Fish Lake). The surface of the cone is braided with numerous dry stream channels giving the cone a fan-like appearance. The active portion of the cone, at its apex, is relatively devoid of vegetation and organic topsoil. A thin veneer of topsoil supports a growth of moss and very sparse bushes. Black spruce becomes more pronounced on the lower reaches of the alluvial cone.

The adjacent terrain to the east and west sides of the cone is relatively flat muskeg with numerous lakes. The drainage off the slopes of the cone is primarily in a southerly direction as indicated by the stream channels.

The alluvial cone contains well-graded coarse to medium sized gravels with a trace of silt.

The peripheral area along the northern edge of Site NW 10X supports spruce growth that ranges up to 40 feet in height. This spruce growth continues northward up the flanks of the Franklin Mountains. The west side of the site is characterized by muskeg terrain with some tamarack development. The east side of the site is bounded by Fish Lake. The steep vertical face of Kee Escarpment, generally, defines the southern periphery of the site.

A dirt road along the top of Kee Escarpment provides access to the east end of Fish Lake. This area is utilized by the residents of Norman Wells for recreation and sport fishing.

Although the site is relatively close to the community of Norman Wells, the presence of Kee Escarpment immediately south of the cone requires that a new access road of approximately 4 to 5 miles in length be constructed from the site around the west end of Kee Escarpment back to the all weather road at the existing quarry.

DEVELOPMENT

In view of the difficult access to Site NW 10X which involves the traversing of a large portion of wet muskeg terrain along the north edge of Kee Escarpment, the development of this cone as an immediate source of granular materials is not foreseen. A number of sites with equally good quality material with better access facilities is available in the Norman Wells Study Area.

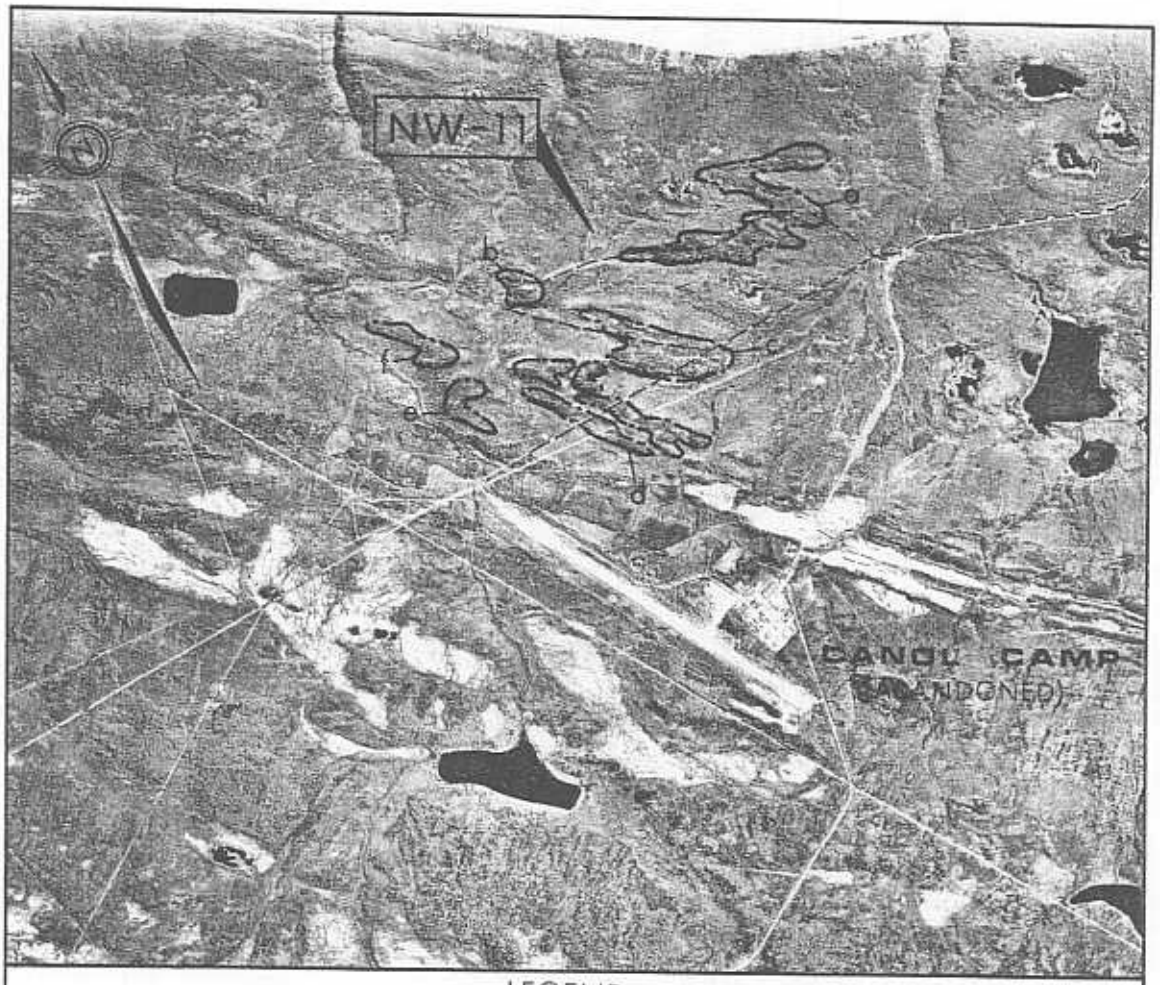
SITE NO. NW 11

Located about 7 miles southwest of Norman Wells, between the south bank of the Mackenzie River and the abandoned Canol Camp airstrip, Site NW 11 is a series of minor to moderately sized sand dunes.

Type of Material: Sand; little silt, fine.

Estimated Volume: 750,000 cubic yards

Assessment: Low quality material for marginal general fill. Better material and better access to other sites suggests that this site should not be developed for the granular material requirements for the community of Norman Wells at this time.



LEGEND

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

Airphoto No. A22862/9

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW II is located approximately 7 miles southwest of Norman Wells on the south bank of the Mackenzie River north of the abandoned Canol airstrip. The site, located on a glaciofluvial floodplain, consists of groups of minor to moderately sized sand dunes encompassing an area $1\frac{1}{2}$ miles in length and 3/4 of a mile in width. The dunes rise 10 to 50 feet above the adjacent terrain. As noted on the site airphoto, the highest and best preserved dune group is "a", while the other dune groups "b" to "f" are partially effaced by erosional processes.

The dune groups contain very fine, silty eolian sand. The localized depression among individual dune groups contain muskeg and the terrain adjacent to the dune areas is topped by shallow peat and organic topsoil layers.

The dunes, elevated above the adjacent terrain represent the only well drained feature in this area, which in turn promotes the growth of scattered birch. The poorly drained and wet terrain, adjacent to the dunes, is predominantly covered with dense growths of tamarack and black spruce.

Site NW II is within the extensive waterfowl migration and staging area which parallels the Mackenzie River (Figure 2). Occasionally, this area is also trapped for beaver, mink and lynx by the natives of Norman Wells. The river bank and islands in this area are hunted for moose in the fall.

The access to Site NW II consists of the winter road to the abandoned Canol Camp and numerous seismic cutlines which traverse several of the major dune groups. It should be noted that transportation of material across the Mackenzie River will have to be considered if this site is developed for the needs of the Norman Wells community.

DEVELOPMENT

The development of Site NW II for borrow material is not anticipated in the near future. Sources of granular materials of better quality and better access to the community of Norman Wells are available at other sites within this Study Area.

However, if extensive removal of material from this site is anticipated at a future date, then the following development guidelines should be considered:

- The best location for a borrow pit is represented by the dune complex denoted as "a" on the site airphoto (Page II-I) because the winter road to the abandoned Canol Camp and an existing cutline provides direct and immediate access to this area.

- The access to this site from Norman Wells community involves the crossing of the Mackenzie River which suggests that the material be trucked across the river during the winter months for stockpiling in the community area.

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

- The material from the dune complexes can be excavated by dozers, backhoes, overhead loaders or similar equipment.

- The shallow topsoil should be carefully stripped and stockpiled on higher well drained ground such as the side slopes of the dunes for reutilization and restoration of pit areas after removal of granular materials.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures for this site should include:

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

- The recontoured pit area should be resurfaced with the stockpiled waste topsoil.

- Revegetation of the recontoured areas.

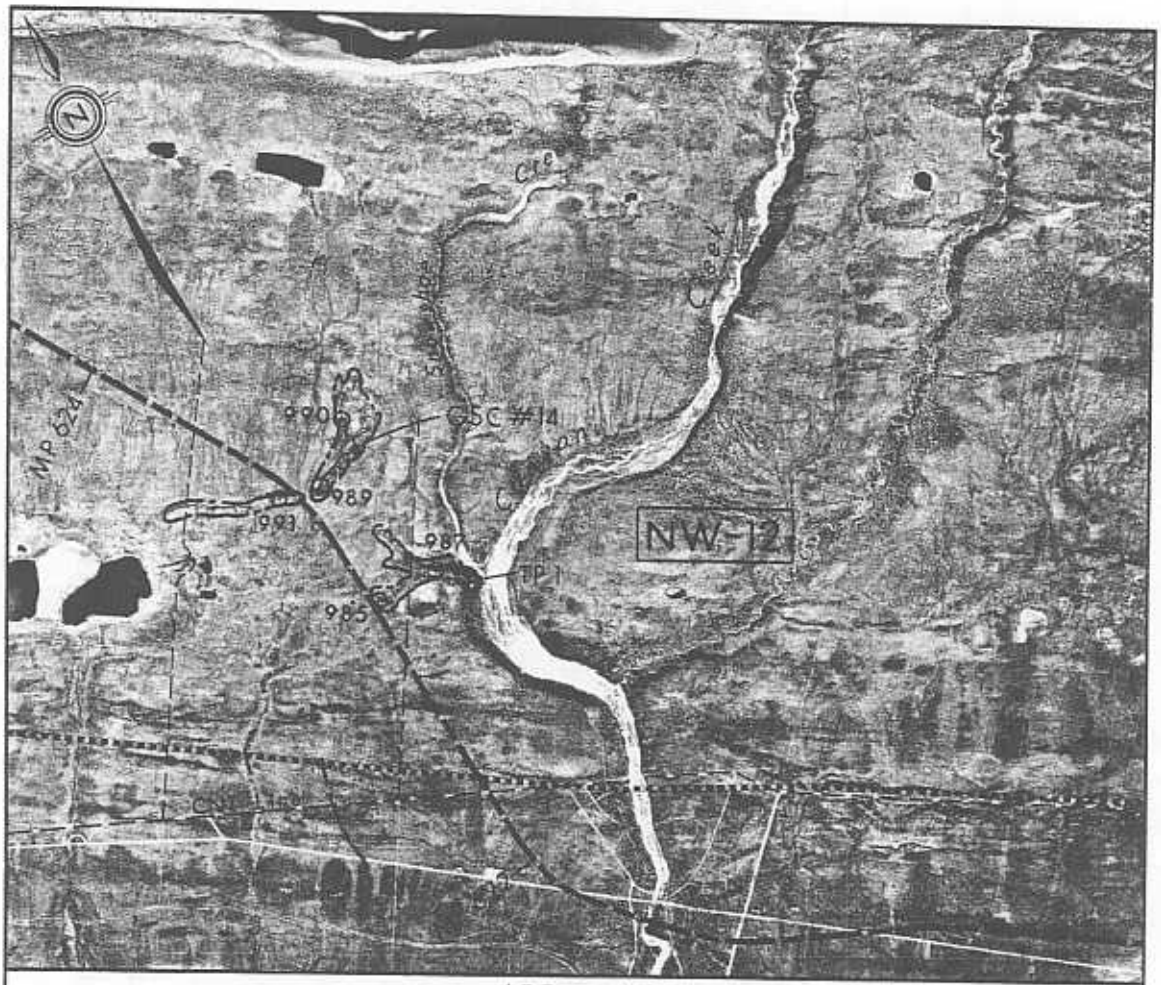
SITE NO. NW 12

Located approximately 9 miles east of Norman Wells, Site NW 12 is a series of small esker ridges on the western bank of Canyon Creek near the confluence of Snowshoe Creek.

Type of Material: Sand; some silt, fine to medium grained

Estimated Volume: 200,000 cubic yards

Assessment: Fair to good quality material for general fill. Relatively difficult access and minor amount of material suggests that this site should not be considered for development at this time.



LEGEND

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

Airphoto No. A22934/98

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 12 is located approximately 9 miles east of Norman Wells adjacent to the west bank of Canyon Creek. The granular material is located in a series of discontinuous esker ridges, generally 100 to 150 feet in width and 20 to 30 feet in height. The discontinuous eskers range from approximately 200 to 1500 feet in length. The prominent esker ridge is located at the confluence of Canyon Creek and Snowshoe Creek, orientated perpendicular to the west bank of Canyon Creek.

The site is located on a gently undulating glaciofluvial plain and the general drainage is in a southerly direction towards the Mackenzie River. The adjacent terrain is generally muskeg and relatively wet, supporting stands of black spruce and tamarack. Exposures of shale bedrock were noted in the stream bed of the deeply incised Canyon Creek.

The esker ridges contain fine to medium grained sands with some silt. The esker slopes are covered with a thin organic topsoil cover supporting growths of moss, small bushes, spruce and birch.

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

Existing seismic cutlines connect the site area to the existing winter road. Access to the site would require traversing thermally sensitive terrain and any disturbance of the existing organic cover may result in subsidence or gullying.

DEVELOPMENT

The development of Site NW 12 is not considered practical because of the marginal quality of the granular material, relatively difficult access and limited quantity of material. A considerable degree of surficial area relative to source exploitation and access roads has to be cleared for the relatively small quantity of granular materials available at this site.

The detailed findings of the winter drilling program which was conducted on Site NW 12 by the engineering consultant for The Federal Department of Public Works has been assessed and incorporated into this report. The following conditions relative to the quality and quantity of available granular materials are outlined.

- Fair quality granular materials consisting of stratified and pocketed deposits of sands and gravels of varied gradation were encountered in these esker ridge segments. These sands and gravels are suitable for good quality embankment fill material in the construction of road grades.

- Overburden material consisting of topsoil and organic silts overlie the granular material deposits and vary in depth from 1 to 3 feet.

- The depth of the in situ sand and gravel deposits vary from a few feet to in excess of 15 feet.

- An estimated volume in the order of 200,000 cubic yards is considered available from the various esker ridge segments.

However, if this site is developed to provide material for construction of utilities within the economical reaches of this site, the following procedures should be observed:

- The organic topsoil and vegetation should be stripped and cleared prior to borrow pit excavation operations.

- The waste material should be stockpiled for easy recovery for future use in recontouring the borrow pit areas.

- The large esker located on the western bank of Canyon Creek at the confluence of Snowshoe Creek should be opened from the western end to minimize any damage to the existing stream channels.

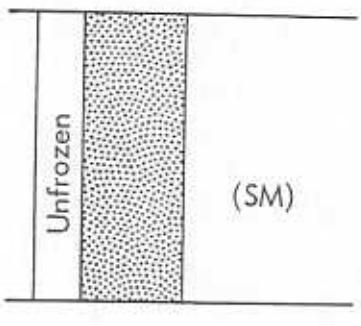
- Dozers, overhead loaders and light ripping equipment should be adequate for the removal of material from this site.

ABANDONMENT AND REHABILITATION

Operating procedures should be maintained whereby waste materials do not drain eastwards into existing water courses. Abandonment procedures should include recontouring of the pit area by utilizing the stockpiled stripping and waste materials. Rehabilitation might include reseeding although existing cutlines in the area indicate that the understory growth and eventually spruce will be naturally reestablished.

DETAILED TEST PIT LOG

NW 12/TP 1



Sand; some silt, fine to medium grained, light grey with occasional pebbles to $\frac{1}{4}$ inch. Unfrozen to depths tested.

DETAILED DRILL HOLE LOG

SITE NO. NW 12 HOLE NO. C 985

DATE: MAR. 15, 1973 | LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		O	0.3 MOSS:		Vx	H		0
2		CI	CLAY: silty, sandy, rustic color, organic silt inclusions		Vx	H		2
			3.0			M		
4		GM	GRAVEL: sandy, silty, grey, shale and clay (till) inclusions		Nbn			4
6					Nf			6
8								8
10								10
12								12
14								14
			15.0					
16			END OF HOLE 15.0'					16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 12 HOLE NO. 987

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

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0								0
2		SM	SAND: silty, non plastic, brown		Nbn			2
4					Nf			4
6								6
8								8
10			- coarser					10
12			= siltier and finer					12
14								14
16								16
18			- coarser					18
20			20.0 END OF HOLE 20.0'		Nbn			20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 12 HOLE NO. 989

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

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		SM	SAND: silty, non plastic, brown, coarse		Nf			0
1								1
2								2
3								3
4								4
5								5
6			- boulders					6
7								7
8								8
9								9
10			10.0 END OF HOLE 10.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 12 HOLE NO. 990

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

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		ML	0.3 SILT: sandy clay, organic		Nbn			0
2		SM	SAND: silty, brown, coarse grained		Nf			2
			3.0					
4		GP	GRAVEL: clean					4
6								6
8			- siltstone inclusions					8
10			- siltier					10
12		GM	- very silty					12
14								14
16					Nbn			16
			- shale inclusions					
18			18.0					18
		CH	CLAY (TILL): grey, high plastic, silty, few pebbles and siltstone inclusions					
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 12 HOLE NO. 991

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

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		O	MOSS		Vx	H		0
0.3								
1		SM	SAND: clean, occasional pebble, shalestone inclusions, brown		Nf			1
2								2
3								3
4								4
5								5
6								6
7								7
8								8
9								9
			- sloughing					
10			10.0 END OF HOLE 10.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

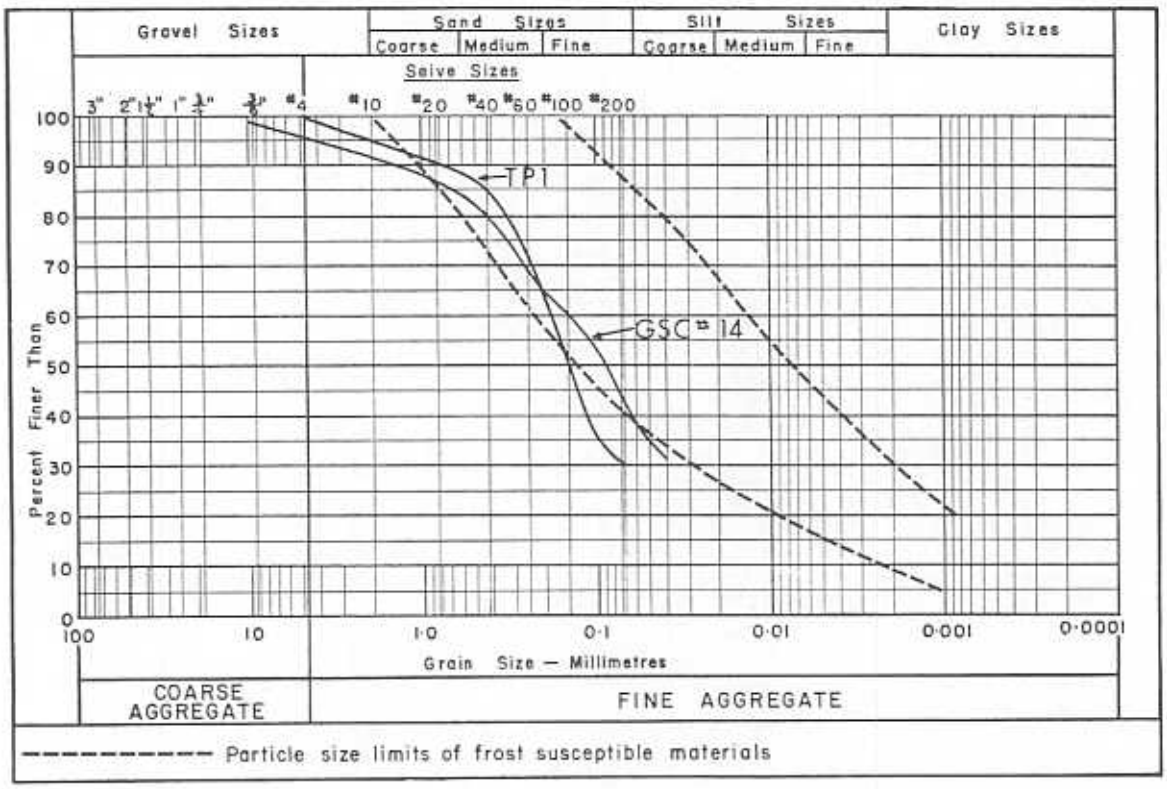
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 12/TP 1	GSC #14
Sample Depth (Feet):	2.0	-
Moisture Content (%):	5.9	6.8
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:

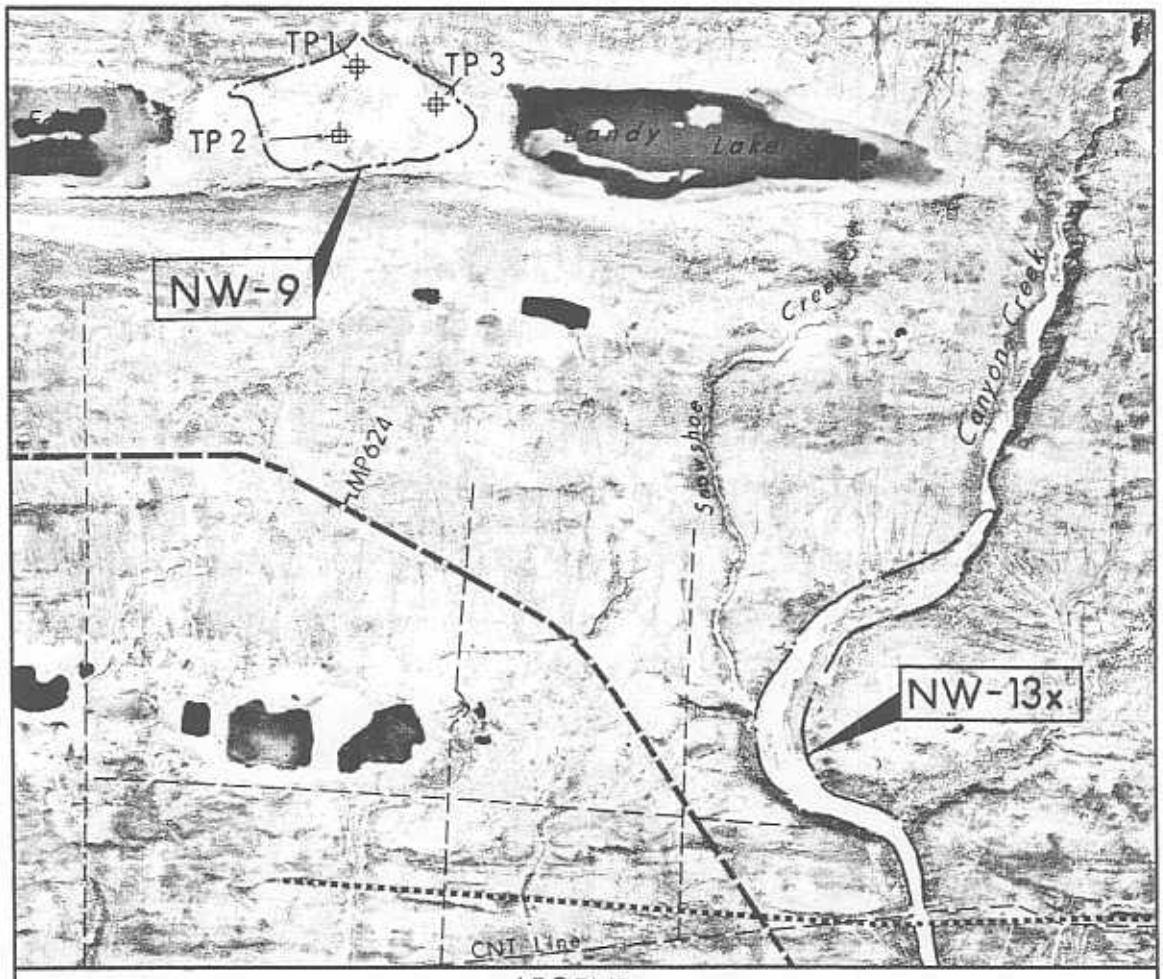


PETROGRAPHIC ANALYSIS:

SITE NO. NW 13X

Located approximately 10 miles east of Norman Wells, within the active stream regime of Canyon Creek, Site NW 13X is approximately 2 miles in length and averages 300 feet in width.

Type of Material:	Sand and Gravel; little silt, stratified.
Estimated Volume:	500,000 cubic yards
Assessment:	This site is not recommended for development because it is located within the regime of an active water course.



LEGEND

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

Airphoto No. A22934/98

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 13X is located approximately 10 miles east of Norman Wells within the active stream channel of Canyon Creek. The deposits of granular material are of alluvial origin and are concentrated in exposed gravel bars and terraces within the braided stream channel. The site encompasses an area approximately 2 miles in length by 200 to 400 feet in width and is, generally, considered to be below the high water level of Canyon Creek. The recoverable depth of material is approximately 5 feet in depth.

The gravel bars and terraces are covered with a very thin veneer of organic silt supporting very sparse growths of small bushes. Stratified silty sands and gravels were encountered in the stream bed deposits.

Most areas adjacent to the channel of Canyon Creek support spruce that attain in some cases, trunk diameters of 10 to 14 inches. Wet and poorly drained sites are characterized by tamarack.

The downstream portion of Canyon Creek lies within the waterfowl staging and migration route as shown on Figure 2.

The drainage area of Canyon Creek is approximately 30 miles. Along its length of 12 miles, it is estimated that approximately 20,000 cubic yards of gravel are potentially suitable for spawning. The use of Canyon Creek by fishery resources is primarily seasonal as it usually becomes very shallow by early to mid summer.

Access to this site can be achieved from the existing winter road which traverses Canyon Creek at the southern extremities of this source. Since the material cannot be extracted during the winter season when the site is accessible, the development of this source may be delayed until an all weather road (or a highway) is built. Then a short access road can be constructed on either side of the creek.

DEVELOPMENT

Site NW 13X is not recommended for development since the granular material is located within the stream channel of an active water course.

However, if in the future, local demands for granular materials dictates the development of this source for gravels; then specific guidelines must be formulated to minimize any environmental damage to the area. The following considerations should be reviewed and assessed prior to any removal of granular material from this site.

- Excavation of materials should be restricted to areas which are as far as possible removed from the currently active water channels.

- Operating periods should be restricted to the low water period of the water course to minimize downstream siltation.

- Berms, dykes, undisturbed buffer zones and settling ponds should be utilized to isolate the pit excavation operations from the flowing water channels.

- Waste materials from the pit should be stockpiled as far removed as possible from the flowing water channels.

- The borrow area, such as gravel bars, selected for the extraction of materials should be abandoned if invaded by water due to the stream shifting.

ABANDONMENT AND REHABILITATION

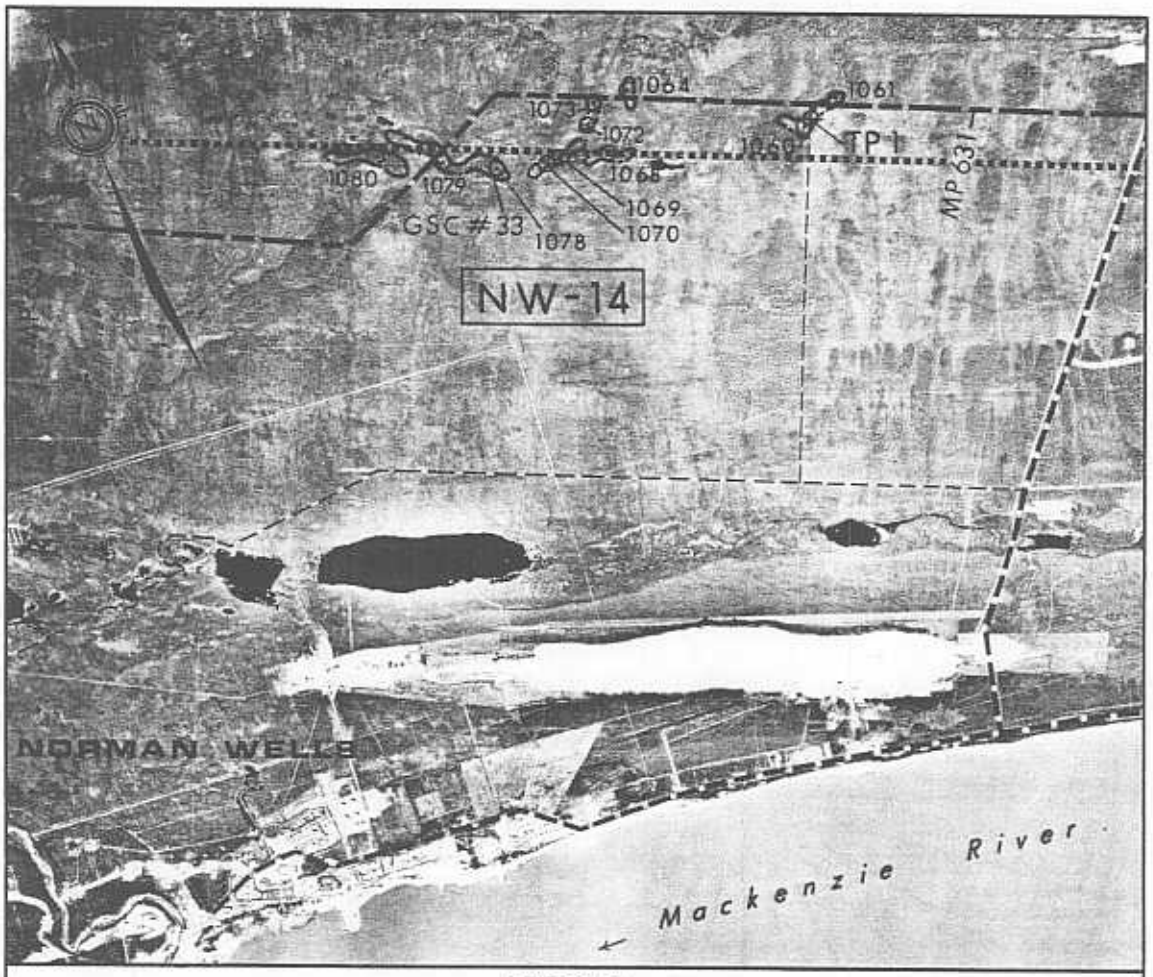
Future development of this site should be preceded with the formulation of guidelines for abandonment and rehabilitation related to the physical and biotic framework of this site. Such guidelines should include:

- Development of guidelines that incorporate procedures for revegetation and recontouring of abandoned sites.

SITE NO. NW 14

Located approximately 2 miles northeast of Norman Wells, Site NW 14 is a series of small discontinuous esker ridges.

Type of Material:	Sand; some silt, fine to medium grained.
Estimated Volume:	1,500,000 cubic yards
Assessment:	Good quality granular material for general fill; not recommended for immediate development because of requirements for extensive new access and intersite access.



LEGEND

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

Airphoto No. A22934/138

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 14 is located approximately 2 miles northeast of Norman Wells. A series of discontinuous and sinuous esker ridges, 200 to 1000 feet in length and 20 to 40 feet in height comprises the granular material source. The adjacent terrain, a glaciofluvial plain, is relatively flat. The organic peat cover on the adjacent terrain is shallow and supports a relatively dense growth of small bushes, black spruce and some birch on the better drained portions of the site.

The esker ridges consist primarily of fine to medium grained sands with some silt and occasional cobbles and boulders. A thin veneer of organic topsoil, approximately 3 to 6 inches in depth supporting sparse tree growth covers the esker ridges.

Away from the esker ridges the terrain is predominately muskeg and is characterized by growths of willow, spruce and tamarack. The aesthetic value of the site area would be considerably altered because of the large areas of clearing that would be required if the sites were to be extensively developed.

There are no known critical wildlife areas within the vicinity of the site. The proximity of the site to both the Norman Wells community and the airport likely negates any severe implications to the wildlife of the area as they have either become necessarily adjusted to the human encroachment or have moved further away from the development.

An existing seismic cutline, approximately 2 miles in length, connects the eastern portion of the site to the all weather Kee Escarpment quarry access road. However, in view of the scattered nature of the various esker ridges, a considerable amount of inter-site access roads would have to be developed in order to exploit the granular material deposits.

If the proposed highway is constructed as noted on the accompanying site airphoto, then this site would become very accessible for the local needs of the community.

DEVELOPMENT

Site NW 14 is not recommended for immediate development and exploitation for the following reasons:

- The granular material from this site is, generally, only suitable for fill material in the pit run condition. Therefore, the material quality is of relatively low priority.

- A large surface area of terrain will have to be cleared to develop a comparatively small volume of material.

- A comparatively extensive amount of new access roads for access to the various esker ridges and, inter-deposit access will have to be developed over marginally soft and wet terrain.

- Other sites with better quality material and better access are available for development in the Norman Wells community area.

The detailed findings of the winter drilling program which was conducted on Site NW 14 by the engineering consultant for The Federal Department of Public Works has been assessed and incorporated into this report. The following conditions relative to the quality and quantity of available granular materials are outlined.

- Fair quality granular materials consisting primarily of stratified sands with gravel pockets of varied gradation were encountered in these esker ridge segments. These sands and gravels are suitable for good quality embankment fill material in the construction of road grades.

- Overburden material consisting of topsoil and organic silts overlie the granular material deposits and vary in depth from 1 to 3 feet.

- The depth of the in situ sand and gravel deposits vary from a few feet to in excess of 15 feet.

- An estimated volume in the order of 1,500,000 cubic yards is considered available from the various esker ridge segments.

- The adjacent terrain consists of lacustrine silts and sands of shallow depth underlain by a glacial till sheet.

However, if this site is developed at a future date to supply the fill requirements of a local utility such as the proposed highway or gas pipeline, the following guidelines for borrow pit development should be maintained:

- The existing tree growth and related vegetation should be cleared and removed in accordance with the land use guidelines that are in effect at that time.

- The thin veneer of organic topsoil and peat should be stripped and stockpiled for future restoration of borrow pit areas.

- The in situ granular material can be removed with conventional excavation equipment such as dozers, overhead loaders and light ripping equipment.

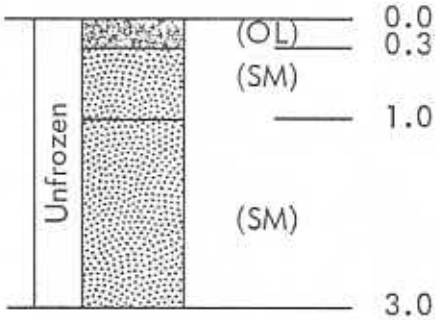
- In view of the relatively soft and wet terrain the borrow pit excavation operations may have to be restricted to a winter operation unless the access roads are developed to an all weather status.

ABANDONMENT AND REHABILITATION

Abandonment procedures should include recontouring of the pit areas to prevent ponding of water in the pit areas after removal of the granular material. The stockpiled surficial waste material should be replaced on the abandoned pit areas. Rehabilitation might include some reseeding although existing cutlines in the area indicate that the understory growth and eventually tree growth will be naturally reestablished.

DETAILED TEST PIT LOG

NW 14/TP 1



Topsoil; organic, some silt, trace of gravel.

Sand; some silt, trace of gravel and cobbles, light brown, rootlets.

Sand; some silt with powdery silt pockets and lenses, trace of gravel to 2 inch maximum size. Few limestone fragments.

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1060

DATE: MAR. 17, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL SM	SAND: very organic, silty, rootlets, brown		Nf			0
2		CL	2.0 CLAY (TILL): silty, sandy, low plastic, brown					2
4		GM	4.0 GRAVEL: sandy, silty, non-plastic, brown					4
6								6
8		SP	8.0 SAND: clean, fine, sharp, rootlets		Vc	L		8
10								10
12			12.0 END OF HOLE 12.0'					12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1061

DATE: MAR. 17, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, sandy, low plastic, brown		Nf			0
2			2.0					2
		GP	GRAVEL (TILL): silty, angular fract., odd shale incl.					
4			- lacking fines - clay (till) inclusions					4
6								6
8			- siltstone incl.					8
10								10
12			12.0					12
14		SW	SAND (TILL): gravelly, clean, siltstone chunks					14
16			16.0					16
18		GM	GRAVEL (TILL): sandy, clean, siltstone chunks					18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

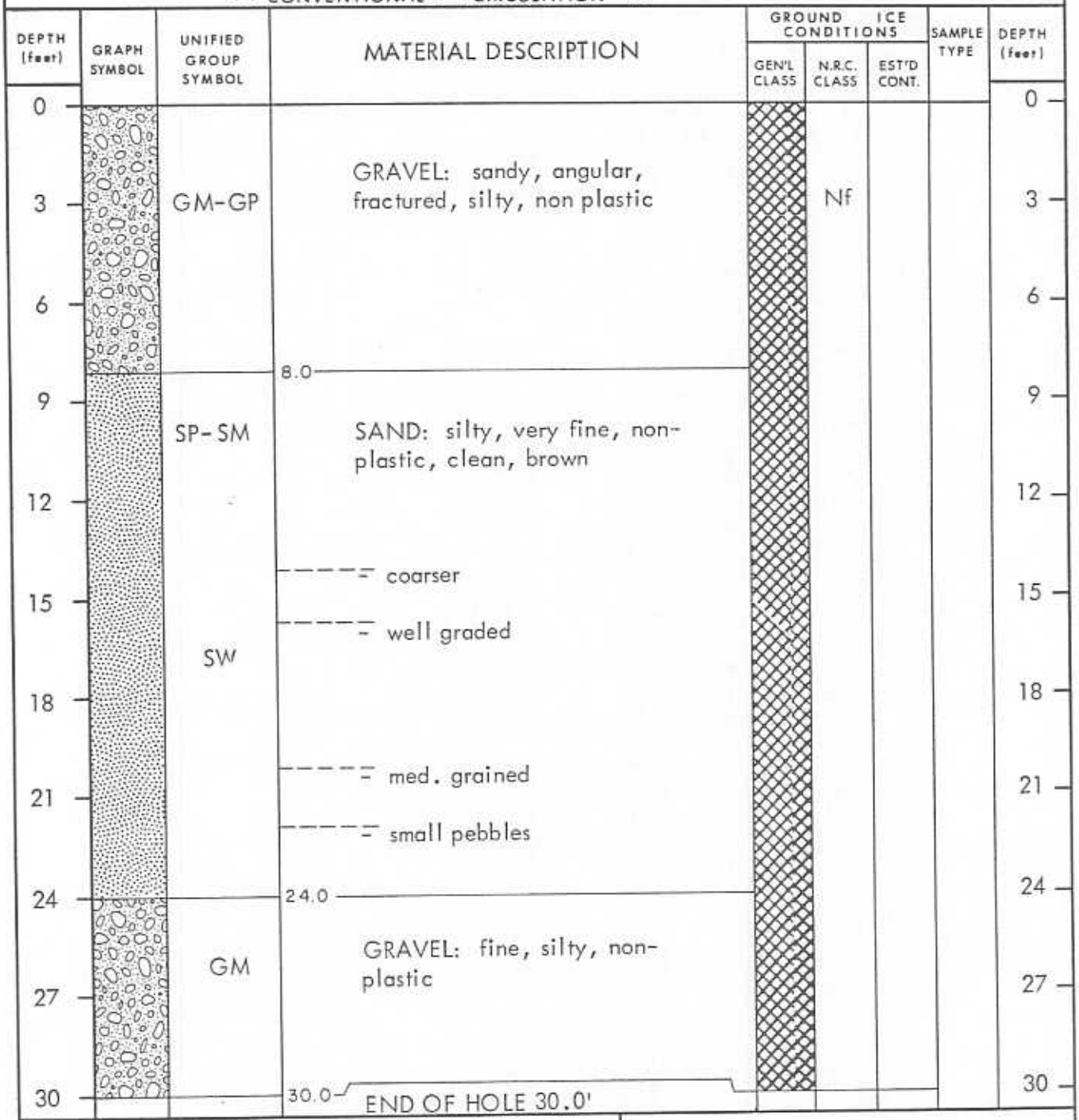
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1064

DATE: MAR. 18, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1068

DATE: MAR. 17, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	0.3 MOSS:		V	M		0
2		SM	SAND: silty, medium grained, non plastic, odd pebble, reddish brown		Vr	L		2
4			- - - - - - coarser					4
6			6.0					6
8		CL-CI	CLAY (TILL): silty, sandy, pebbles, occasional stone, low-medium plastic, brown		Nbn			8
10								10
12								12
14								14
			15.0 END OF HOLE 15.0'					
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1069

DATE: MAR. 18, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0								0
1		OL	SILT: organic, clayey, sandy, low plastic, brown		Nbn			1
2			2.0					2
3		ML	SILT: sandy, clayey, low plastic, brown					3
4			4.0					4
5		MH	SILT (TILL): clayey, sandy, pebbles, medium plastic, brown					5
6								6
7								7
8			8.0					8
9		GM	GRAVEL: fine sandy, clean, occasional shale inclusions		Nf			9
10			10.0 END OF HOLE 10.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1070

DATE: MAR. 18, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, clayey, low plastic, brown		Vr	M		0
2			2.0					2
		CI	CLAY (TILL): silty, sandy medium plastic, pebbles, brown		Vr	M		
4								4
					Vs	M		
6			- sandy					6
8			- grey					8
					Nbn			
10								10
12		CL-CI	- low-medium plastic		Vr	M		12
14								14
16			16.0					16
		GM	GRAVEL (TILL): clayey, sandy, low-medium plastic, grey		Nf			
18			- very sandy					18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1072

DATE: MAR. 18, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0		Pt	0.3 MOSS		Vx	M		0
		OL	SILT: organic, clayey, medium plastic		Nbn			
2			2.0					2
		ML	SILT (TILL): clayey, sandy, stones, medium plastic, brown					
4			- sandier					4
6			6.0					6
		SM	SAND: silty, coarse grained, shale inclusions, non plastic, brown					
8								8
10								10
12								12
14			14.0					14
		GW	GRAVEL: fairly clean					
16								16
18								18
		GM	- sandier, silty					
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1073

DATE: MAR. 17, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	ORGANIC SILT: low plastic		Nbn			0
2			2.0					2
4		CL	CLAY (TILL): silty, sandy low plastic, brown, occasional pebbles		Vr	M		4
6			- sandier					6
8			- grey					8
10			- dark brown		Nbn			10
12			- grey					12
14			- low plastic, grey-brown					14
16			- siltstone inclusions					16
18								18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1078

DATE: MAR. 19, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0								0
1		OL	SILT: organic, clayey, sandy, low plastic		Nbn			1
2			2.0					2
3		CI	CLAY (TILL): silty, sandy stones, cobbles, medium plastic, brown					3
4								4
5								5
6			6.0					6
7		GW	GRAVEL: well graded, silty		Nf			7
8			8.0					8
9		SW	SAND: well graded, fairly clean					9
10			10.0 END OF HOLE 10.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1079

DATE: MAR. 19, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL-CI	ORGANIC SILT-CLAY: sandy, med. plastic, brown, rootlets		Nbn			0
2			2.0					2
4		CI	CLAY (TILL): silty, sandy, medium plastic, brown, occasional stone					4
6								6
8			8.0					8
10		SM	SAND: clayey inclusions, fine grained, angular, round, becomes coarser		Nf			10
12								12
14		SW	- well graded, clean					14
16			16.0 END OF HOLE 16.0'					16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 14 HOLE NO. 1080

DATE: MAR. 19, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0								0
2		SP	SAND: coarse grained, fairly clean		Nf			2
4								4
6			- finer					6
8								8
10			- medium to coarse grained, slightly silty		Nbn			10
12		SM-SW	- coarse grained, fine gravelly silty, trace of clay		Nf			12
14								14
16								16
18		SC	- coarse, silty gravelly, non to low plastic, trace of clay					18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

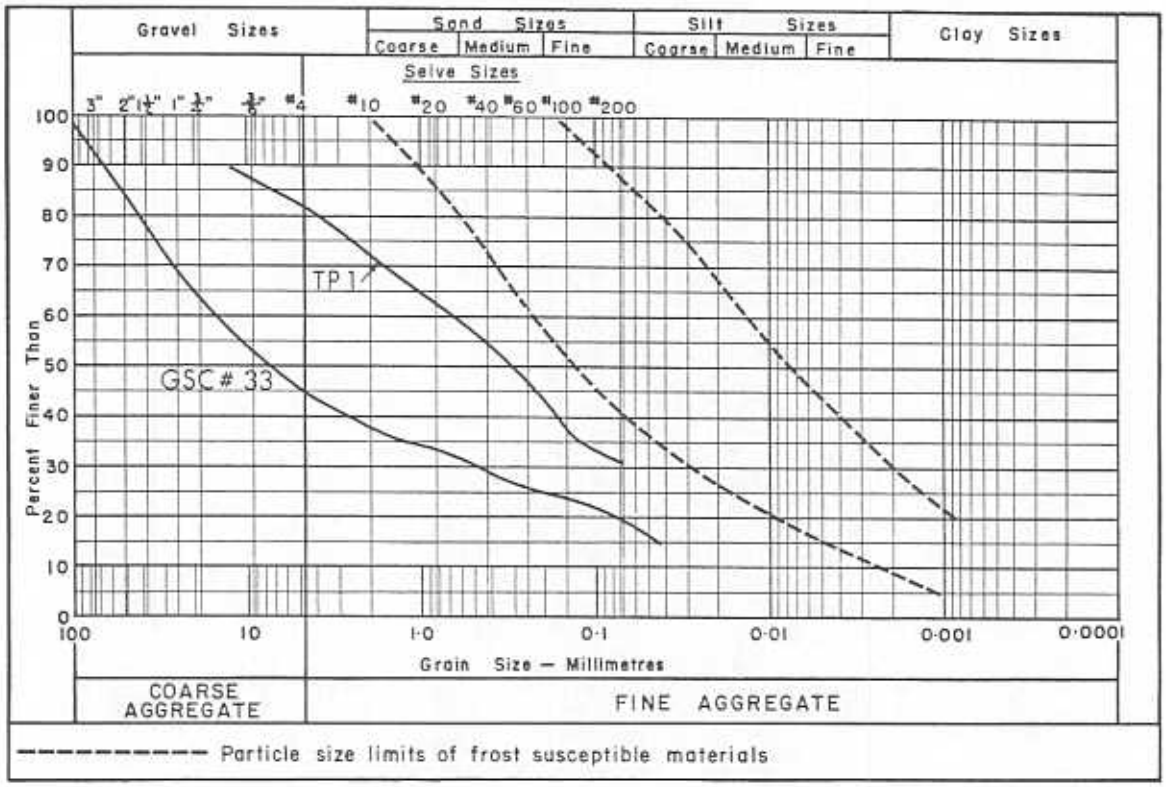
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 14/TP 1	GSC #33
Sample Depth (Feet):	1.0 - 3.0	-
Moisture Content (%):	-	7.4
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SITE NO. NW 15

Located 4 miles north of Norman Wells in the vicinity of Bosworth Creek, Site NW 15 is a series of ice contact ridges and knolls.

Type of Material: GRAVEL; some sand and silt, fine grained

Estimated Volume: 1,000,000 cubic yards

Assessment: Good quality material for general fill. Immediate development of site is not practical at this time because of requirements for extensive access roads and stream crossings at Bosworth Creek.

LEGEND

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

Airphoto No. A22934/136

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 15 is located approximately 4 miles north of Norman Wells, and consists of a series of eskers, kames and other ice contact deposits. These deposits encompass an area approximately $1\frac{1}{2}$ miles by $\frac{1}{2}$ mile in the immediate vicinity of Bosworth Creek. The adjacent terrain slopes gently to the southwest and the general drainage is to the Mackenzie River.

The material in the ice contact deposits is highly variable and ranges from inorganic silts with some clay to medium grained, well graded gravels with some sand. These varying granular material deposits are, generally, intermixed and moderately scattered throughout the entire site area, although the more well defined esker-like and kame-like features appear to contain pockets or layers of better quality granular materials. A thin veneer of silty organic topsoil supporting growths of moss, small shrubs, spruce and birch covers the site area. The adjacent terrain is relatively flat and poorly drained and consists of numerous wet, boggy muskeg areas.

A small waterfall on Bosworth Creek occurs within the eastern portion of the site area. This waterfall, considered as a recreation and aesthetic tourist attraction, is accessible from Norman Wells by means of a hiking trail that traverses the east bank of Bosworth Creek.

Access to Site NW 15 from Norman Wells is currently restricted to the utilization of the winter road, the hiking trail along the east bank of Bosworth Creek and existing seismic cutlines on the west side of Bosworth Creek. Furthermore, any development of granular materials from the west side of Bosworth Creek will require a major stream crossing. The terrain conditions, approximately one mile south of the site area within a lacustrine surficial deposit, are quite sensitive to thermal changes and any disturbance of the existing organic cover may result in subsidence and gullying. This area exhibits a high incidence of thermokarst features and may present a significant obstacle for the routing and construction of inexpensive access roads. The existing stream crossing at the Mackenzie River bank cannot be used because of refinery utilities, such as wellheads and pipelines.

The proposed Mackenzie Highway and gas pipeline routes traverse the entire site area. The highway will provide excellent access from Site NW 15 to the community of Norman Wells.

DEVELOPMENT

The detailed findings of the winter drilling program has confirmed the availability of exploitable granular materials at Site NW 15. On the basis of the drill hole data, the following comments relative to material types are outlined as follows:

- The material represented by these ice contact features are extremely variable ranging from inorganic silts with some clay to relatively well graded gravels.

- The potentially exploitable granular materials of reasonable quality are scattered throughout these ice contact features as pockets and layers.

- The material type within an individual ice contact feature is variable in quality, mode and depth of deposition and recoverable quantities.

- In general, the better quality granular materials appear to be located within the ice contact features which immediately flank the east and west banks of the Bosworth Creek channel.

- The depth of overburden overlying the granular material deposits varies in depth from a few feet to in excess of several feet.

- The better quality granular materials, consisting of medium grained, well graded gravels with some sand were noted at drill hole locations DH 5, DH 5A, DH 6, DH 7 and DH 10. (Ref. Airphoto Site Description - Page 15-1)

Site NW 15 is considered to be a relatively important source for granular materials as an alternate to the proposed quarry operation at Site NW 4, particularly, when the access to the site area becomes more viable if the Mackenzie Highway is constructed on its proposed route. At this time, however, the exploitation and development of Site NW 15 is considered difficult and possibly uneconomical for the following reasons:

- Access to the site area from the Norman Wells community is available only by utilizing the winter road, the hiking trail along the east bank of Bosworth Creek and existing seismic lines on the west side of Bosworth Creek. Therefore, access to the site would be restricted to the winter months.

- The required access roads from the winter road to the site area, on both the east and west sides of Bosworth Creek, traverses a terrain consisting of lacustrine material which is very sensitive to thermal changes. Therefore, any major disturbance of the organic surface cover in this area may result in severe erosional damage to the existing terrain. It should also be noted that occasional muskeg bog areas were observed to be unfrozen during the winter drilling program in January, 1973.

- A major stream crossing is required to provide access for the removal of granular materials from the west side of Bosworth Creek. The water from Bosworth Creek is currently utilized as a water supply for the community of Norman Wells.

- The scattered nature of the potentially exploitable granular materials in the ice contact features may entail a comparatively large degree of surficial area being cleared and stripped in order to recover a relatively small quantity of material.

However, if this site is developed to supply the requirements for the construction of a local utility (such as the proposed Mackenzie Highway), or if it is reserved for future

use (when short access roads from the highway can be established), the following development guidelines should be followed:

- In view of the highly variable quality and scattered nature of the available granular materials, Site NW 15 should be considered essentially for pit run aggregates to be utilized in building pads, road and airstrip sub-base construction. However, if careful and selective excavating procedures are utilized during the development of borrow pits, then the pockets or layers of high quality gravels could be exploited for use in production of base course and surface course aggregates.

- The development of borrow pits for Site NW 15 should be initiated with the ice contact features represented by drill holes DH 5, DH 5A, DH 6, DH 7 and DH 10 which have proven depths of fair quality gravels at their specific locations.

- The individual ice contact features should be further investigated by probing at closer intervals with shallow test pits or drill holes to more specifically delineate and assess the quantity of available granular materials.

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

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

- Relative to granular deposits immediately adjacent to the east and west sides of Bosworth Creek, the development procedures should be commenced at the source area farthest removed from the water course. A buffer zone of adequate width and breadth should be maintained between the stream and the final limits of the borrow pit.

- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain to the active Bosworth Creek stream channel.

- Adequate buffer zones should be retained around the site of the waterfall and along the hiking trail that provides access to this feature.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

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

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

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

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-1

DATE: DEC. 7, 1972 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								0
		OL	SILT: some clay, organic		Vx	L		
0.3								
		ML-MH	SILT: some clay, few pebbles, boulders & cobbles					
1.5								
2								2
		SM	SAND & SILT: non plastic, fine grained, light brown		Vx	L		
4								4
							M.C.	
5.5								
6			SAND & GRAVEL: little silt, predominantly medium grained, well graded, light brown					6
		SW-GW						
8							M.C. G.S. P.	8
10								10
10.0								
		SW-SM	SAND: some silt, medium grained, few pebbles to ½"		Vx-Vr	M-H	M.C. G.S.	
12								12
13.5								
14			TOTAL DEPTH 13.5'					14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-2

DATE: DEC. 7, 1972 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								0
2		MH	SILT: some clay, little sand, few pebbles & cobbles		VxVr	L-M		2
3.5								
4		SW-GS	SAND & GRAVEL: little silt, sub-angular pebbles to 1½", brown		VxVr	L	MC GS	4
6.0								
6		ML	SILT: some sand, little clay, greyish brown, few pebbles		VxVr	L-M		6
7.5			TOTAL DEPTH 7.5'					
8			Note: This drill hole area had been stripped prior to investigation					8

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-3

DATE: DEC. 7, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt.	PEAT: fibrous, dark brown		VxVr	M		0
0.8								
2		ML-MH	SILT: some clay, light brown					2
4		ML	- thin lenses of stratified sand at 3.5' to 6'		Vs	M-H		4
6								6
6.0								
8		CI-CL	SAND, SILT, CLAY: few pebbles to 3/8", light brown (TILL-LIKE)					8
8.0			TOTAL DEPTH 8.0'					
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-4

DATE: DEC. 7, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: fibrous, dark brown		Vx	L		0
0.5								
2		ML-MH	SILT: some clay, medium brown		Vs	M-H		2
4								4
4.5								
6		ML	SILT: some clay, little sand (medium to fine grained), medium to light brown		Vs	M-H		6
8								8
8.0			TOTAL DEPTH 8.0'					
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-5

DATE: DEC. 8, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: fibrous, dark brown		V	L		0
0.4								
		ML-MH	SILT: some clay, stratified, medium brown		Vs	L-M		
2								2
2.0								
		GP-GW	GRAVEL: some sand, trace silt, medium grained, poor to well graded, rounded to sub-angular particles, sound					
4								4
6							MC GS	6
8								8
8.0								
		ML	SILT: trace of sand, non to low plastic, blue-grey		V	L		
10								10
12								12
13.0			TOTAL DEPTH 13.0'					
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-5A

DATE: DEC. 7, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0								0
2		ML-MH	SILT: some clay, medium plastic, stratified, light brown		Vs	M		2
3.5								
4		GP-GM	GRAVEL: some sand, little silt, poorly graded, rounded to sub-angular	UF				4
5.5			TOTAL DEPTH 5.5'					
6			Note: Site area had been stripped prior to drilling and ½' to 1' of organic topsoil had been removed					6

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-6

DATE: DEC. 8, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: some clay, organic, roots		Vx	L		0
0.5								
2		GP	GRAVEL: little sand, trace of silt, rounded to sub angular particles, poorly graded, brown				MC GS P	2
4			- becoming more silty, gap graded with little or no sand, frequent fragments of flakey shale					4
6		GM					MC GS	6
8								8
9.5								
10		ML	SILT: some clay, medium plastic					10
10.5			TOTAL DEPTH 10.5'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-7

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: fibrous, muskeg					0
			1.0					
		ML	SILT: few pebbles, light brown		Vs	M-H		
			2.5					
4		GM	GRAVEL: some sand, trace of silt, rounded particles, predominantly limestone and quartzite pebbles		Vx	L	MC	4
8								8
			10.0					
12		GP-GW	GRAVEL and SAND: trace of silt, some large cobbles and boulders, rounded particles, predominantly limestone and quartzite		Vx	L		12
16							MC	16
			18.0					
20		SW	SAND: little silt, well graded, grey		Vx	L-M		20
24							MC	24
			26.0					
28			TOTAL DEPTH 26.0'					28

GOVERNMENT OF CANADA
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AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-8

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	PEAT: fibrous, muskeg		V	L		0
1.0								
2		ML	SILT: little sand, few pebbles, brown		Vs	M-H		2
4								4
4.5								
		SP	SAND: little silt, fine grained, brown			L	MC GS	
5.5								
6			SHALE: soft, blue-grey		Vs	L		6
8								8
8.0								
			SAND: some silt, fine grained, medium brown					
10		SM-SP						10
12								12
					Vs	L		
14							MC	14
16								16
16.0			TOTAL DEPTH 16.0'					
18								18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-9

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, organic		Vr	L		0
0.5			SILT: trace of sand, frequent pebbles to ½" size, medium brown					
2								2
4		ML			Vx	L-M	MC GS	4
6								6
8								8
8.0		GM	GRAVEL: some sand, little silt, well graded, rounded to sub-angular, medium brown		Nf		MC GS P	
10.0		ML	SILT: some sand, few pebbles to ½" size, medium brown					10
12			TOTAL DEPTH 12.0'					12
12.0								
14								14

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-10

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	TOPSOIL: little silt, organic, fibrous, roots		Vx	L		0
1.0								
2			GRAVEL: some sand, little silt, predominantly rounded to sub-angular limestone pebbles, few cobbles, medium brown					2
4							MC GS	4
6		GM			Vx	L		6
8			- layer of brown sand at 8'					8
10			- occasional clay pockets at 10' and deeper				MC	10
12					Nf	L		12
14			TOTAL DEPTH 14.0'					14
14.0								
16								16

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 15 HOLE NO. DH-11

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	TOPSOIL: little silt, organic, roots		Vr	L		0
1.0								
2		GM-GP	GRAVEL: little silt, trace sand, poorly graded, rounded to sub-angular, medium brown		Vx	L		2
3.5								
4		ML-MH	SILT: some sand, trace clay, few pebbles to 1" size, light to medium brown					4
6			- becoming sandier with depth and also lighter brown in color, fine to medium grained				MC	6
8					Vx	L		8
10		ML						10
11.0			TOTAL DEPTH 11.0'					
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

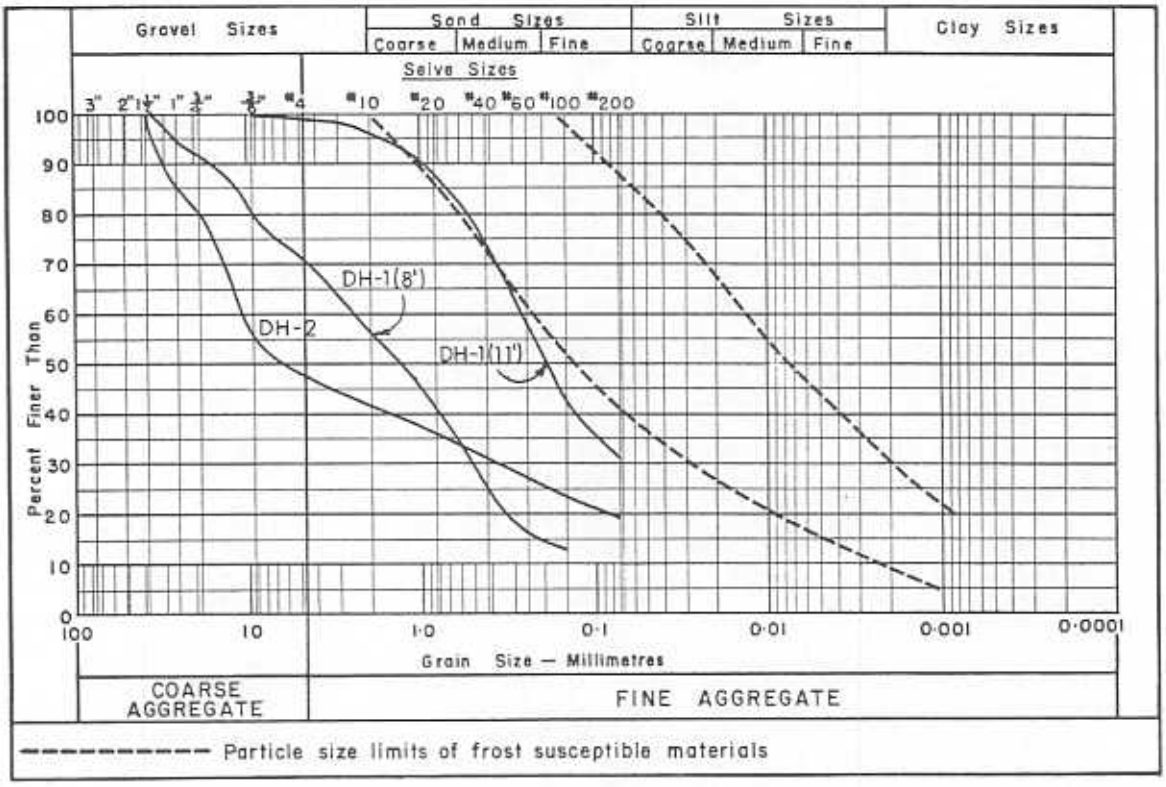
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 15/DH 1	NW 15/DH 1	NW 15/DH 2
Sample Depth (Feet):	8	11	4 - 5
Moisture Content (%):	7.3	20.1	8.6
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



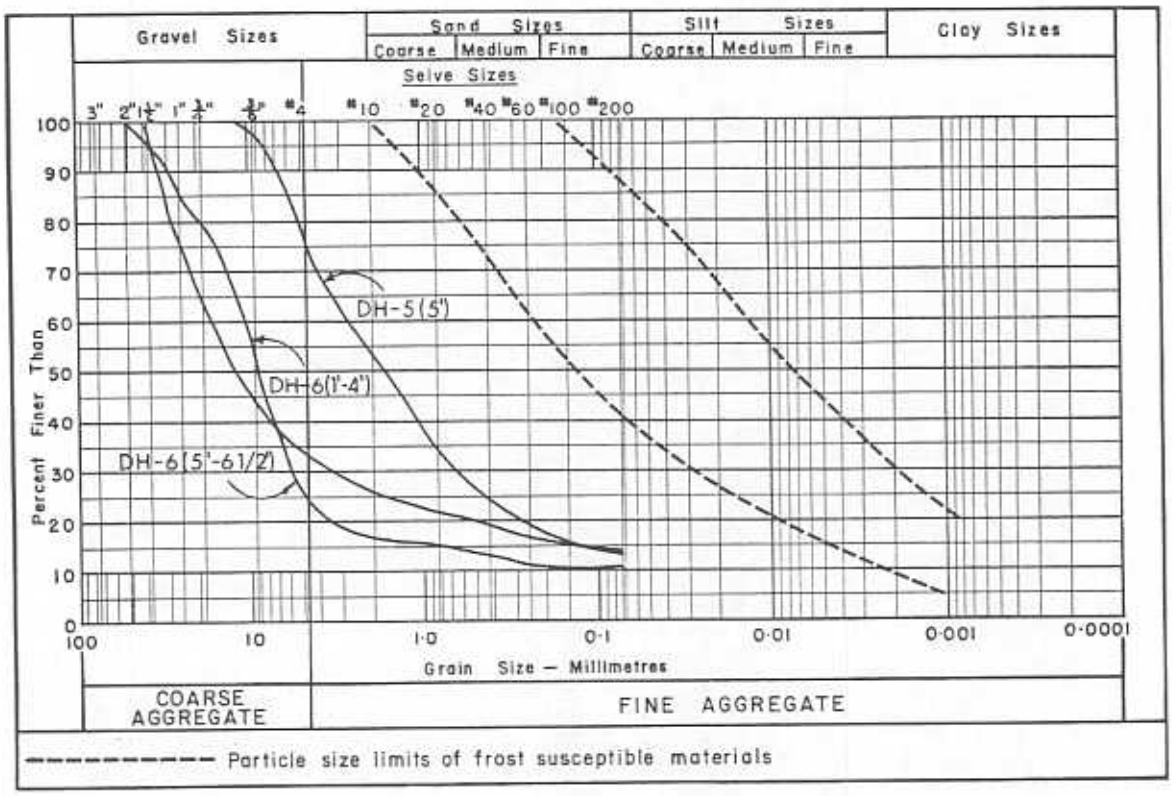
PETROGRAPHIC ANALYSIS: (NW 15/DH 1 @ 8')

Igneous rock	8.7%
Quartzite	26.8%
Limestone & dolomite	30.5%
Conglomerate (Quartzitic)	6.0%
Deleterious components:	
Siltstone, weathered, weak	13.6%
Sandstone, weathered	13.6%
Shale	trace

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 15/DH 5	NW 15/DH 6	NW 15/DH 6
Sample Depth (Feet):	5	1.4	5 - 6.5
Moisture Content (%):	10.7	8.3	6.2
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



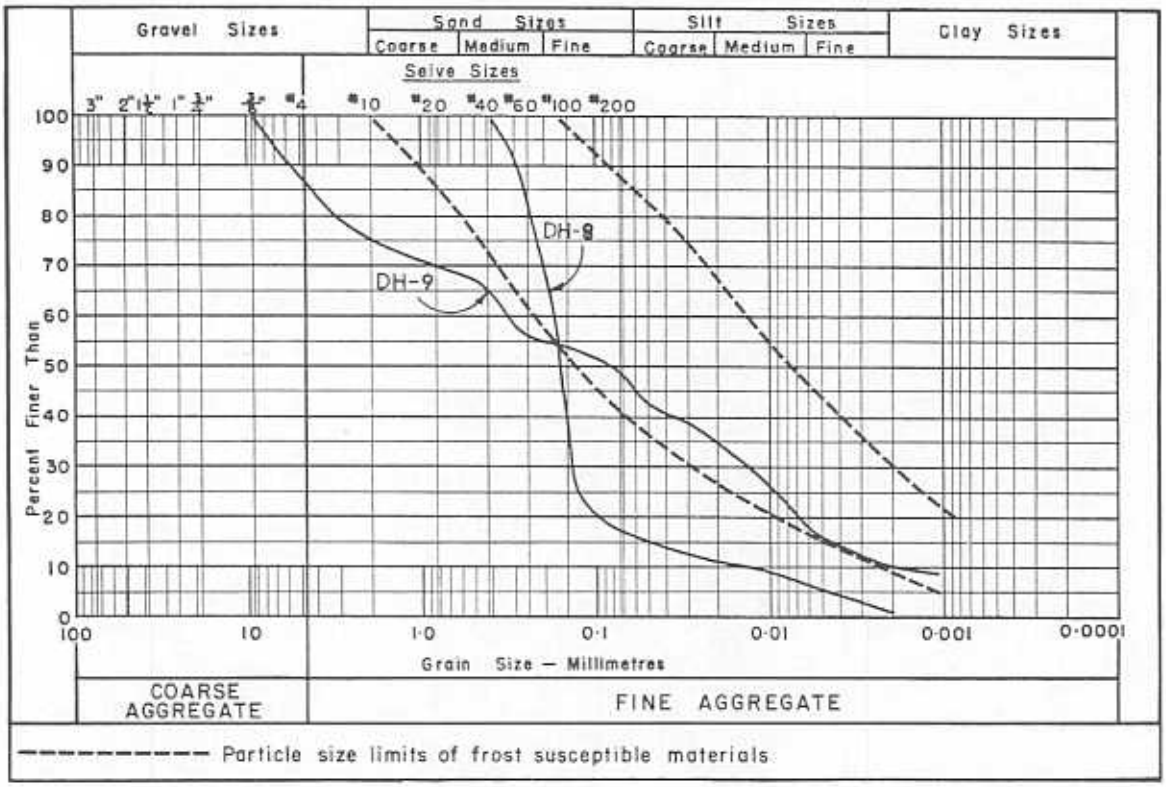
PETROGRAPHIC ANALYSIS: (NW 15/DH 6 @ 4')

Limestone & dolomite	58.7
Quartzites	22.8
Siltstone, sound	5.7
Cherts, dark	0.1
Igneous rock	3.9
Deleterious components:	
Sandstone & siltstone, ferrugeneous and calcareous	7.5
Limestone & dolomite, porous	1.1

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 15/DH 8	NW 15/DH 9
Sample Depth (Feet):	5	4
Moisture Content (%):	-	-
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



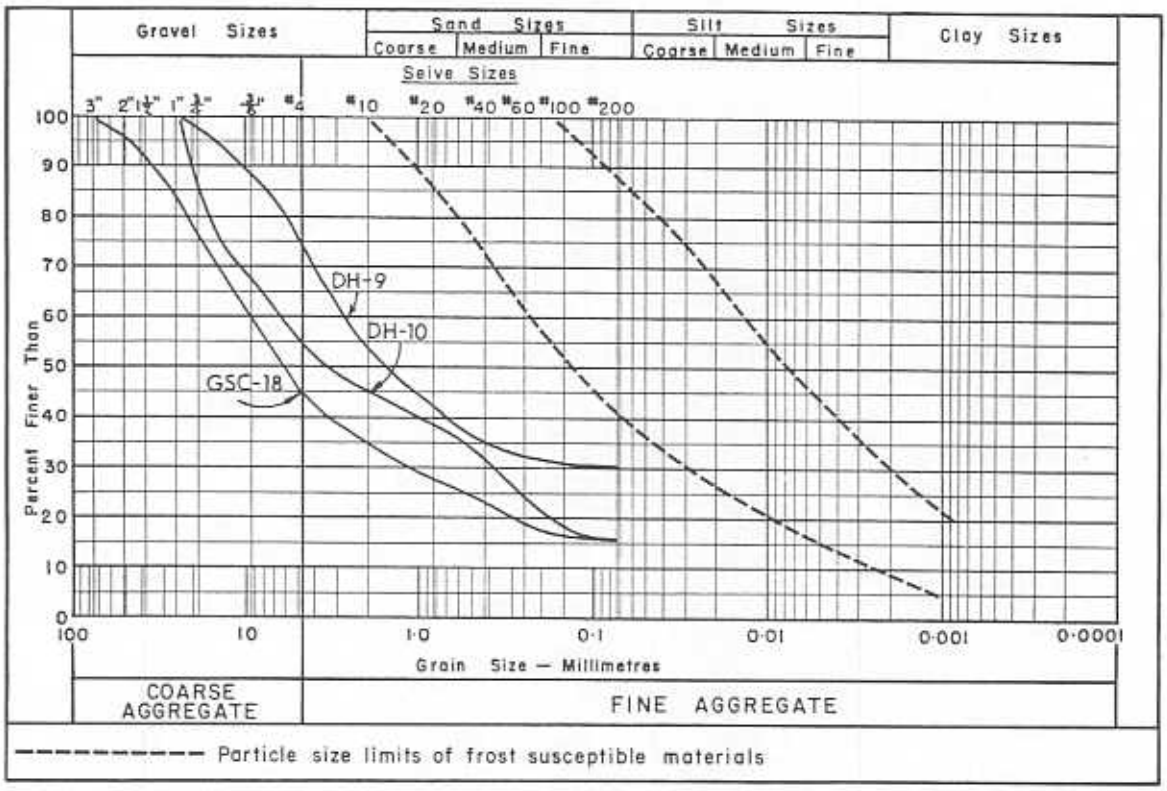
PETROGRAPHIC ANALYSIS: (NW 15/DH 9 @ 9')

Quartzites	31.3%
Limestone & dolomite	24.0%
Shale	16.3%
Cherts, dark	4.2%
Igneous rocks	4.9%
Deleterious components:	
Ferrugeneous siltstone and sandstone	15.5%
Calcareous siltstone and sandstone	3.7%

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 15/DH 9	NW 15/DH 10	GSC #18
Sample Depth (Feet):	9	4	-
Moisture Content (%):	-	-	8.9
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SITE NO. NW 16X

Located approximately 7 miles northwest of Norman Wells, Site NW 16X is a bedrock escarpment along the base of Discovery Ridge on the southern flank of the Norman Range.

Type of Material: Limestone; slightly weathered, sound.

Estimated Volume: Not established.

Assessment: This source is not recommended for development because similar limestone may be processed from granular material at Kee Escarpment (Site NW 4).

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. A 22934/135

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 16X is located approximately 7 miles northwest of Norman Wells at the base of Discovery Ridge on the southern flank of the Norman Range. The site is a large bedrock escarpment approximately $2\frac{1}{2}$ miles in length and $\frac{1}{4}$ mile in width. The top of the escarpment slopes gently to the southwest and eventually blends in with the adjacent flat terrain. The site is divided into two major sections by an erosion gully which has incised itself through the bedrock escarpment in the western half of the site. The general drainage is in a southwesterly direction toward the Mackenzie River.

The site area is covered with a shallow mantle of glacial till and supports a relatively dense stand of black spruce. The bedrock escarpment is of similar material as noted at Kee Escarpment (Ref. Site NW 4), consisting primarily of blocky, sound limestone which is slightly weathered and fractured at the surface. The bedrock is interspersed with siltstone and sandstone beds.

The site does not traverse any known critical or important wildlife or waterfowl areas.

As noted on the airphoto, access to the site is currently available by utilizing the existing seismic cutlines which traverse the site area at various locations.

DEVELOPMENT

This site is not recommended for development in view of the relatively inexhaustible sources of potential quarried material from Site NW 4 at Kee Escarpment. Any future development of Site NW 16X would entail a quarry operation.

The data from the drill holes carried out on Site NW 16X confirms the relatively shallow depth of overburden, which varies from $1\frac{1}{2}$ feet at DH 1 to slightly in excess of 9 feet at DH 3. Generally, it would appear that the overburden depth increases towards the western portion of the site area. The petrographic analysis of the limestone bedrock shows the limestone to be granulated and crystalline rather than fossiliferous. Siltstone encountered in DH 2 is thinly laminated, weak and may easily deteriorate when exposed to weathering processes. Higher quantities of siltstone would adversely affect the quality of quarried material.

DETAILED DRILL HOLE LOG

SITE NO. NW 16X HOLE NO. DH-1

DATE: JAN. 16, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		Pt	TOPSOIL: little silt, organic		Vr	L		0
0.5								
1		ML	SILT: some clay, trace of sand, light brown		Vx	L		1
1.5								
2			LIMESTONE: slightly weathered, sound, light brown		Nbn		P	2
3								3
3.5			TOTAL DEPTH 3.5'					
4								4

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

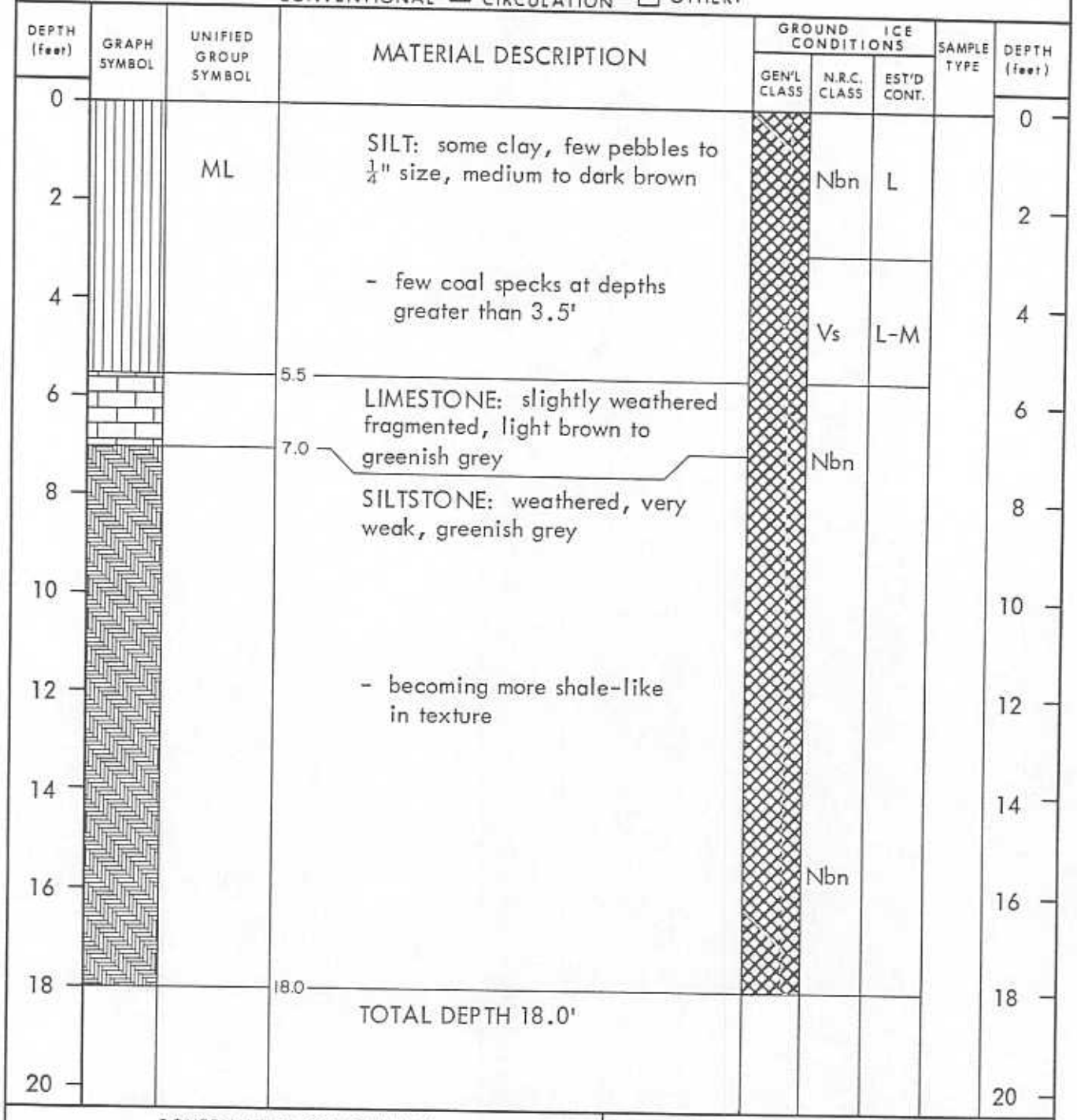
DETAILED DRILL HOLE LOG

SITE NO. NW 16X

HOLE NO. DH-2

DATE: JAN. 16, 1973 | LOGGED BY: ☒ PEMCAN ☐

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



GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 16X

HOLE NO. DH-3

DATE: JAN. 16, 1973 | LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0								0
2		ML-CL	SILT: some clay, few pebbles to 3/8" size, medium brown		Nbn	L		2
4								4
5.0								
6		CI	CLAY: some silt, few $\frac{1}{4}$" size pebbles, coal specks, medium brown		Nbn	L		6
8								8
9.0			TOTAL DEPTH 9.0'					
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

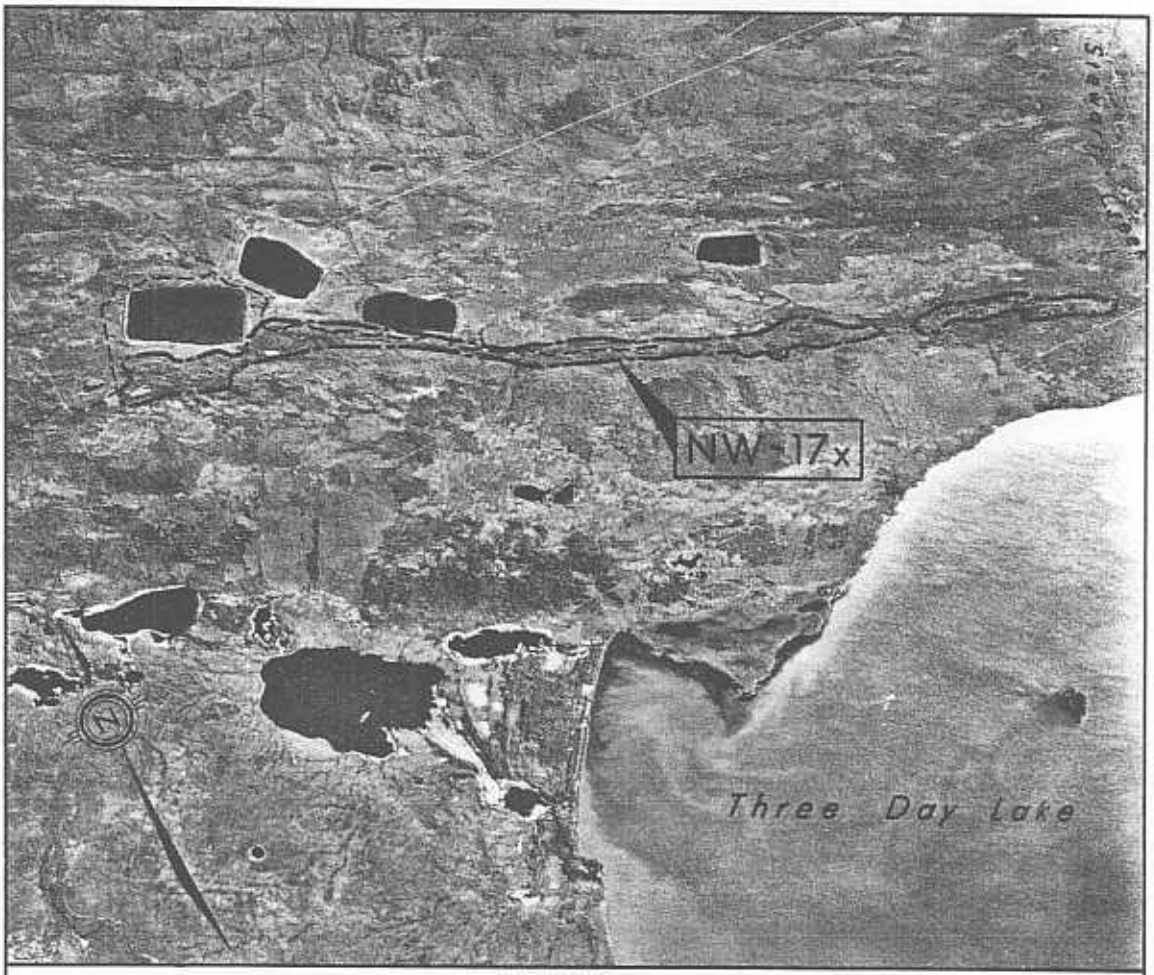
SITE NO. NW 17X

Located approximately 7 miles south of Norman Wells near Three Day Lake, Site NW 17X is a large longitudinally duned, sand-beach ridge. Access from Norman Wells along existing winter roads and cut lines is about 17 miles.

Type of Material: Sand; some silt, fine.

Estimated Volume: 3,000,000 cubic yards

Assessment: This site is not recommended for development because of its current remoteness to Norman Wells and difficult new access required across deeply incised creek channels. Also, similar quality material in large quantities is available at sites with better access.



LEGEND

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

Airphoto No. A22862/14

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 17 X is located on the glaciofluvial floodplain on the southern bank of the Mackenzie River between Loon Creek and Stewart Creek approximately 1 mile northwest of Three Day Lake. This site which is very remotely situated relative to the community of Norman Wells, involves a crossing of the Mackenzie River; a total access distance of 17 miles along existing winter roads and seismic cutlines is required between Norman Wells and the site.

The site consists of a relatively narrow duned sandy beach ridge, approximately $2\frac{1}{2}$ miles in length, and rises 10 to 30 feet above the flat, poorly drained adjacent terrain. The sandy beach ridge contains very fine, silty eolian sand similar to the material encountered at Sites NW 5, 6, 7 and 11.

The sandy beach ridge represents the best drained terrain in this area which has enhanced the growth of scattered birch trees. The organic topsoil layer on the slopes of the beach ridge is relatively shallow. The adjacent thermally sensitive and poorly drained terrain is generally muskeg and supports clustered growths of tamarack and black spruce.

Site NW 17 X is within the extensive waterfowl migration and staging area which parallels the Mackenzie River in this region (Figure 2). The area around Canol Lake and Three Day Lake is trapped for beaver, mink and lynx by the natives of Norman Wells. The river bank and islands in this area are hunted for moose in the fall. Stewart Creek is a migration route for fish between Three Day Lake and the Mackenzie River. A gill net fishing operation is located near the mouth of Stewart Creek on the Mackenzie River (Figure 2).

The existing access to Site NW 17 X consists of the winter road south from Norman Wells to the abandoned Canol airstrip and east along a poorer winter road to the site, which represents a total haul distance of 17 miles. The existing access involves the crossing of the Mackenzie River, a deeply incised Loon Creek valley and four additional minor gullies.

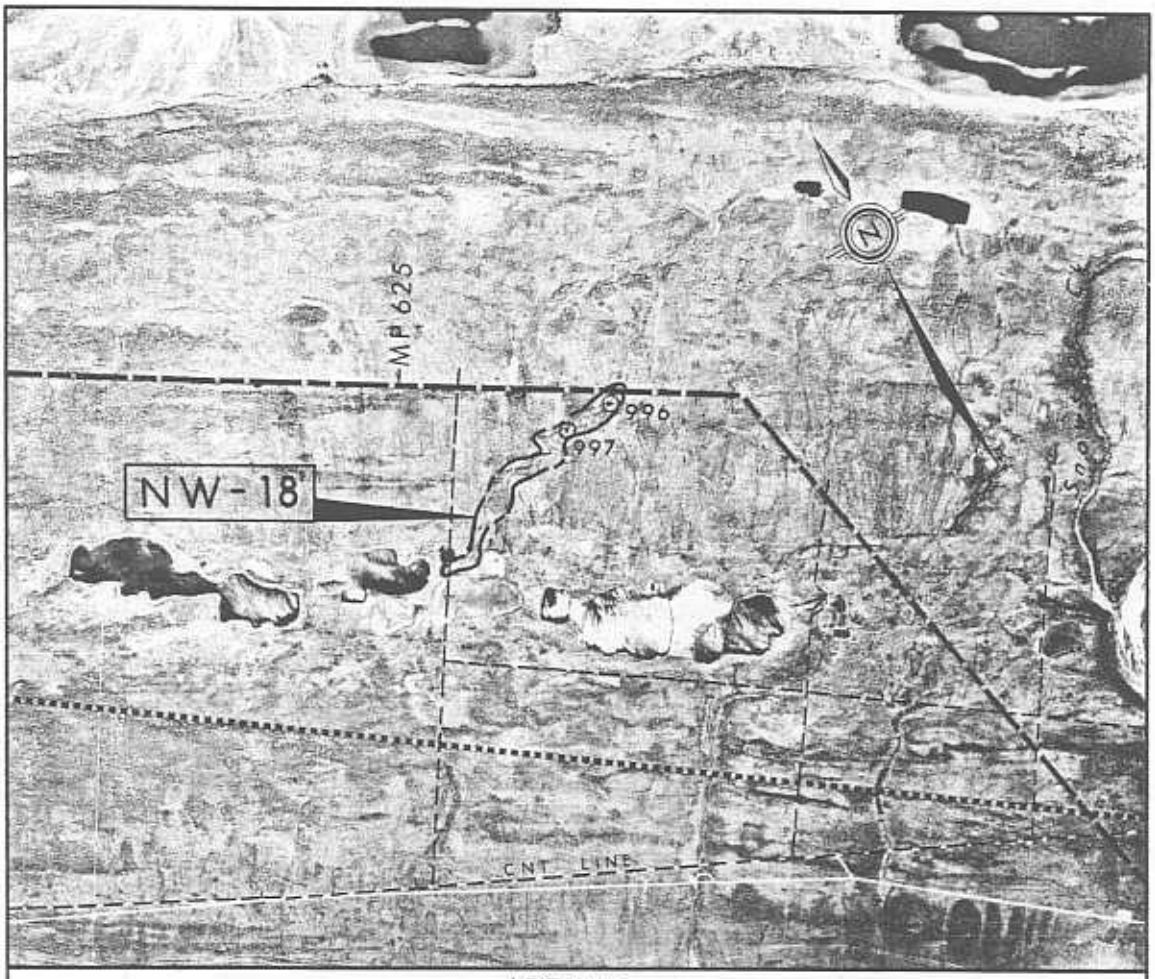
DEVELOPMENT

Site NW 17 X is not recommended for development in view of its remoteness from the community of Norman Wells, poor quality of material and difficult access to the site. Similar quality in relatively large quantities is available at Sites NW 5, 6, 7 and 11 for development and utilization if demands for this type of material becomes necessary.

SITE NO. NW 18

Located about 9 miles east of Norman Wells, Site NW 18 is a narrow and small sandy esker ridge.

Type of Material:	Sand; trace of gravel.
Estimated Volume:	100,000 cubic yards.
Assessment:	Low quality general fill. Not recommended for development unless there is a need for fill material in the immediate vicinity of the source.



LEGEND

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

Airphoto No. A22934/99

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 18 is located approximately 9 miles east of Norman Wells between D.O.T. Lake and Bandy Lake and consists of a small discontinuous, sinuous esker ridge. The esker is narrow and is approximately 2/3 mile long and varies in height from several feet to a maximum height of about 20 feet. This esker appears to be of similar origin and structure to the esker remnants investigated at Site NW 12.

Therefore, it is expected that this esker ridge is also composed mainly of silty sands with traces of gravel. A relatively shallow layer of organic topsoil can be assumed to cover the esker ridge.

The esker ridge is well-drained and supports mixed growths of birch and spruce. The adjacent terrain is poorly drained and is covered with muskeg characterized by growths of tamarack and stunted black spruce. A greater muskeg thickness is anticipated at the southwestern end of the esker ridge where the adjacent terrain becomes depressional and is highlighted with numerous small lakes.

Access to the site is currently restricted to the winter road from Norman Wells and an existing cutline to the southwestern end of the source area. Better and more direct access to Site NW 18 may become available when the proposed Mackenzie Highway is constructed since the proposed route of the highway cuts through the northeastern portion of the site.

DEVELOPMENT

The development of Site NW 18 for granular materials is not currently recommended for the following reasons:

- The quality of material available is very poor for granular fill and the volume available is quite minimal.
- The current access to the site is very poor and involves a relatively long haul to the community of Norman Wells.
- The extraction of material from this site may have a considerable effect on the terrain resulting in degradation of both vegetation and ground conditions.
- Better quality material at sites with better and closer access to the community are available in the Study Area.
- The aesthetic value of the area will be considerably altered by the clearing of a relatively large area of terrain in order to forage for a comparatively small quantity of material.

ABANDONMENT AND REHABILITATION

Site NW 18 is not recommended for development. If, however, the site is developed at a later date in order to meet increased demands, then an assessment of development procedures coupled with environmentally acceptable restoration guidelines should be established in conjunction with the land use regulations that are in effect at that time.

The results of the exploratory drilling which was conducted by the engineering consultant for the Federal Department of Public Works has been included herewith for further reference.

DETAILED DRILL HOLE LOG

SITE NO. NW 18 HOLE NO. 996

DATE: MAR. 15, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	SILT: organic, clayey, low plastic, dark brown, rootlets		Vx	H		0
					Vx	M		
2			2.0					2
		CI	CLAY (TILL): sandy, silty, medium plastic, brown					
					Vs	M		
4			- sandier					4
					Nbe			
		CH	- high plastic - mottled brown - shale inclusions					
6					Vx	M		6
		CI	- medium plastic					
8					Vx	M		8
		CH	- high plastic					
			- grey					
10		CI	- medium plastic		Nbn			10
			11.5					
12		CH	CLAY (SHALE): laminated, rust fissured with clay deposited in fissures, friable dry strength, medium to high plastic, siltstone (sandy) beddings, high plastic, grey, more intact with depth					12
14					Vs	M		14
16					Vr	M		16
18								18
20			20.0 END OF HOLE 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

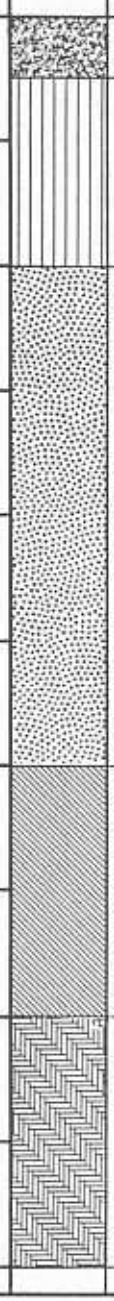
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 18 HOLE NO. 997

DATE: MAR. 15, 1973 LOGGED BY: ☐ PEMCAN ☒ R.M. HARDY & ASSOCIATES

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



DEPTH (feet)	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0	OL	ORGANIC SILT: low plastic, black		Nbn			0
1.0							
2	ML	SILT (TILL): clayey, sandy, medium plastic, brown, pebbles, shale inclusions		Vs	M		2
4							4
4.0							
6	SC	SAND (TILL): clayey, medium plastic, brown, silt (till) and shalestone inclusions					6
8							8
10							10
				Nbn			
12							12
12.0							
14	CH	CLAY (SHALE): high plastic, grey					14
			UF				
16							16
16.0							
18		SILTSTONE: fine, sandy, hard, grey					18
20							20
20.0		END OF HOLE 20.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

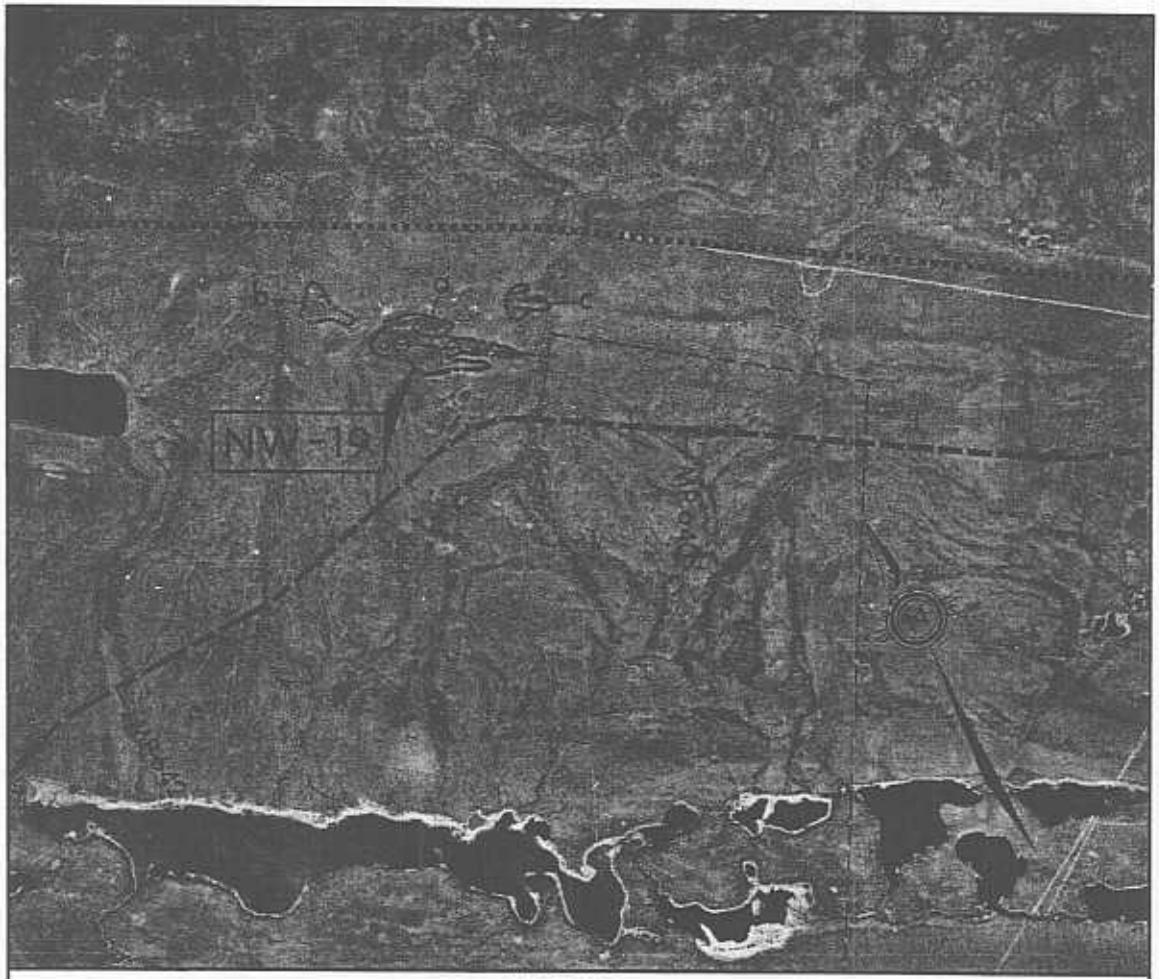
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SITE NO. NW 19

Located about 10 miles northwest from Norman Wells, the site consists of three shallow sandy mounds (kame-esker groups).

Type of Material:	SAND and GRAVEL; medium grained, well graded, trace silt
Estimated Volume:	1,000,000 cubic yards
Assessment:	Good quality general fill. Possible consideration for concrete sand. Existing access to site is very difficult, currently Site NW 19 is not recommended for development.



LEGEND

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

Airphoto No. A22934/134 Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 19 is located approximately 10 miles northwest of Norman Wells and consists of one moderately sized and two small kame-esker complexes. These kame-esker deposits range from 200 to 1500 feet in length and rise from several feet to a maximum of approximately 30 feet above the adjacent flat margin of a former glacial lake basin.

The kames do not form regularly shaped knobs, and their surface is pitted and disturbed by elongated troughs. It is very likely that the kames have been effaced by wind action. The best source for granular material, relative to quantities available, is the kame-esker complex noted as "a" on the site airphoto.

The kames are considerably better drained than the adjacent terrain, and are characterized by growths of birch with scattered black spruce. In general, the drainage of the adjacent terrain is southerly towards the Mackenzie River.

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

Access to Site NW 19 is restricted to the winter road from Norman Wells and 5 miles of existing seismic cutline to the eastern edge of the site. The proposed Mackenzie Highway route approaches within $\frac{1}{4}$ mile of the southern extremity of this site.

DEVELOPMENT

The kame-esker formation noted as "a" on the site airphoto (ref. Page 19-1) was investigated in detail with drill holes during the winter field drilling program and the following subsurface conditions were noted:

- The material type, as denoted by the drill hole information, consists mainly of medium grained, clean sands with interbedded strata of fine to medium grained gravels. This material is of excellent quality for utilization as fill in most construction requirements.

- It is considered that the medium grained sands may be suitable for utilization as concrete sand with a minor screening operation. However, this sand would have to be analyzed in further detail for such considerations.

- The depth of overburden is very shallow ranging from none to only a few feet.

- The depth of expoitable sands and gravels contained within portion "a" of Site NW 19 is in excess of 16 feet.

Site NW 19 is not currently recommended for development for the following reasons:

- The site is currently only accessible during the winter season and would entail

considerable upgrading of the winter road and seismic cutlines for the transportation of material.

- The access from the existing winter road along seismic lines entails the traversing of thermally sensitive terrain.

It is suggested that the development of this site be delayed until the proposed Mackenzie Highway is constructed into the site area as the highway will provide excellent access from Site NW 19 to the community. In view of the above and with respect to a lack of good quality natural granular materials in the vicinity of Norman Wells, this site is of significance to the requirements of the community.

- Possible use of heavy ripping equipment may be required for loosening the frozen material if borrow pit operations are restricted to the winter season.

- Good quality concrete sand may be recovered from this site with only a minimal screening requirement. Additional laboratory analyses would be required to fully assess the suitability of this material in the production of concrete mixes.

ABANDONMENT AND REHABILITATION

Site NW 19 is not recommended for immediate development. If, however, the site is developed at a later date when a short access road from the highway can be established, then an assessment of development procedures coupled with environmentally acceptable restoration guidelines should be established in conjunction with the land use regulations that are in effect at that time. In general, the following development guidelines should be followed:

- The veneer of organic topsoil and peat should be stripped, removed and stockpiled adjacent to the borrow pit area for the rehabilitation of exploited terrain. Such stockpiles should be located at the outside site limits and preferably within the site itself since the granular deposits are considerably less thermally sensitive than the adjacent ground.

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

- Replacing stockpiled surficial material on the abandoned borrow areas.

- Reseeding of the rehabilitated terrain may be considered although existing cutlines indicate that vegetation cover will be naturally reestablished.

DETAILED DRILL HOLE LOG

SITE NO. NW 19 HOLE NO. DH-1

DATE: JAN. 17, 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								0
		ML	SILT: little sand, trace gravel, medium to light brown		Nbn	L		
2			2.0					2
			GRAVEL: some sand, little silt					
4		GM-SM			VrVx	L-M		4
6								6
			7.0					
		SM	SAND: little silt, medium grained, stratified		Vx	L		
8			8.0					8
		GM-GP	GRAVEL: some sand, little silt, medium brown		Vx Vc	L-M		
10			10.0					10
			SAND: trace of gravel, well graded, medium grained				GS	
12		SW			Vx Vc	L		12
14								14
							MC	
16			16.0 TOTAL DEPTH 16.0'					16
18								18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 19 HOLE NO. DH-2

DATE: JAN. 17, 1973 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (Feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (Feet)
0		GM	GRAVEL: some sand, little silt, light to medium brown		Nf	L		0
2			2.0					2
			SAND: some gravel, well graded, medium to coarse grained					
4		SW					MC GS	4
6					Nf	L		6
8			- becoming fine to medium grained					8
10			- occasional boulders at 11'					10
12								12
14								14
16			16.0 TOTAL DEPTH 16.0'					16
18								18

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

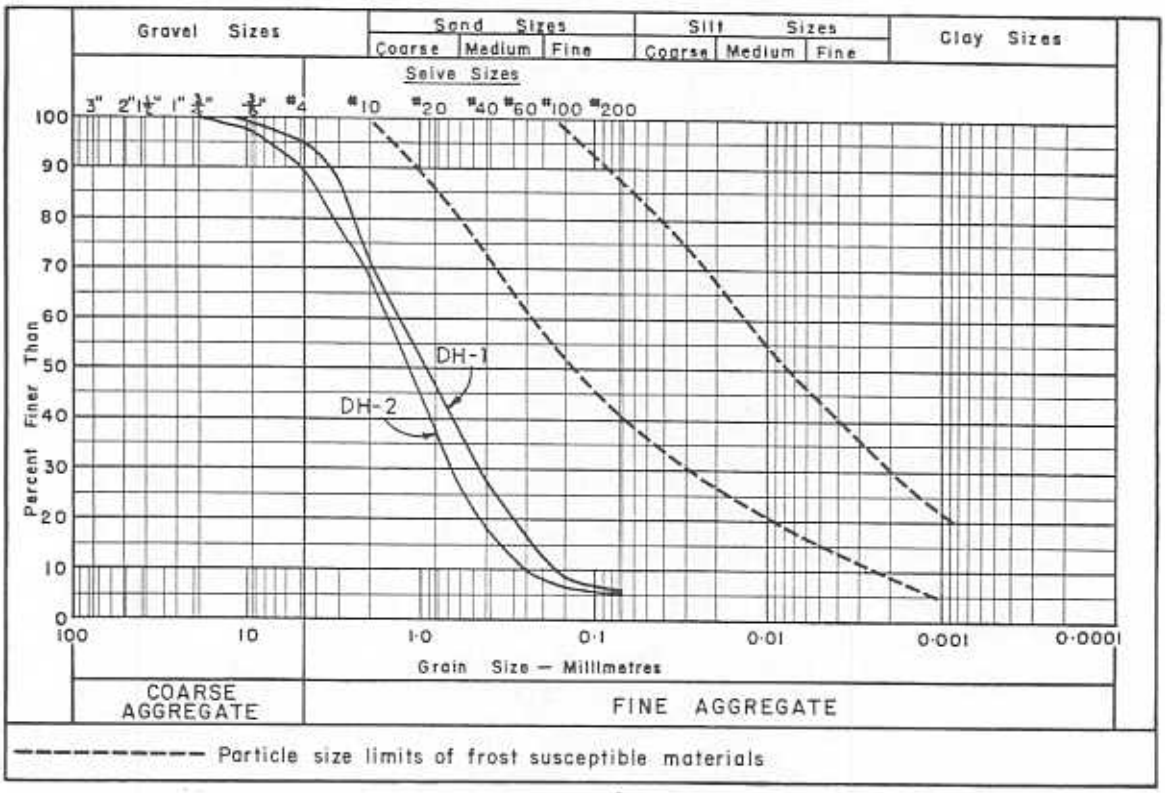
GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	NW 19/DH 1	NW 19/DH 2
Sample Depth (Feet):	14 - 16	4 - 5
Moisture Content (%):	-	-
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:

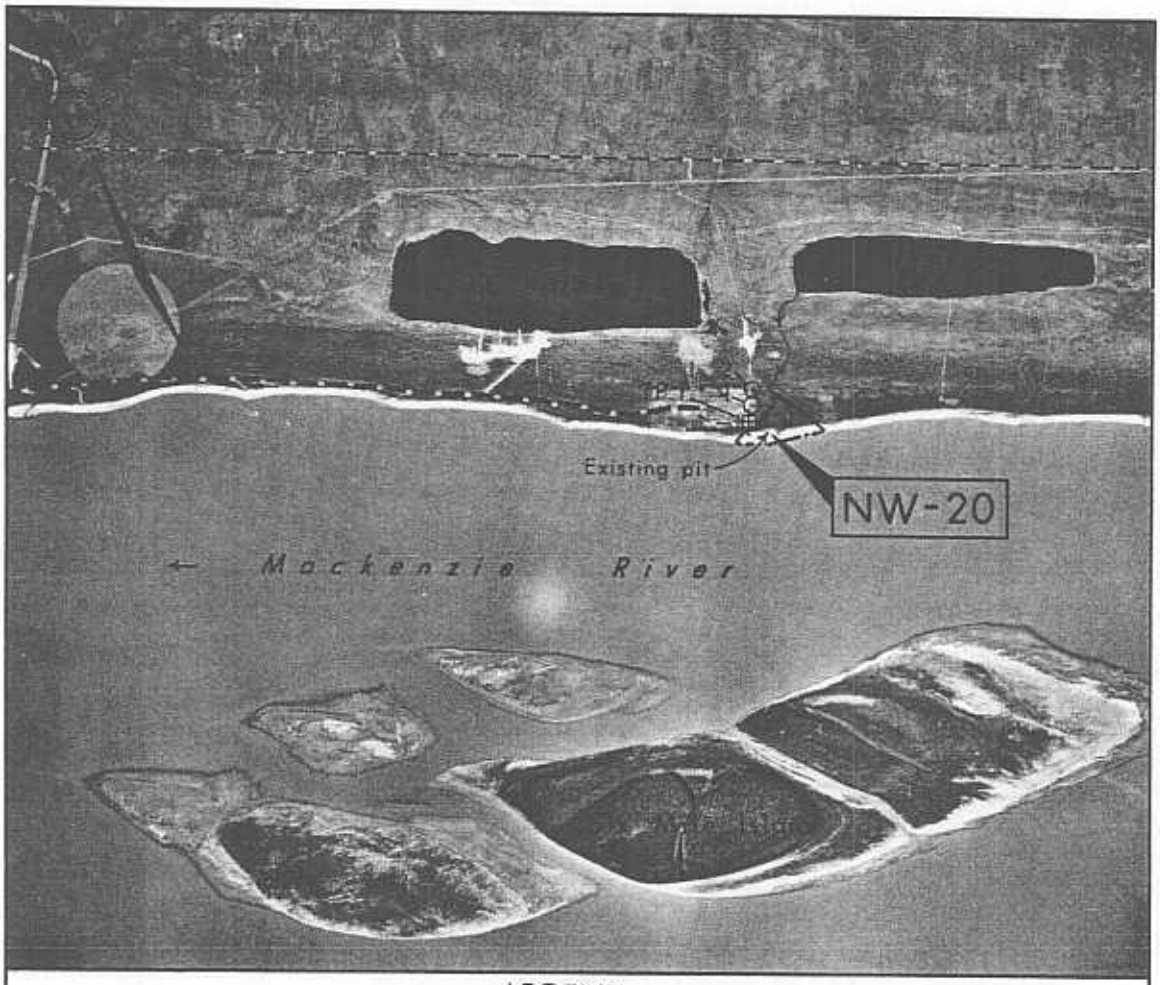


PETROGRAPHIC ANALYSIS:

SITE NO. NW 20

Located approximately 4 miles east of Norman Wells, Site NW 20 is a small alluvial cone at the mouth of Joe Creek on the northern shoreline of the Mackenzie River.

Type of Material:	GRAVEL; coarse grained, well graded, some silt
Estimated Volume:	5,000 cubic yards
Assessment:	Fair quality material for general fill. Limited volume does not justify development of regular borrow pit.



LEGEND

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

Airphoto No. A22934/140

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 20 is located approximately 4 miles east of Norman Wells immediately southeast of the Ministry of Transport radio towers. The granular material deposit is contained in a small aluvial cone on the north bank of the Mackenzie River at the mouth of Joe Creek. The cone is approximately 500 feet wide at the river bank and narrows upstream along Joe Creek. Stratified sandy and gravelly deposits overlie shale bedrock. The deposit is above the high water level of the adjacent stream channel of Joe Creek.

A layer of organic topsoil and sandy silt, ranging in depth from 3 to 5 feet, overlies the coarse gravel stratum. The gravel deposit is relatively well graded but is high in silt content. The organic topsoil supports a growth of shrubs, spruce and occasional birch.

Although the site is within the waterfowl staging and migration route (Figure 2), the proximity of the site to Norman Wells suggests that detrimental environmental effects are not likely.

An all weather road from the radio tower installation at the western extremity of the site provides immediate and good access to Norman Wells. A small borrow pit has been established in the bank of the Mackenzie River near the mouth of Joe Creek.

DEVELOPMENT

Two exploratory test holes (DH 1 and DH 2) were drilled in January, 1973 on the northern periphery of Site NW 20 in order to delineate the extremities of the in situ gravel pocket. The data from the drill holes showed no gravel, which confirms the isolated and minimal extent of the exposed gravel pocket at the mouth of Joe Creek on the north bank of the Mackenzie River.

Site NW 20 is not recommended for development because of small quantities of material available.

However, because of good access to this site and the existing small borrow pit, minor quantities of material can be extracted for local use (i.e. road extension in the vicinity of radio towers, etc.). If such requirements arise, the following guidelines should be observed:

- The source should be worked from the river side or its west boundary at the point where the access road crosses the top of the river bank.

- The area to be exploited should be cleared and stripped, working from the river bank inland to prevent silting of the creek and Mackenzie River. The topsoil should be stockpiled north of the borrow pit for restoration of the excavated area after the removal of granular materials.

- If the source is to be used as a maintenance pit, its faces should be graded to smooth, stable slopes to prevent erosion. The pit floor should be graded and leveled.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures for this site should include:

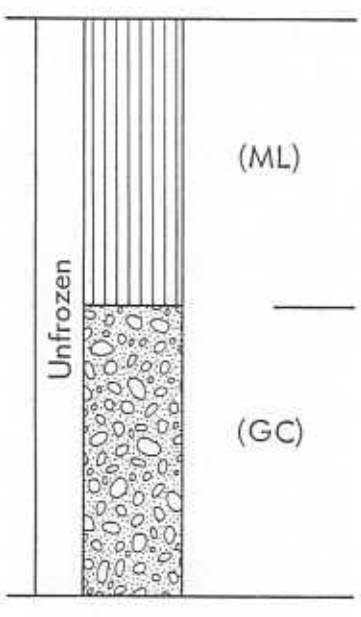
- Recontouring of pit area to provide slopes which blend as far as practicable with the natural contours of immediate area.

- The recontoured pit area should be resurfaced with the stockpiled waste topsoil.

DETAILED TEST PIT LOG

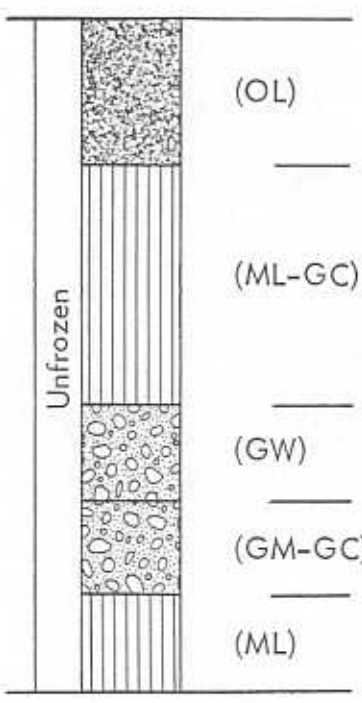
NW 20/TP 1

Old Test Pit (cut by a dozer)



NW 20/TP 2

Profile on River Bank at Existing Pit



DETAILED DRILL HOLE LOG

SITE NO. NW 20 HOLE NO. DH-1

DATE: DEC. 6, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some sand, little silt, organic, dark brown		Vr	L-M		0
1.6								
2		ML	SILT: some clay, trace sand, low to medium plastic, dark brown		Vx	L		2
4			- few pebbles at depths greater than 3.5'	UF				4
6								6
8								8
9.5								
10			TOTAL DEPTH 9.5'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. NW 20 HOLE NO. DH-2

DATE: DEC. 6, 1972 LOGGED BY: ☒ PEMCAN ☐

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	GROUND ICE CONDITIONS: N.R.C. CLASS	GROUND ICE CONDITIONS: EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: some silt, organic, rootlets, dark brown		Vx	L		0
1.0								
2		ML	SILT: some clay, low plastic, few pebbles to 1" size, light to medium brown					2
4								4
6				UF				6
8								8
9.5			TOTAL DEPTH 9.5'					
10								10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

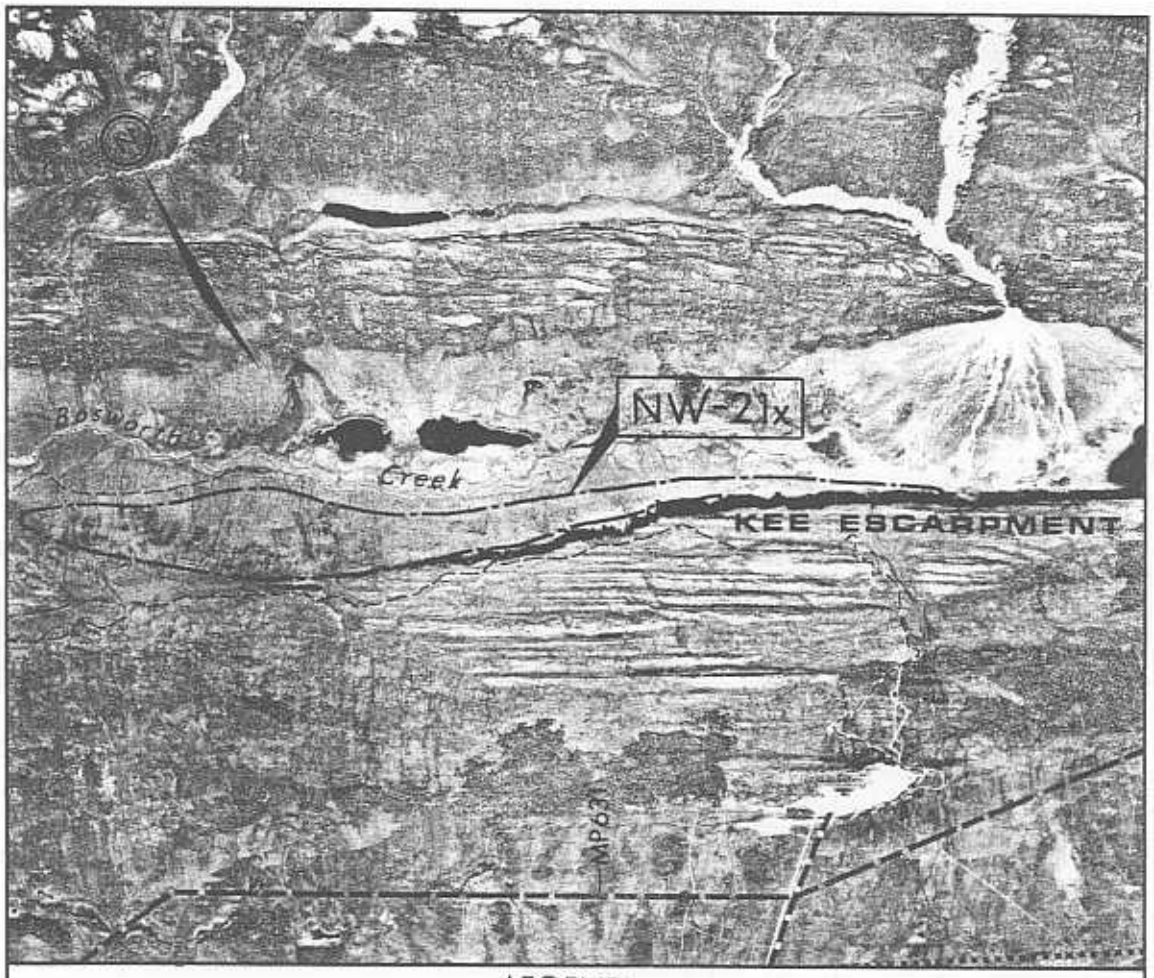
SITE NO. NW 21X

Located approximately 6 miles north of Norman Wells along the base of the northern wall of Kee Escarpment, Site NW 21X consists of steep talus slopes and moderate slope wash terrain.

Type of Material: Angular limestone fragments in a silty matrix.

Estimated Volume: 2,000,000 cubic yards.

Assessment: This site is not recommended for development because of the extremely difficult access and high ice content of the in situ material.



LEGEND

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

Airphoto No. A22934/101

Approximate scale: 1" = 3,000'

ENVIRONMENT

Site NW 21X is located approximately 6 miles northeast of Norman Wells immediately adjacent to the northern wall of Kee Escarpment. This site encompasses the talus slopes at the base of the steep vertical cliffs along the northern edge of Kee Escarpment and also the shallower slope-wash terrain to the west of the Kee Escarpment.

The northern wall of Kee Escarpment forms the southern boundary of a melt water channel which parallels the Norman Range. The general site drainage flows to the north into the headwaters of Bosworth Creek which parallels the northern periphery of Site NW 21X. Bosworth Creek is utilized as the water supply for Norman Wells.

The talus slopes along the north wall of Kee Escarpment consists of coarse angular fragments and blocks of weathered limestone cemented in a silt matrix. In view of the northern exposure of these deposits, a relatively high ice content is expected.

The northern and western flanks of the site area are very sparsely vegetated with occasional groups of spruce and tamarack. There are no known critical wildlife areas within the vicinity of this site.

Access to this site is very difficult because of the presence of Kee Escarpment. A new access road of approximately 4 miles in length will have to be constructed from the site around the west end of Kee Escarpment and back to the all weather road at the existing quarry.

DEVELOPMENT

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

- The access to this site is very difficult because of the presence of Kee Escarpment and a relatively lengthy new access road will have to be constructed.
- The northern exposure of the talus slopes suggests a high in situ ice content which will add to the difficulties in the extraction and utilization of the material.
- The talus slopes will have to be developed in an upslope direction from Bosworth Creek and may detrimentally affect the environmental conditions of the headwater regime of Bosworth Creek. Bosworth Creek is currently utilized as the water supply for Norman Wells.

GLOSSARY

GLOSSARY

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

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

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

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

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

EXPLANATION OF TERMS AND SYMBOLS

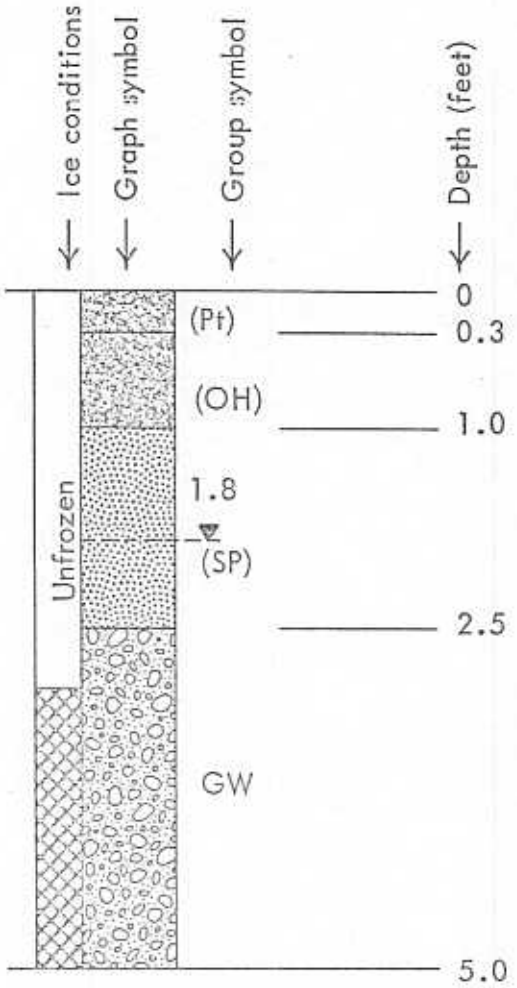
EXPLANATION OF TERMS AND SYMBOLS

DRILL HOLES AND TEST PITS

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

TEST PIT LOG DESCRIPTION

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



DRILL HOLE LOG DESCRIPTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MC:- designates moisture content determinations.

GS:- designates grain size analyses including hydrometer tests.

P:- designates Petrographic analyses.

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

O:- designates Organic Content determinations.

DETAILED DRILL HOLE LOG

SITE NO. 131 HOLE NO. DH-1

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

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

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS: GEN'L CLASS	N.R.C. CLASS	EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
0		OL	TOPSOIL: organic, dark brown		Nf	L		0
1.0								
2		GM-GP	GRAVEL: some silt, little sand, frequent pebbles to 3" size, occasional boulders, medium brown		Vs	L-M		2
4								4
6								6
7.0								
8		ML	SILT: some clay, trace of rust and coal specks, frequent pebbles to 1" size, occasional boulders, medium brown					8
10								10
12								12
12.0			TOTAL DEPTH 12.0'					
	①	②	③	④	⑤	⑥	⑦	⑧	⑨

EXHIBIT

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

MATERIAL CLASSIFICATION

Soil types are designated by a modified version of the Unified Soil Classification System ("The Unified Soil Classification System", Technical Memorandum No. 3-357, Vol.I, 1953, the Waterways Research Station, U.S.A.). The following page defines these terms and symbols. Letters appearing in parentheses denote visual identification which have not been verified in the laboratory. If the soil falls close to the boundaries established between the various groups a double symbol (for example GW-GP) is used.

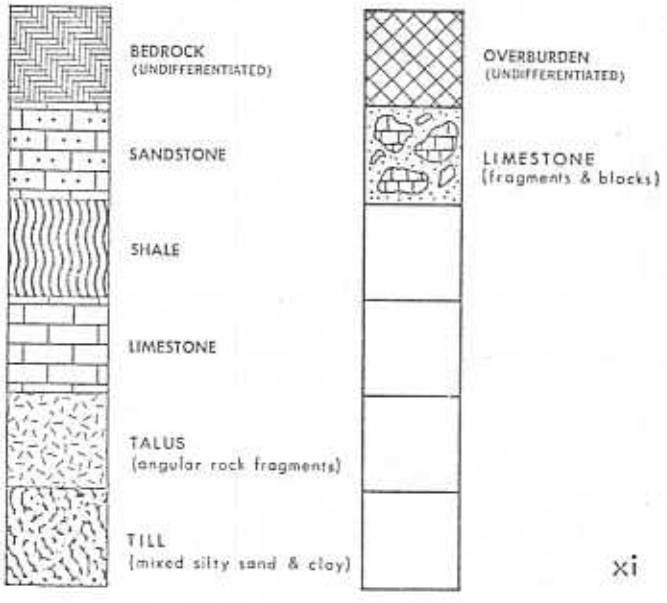
Since the Unified Soil Classification System does not contain detailed subdivisions of granular soils according to percentage proportions of secondary components, the ASTM suggested method for identification of granular soils ("Suggested Methods of Test for Identification of Soils", ASTM Procedures for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

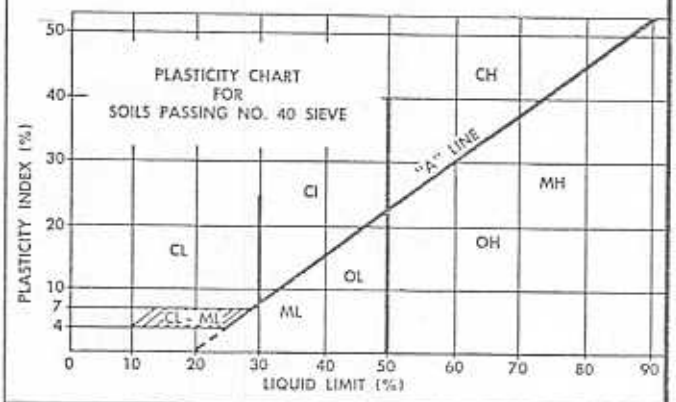
Composite Sand-Gravel Soils		Composite Sand-Silt Soils	
Percentages	Identification	Percentages	Identification
90 to 10	Gravel; trace Sand	95 to 5	Sand; trace - Silt
80 to 20	Gravel; little Sand	90 to 10	Sand; trace + Silt
65 to 35	Gravel; some Sand	80 to 20	Sand; little Silt
50 to 50	Gravel and Sand	65 to 35	Sand; some Silt
35 to 65	Sand and Gravel	50 to 50	Sand and Silt
20 to 80	Sand; some Gravel	35 to 65	Silt and Sand
10 to 90	Sand; little Gravel	20 to 80	Silt; some Sand
	Sand; trace Gravel	10 to 90	Silt; little Sand
			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	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH 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	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH 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

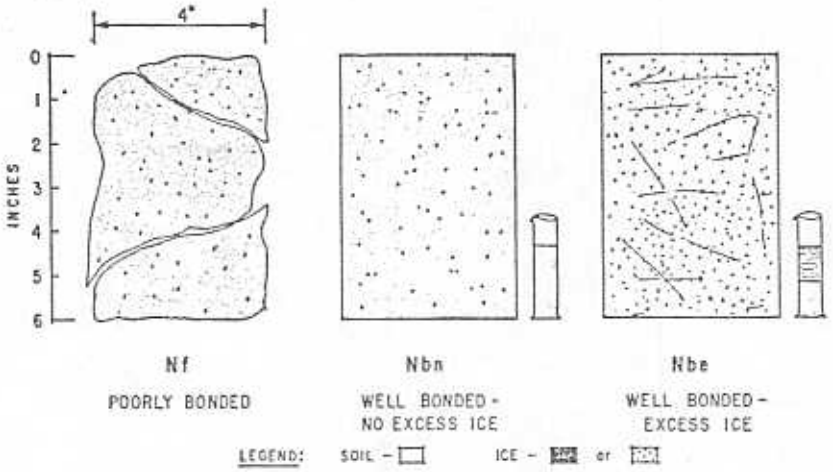


TABLE I (cont'd)

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 B. VISIBLE ICE LESS THAN ONE INCH THICK

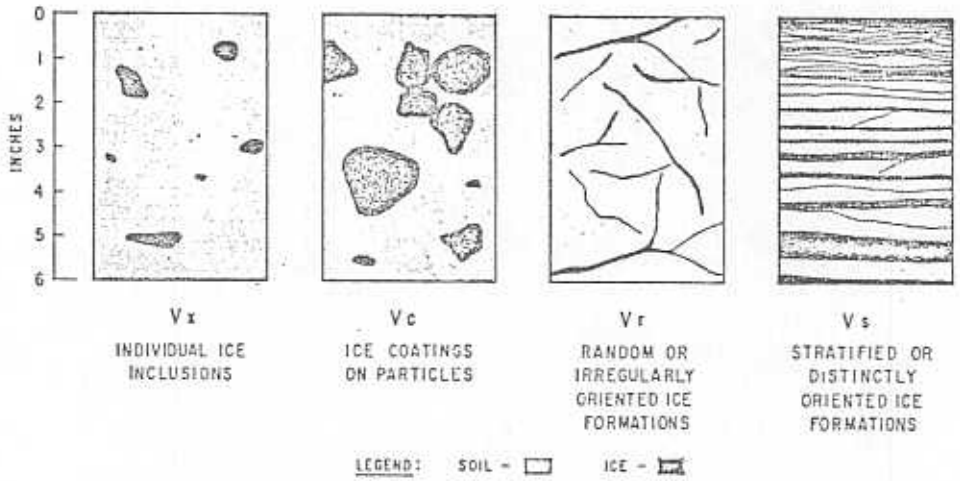


TABLE I (cont'd)

ICE DESCRIPTIONS

C. VISIBLE ICE—GREATER THAN 1 INCH THICK

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
ICE	Ice with soil inclusions	ICE + soil type	Designate material as ICE[a] and use descriptive terms as follows, usually one item from each group, when applicable:
	Ice without soil inclusions	ICE	Hardness: HARD; SOFT (of mass, not individual crystals). Structure[b]: CLEAR, CLOUDY, POROUS, CANDLED, GRANULAR, STRATIFIED. Colour (Examples): COLOURLESS, GRAY, BLUE. 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

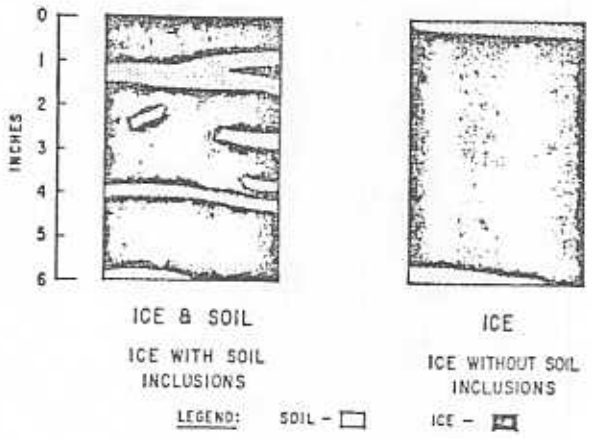


TABLE II

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:

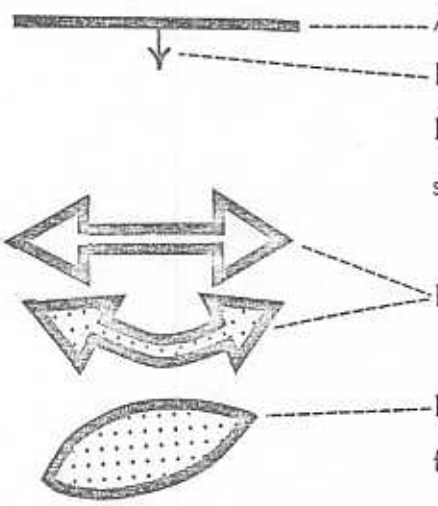
- Wildlife areas are outlined in red.
- Waterfowl areas and, in the case of Fort Simpson, hunting locales, are outlined in yellow.
- Fishery resource areas are outlined in blue.

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:

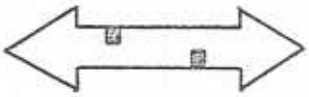
----------Approximate boundary of wildlife area.

----------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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BIBLIOGRAPHY

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