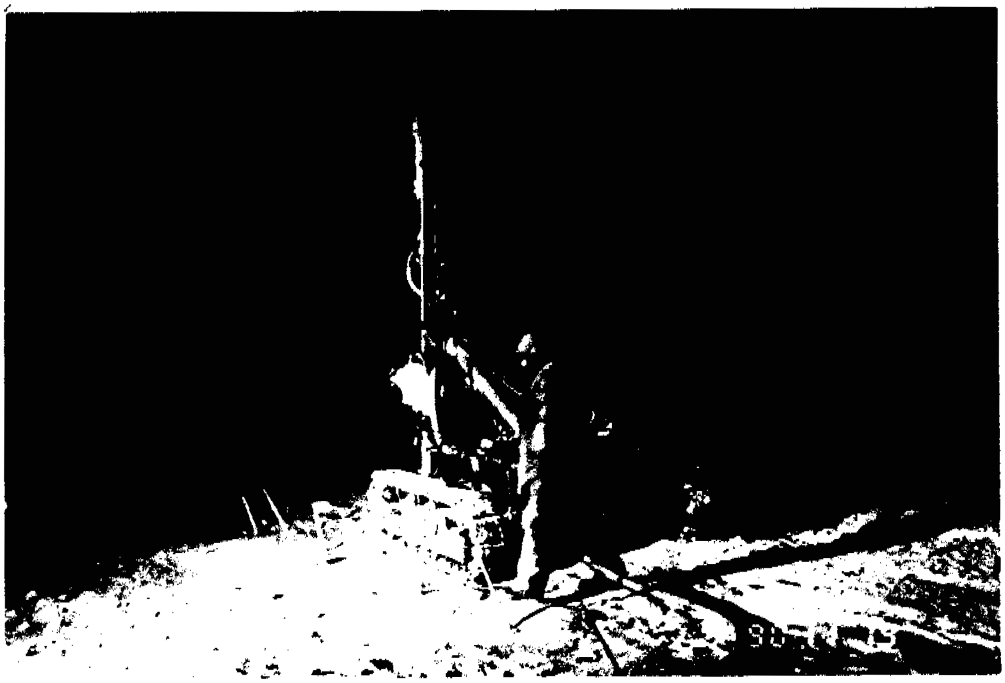
GRANULAR MATERIAL SOURCES INVESTIGATION

REPULSE BAY, N.W.T.

Submitted by Fred Collins
Geotechnical Advisor,
Community Granular Program,
Engineering Division,
Department of Public Works.

March 1991

TABLE OF CONTENTS



REPULSE BAY N.W.T.

NIGHT DRILLING

ACKNOWLEDGEMENTS

This study was produced in association with various departments within the G.N.W.T. and local community representatives. The following are the individuals and organizations associated with this report.

Acknowledgements

Dave Boyle	Canadrill Driller, Iqaluit.
Mike Donovan	Canadrill Blaster, Iqaluit.
Sheldon Dorey	Senior Administration Officer, Hamlet of Repulse Bay.
Doug Edey	Regional Superintendent, Government Services, Rankin Inlet.
John Kaunak	Mayor, Hamlet of Repulse Bay.
Debbie Maracle	Divisional Secretary, Department of Public Works, Engineering Division, G.N.W.T., Yellowknife.
Sandy Murray	Project Officer, Department of Transportation, G.N.W.T., Yellowknife.
Andrew Skelton	Project Engineer, Department of Public Works, G.N.W.T., Rankin Inlet.
Ron Tecsy	Planning Technician, Department of Municipal and Community Affairs, G.N.W.T., Rankin Inlet.

EXECUTIVE SUMMARY

The Hamlet of Repulse Bay, which was incorporated on July 1, 1978, is a mature and growing community of approximately 454 people that needs a reliable and convenient source of all types of granular material.

This report presents the results of a geotechnical study, conducted under the objectives and guidelines of the Community Granular Program, to determine the 20-year demand for granular materials and the best means of satisfying that demand.

In summary, the 20-year demand for granular materials in the community is nearly 78,000 cubic meters. A significant discrepancy exists between projected user demands and existing granular resources over this 20-year period.

In general, naturally occurring "pitrun" sources in the vicinity of Repulse Bay have been depleted. At present, there exists a critical shortage of all grades of granular aggregate for use in capital projects. Potential sources are inaccessible and/or too costly to develop.

Only through the application of a large scale "blast and screen" quarry operation will the short and long term granular needs of the community be satisfied. A quarry and stockpile operation for both select and embankment material should be implemented during the 91/92 fiscal year.

Implementation of a Granular Source Management Plan by the Hamlet of Repulse Bay, based on the technical recommendations of this report and on local concerns, is recommended at the earliest possible date.

1. INTRODUCTION

The geotechnical studies undertaken by the Community Granular Section are an integral part of the Community Granular Program. The goals, principles, definitions and methodology of these reports are discussed in this section.

1.1 General

The Community Granular Program, Engineering Division, D.P.W., provides the capital resources for identifying, laboratory testing, developing, and restoring granular sources for all non-taxed based communities in the N.W.T. The objective is to process, stockpile, and manage granular supplies to ensure materials are available for planned community development projects, ongoing maintenance, and private use, at a reasonable cost.

To meet this objective, geotechnical investigations are planned for various communities throughout the N.W.T. and are priorized on the basis of the granular needs in the communities. These needs are derived through an analysis of the 5 year capital plans and the 20 year capital needs assessment of every GNWT Department, the N.W.T. Housing Corporation, the Federal Government and where available, the private sector, as of November, 1989. Highly speculative needs such as resource development projects (i.e. oil and gas) are beyond the scope of these studies.

The intent of this report is to precisely define the community's available granular resources and its granular needs over a 20 year horizon and develop options for the management of those resources that ensure the community's long term needs are met. The report and recommendations will enable the community, through the consultative process, to develop a comprehensive Granular Resource Development and Management Plan that will provide control of the extraction, development, use and restoration of granular resource areas.

1.2 Geotechnical Investigation Procedure

This granular materials study is a multi-phased investigative and assessment process that may be broken down as follows:

Terrain Analysis
- regional setting
- geology and geomorphology
- drainage
- permafrost distribution

Resource Description and Assessment
- review of pertinent information
- air photograph interpretation
- ground reconnaissance and sampling
- material quantity assessment
- material quality assessment
- ground ice and permafrost assessment
- evaluation of all sources
- access routes
- source summary

Granular Needs Assessment
- granular material breakdown
- 5 year needs assessment
- 20 year needs projections
- needs summary

Recommendations
- comparison of resources and needs
- development of options
- development of estimates
- selection of options

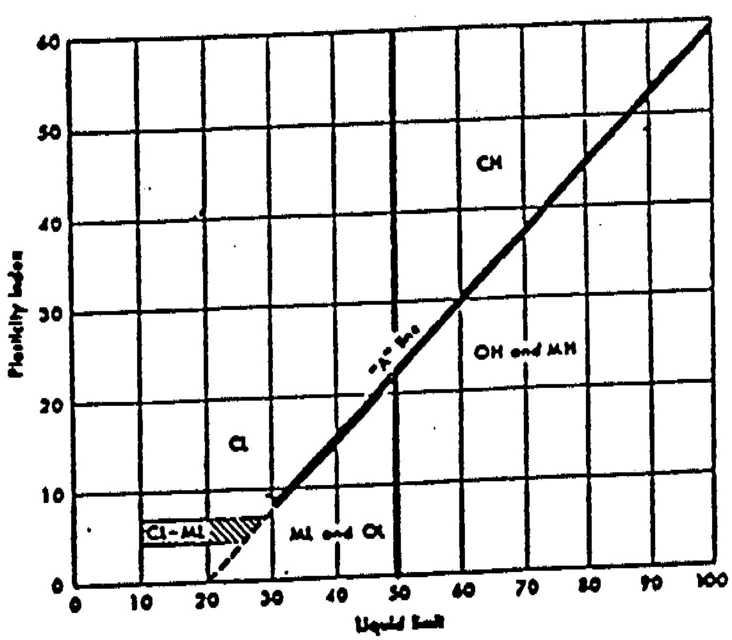
1.3 Specifications and Terminology

A number of systems have been devised for classifying granular materials that are based on soil characteristics and engineering properties of the material. The Community Granular Section uses the following standards, criteria and specifications to describe the material in the granular sources discussed in this report. In addition, a Glossary of Terms is to be found following Section 8.

1.3.1 Classification of Soils

The Unified Soil Classification System (USC) is used to identify various types of soils through visual description in situ and in the laboratory and through tests such as Atterburgh Limits and sieve analysis. The USC system is shown on the following page.

Major divisions			Group symbols		Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent.....GW, GP, SW, SP; More than 12 per cent.....GM, GC, SM, SC; 5 to 12 per cent.....Borderline cases requiring dual symbols**	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM*	d	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
				u				
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
				u				
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		Pt		Peat and other highly organic soils			



Plasticity Chart

1.3.2 Engineering Properties of Materials

Granular materials have been separated into various "types" for the purposes of this report. Each type is based on the intended end use of the material and conforms to the American Association of State Highways and Transportation Officials (AASHTO) specifications, as follows:

Type	Specification
Embankment	AASHTO M 57-80
Sub-base	AASHTO M 57-80
Base	AASHTO M 147-65(80)
Surface	AASHTO M 147-65(80)
Concrete Aggregate - fine	AASHTO M 6-81
- coarse	AASHTO M 80-77(92)

All granular material samples are subjected to standard laboratory tests to ensure conformance with these specifications. The tests are:

- **Washed Sieve Analysis: AASHTO T11-82:**
  Report grain size analysis on standard form showing all calculations, eg. original dry, dry after washing amount retained per sieve and percent error. Use following sieve nest.

100 mm	4 in.	4.75 mm	No. 4
75 mm	3 in.	2.36 mm	No. 8
67.5 mm	2 1/2 in.	2.00 mm	No. 10
50 mm	2 in.	1.18 mm	No. 16
37.5 m	1 1/2 in.	0.60 mm	No. 30
25 mm	1 in.	0.425 mm	No. 40
19 mm	3/4 in.	0.300 mm	No. 50
16.5 mm	5/8 in.	0.150 mm	No. 100
12.5 mm	1/2 in.	0.075 mm	No. 200
9.5 mm	3.8 in.		

- **Dry Sieve Analysis: AASHTO T27-82:**
  Sieve down to No. 4 (4.75 mm) using sieve nest indicated in specification. Prepare grain size curve on standard form.

- **Lab Crushing:**
  Crush to required maximum size using laboratory jaw crusher. Size will be given on sample information.

- **Atterberg Limits: AASHTO T89-81 Method A. T90-81:**
  Report summary list of sample numbers with liquid limit, plastic limit, and plasticity index. Report on standard form.

- **Visual Description and Classification:**
  Give a brief visual description of sample content as per example. Classify the material as per Unified Soils system and AASHTO system including group index. Report on standard form.

- **Natural Moisture Content: AASHTO T265-79:**
  Supply summary list showing sample number and moisture content. Also complete lab data copies.

- **Magnesium Sulphate Soundness, AASHTO T104-77 (1982):**
  Report the loss on each coarse fraction and the total loss by the weighted average based on the grading of the original sample.

- **Los Angeles Abrasion, AASHTO T96-77:**
  Depending on the sample, use the appropriate grading, and report the loss as a percentage.

- **Modified Proctor Standard Proctor, AASHTO T99-81:**
  Report results of five (5) points and prepare proctor curve on standard form.

- **Petrographic Analysis, MTC LS-609:**
  Using coarse aggregate report PN number and flakiness index.

- **Fractured Face Count, MTC LS-607:**
  Report as percentage of original sample mass.
  Refer to AASHTO T4-35, Section 2.

- **Flat and Elongated Particle Count, MTC LS 608:**
  Report as percentage of original sample mass.

- **Hydrometer Analysis: AASHTO T88-81:**
  Supply all lab data and grain size curve. Plot results of grain size on Contractor's standard grain size distribution curve.

- **Washed Sieve Analysis:**
  Minus 0.075 mm: AASHTO T11-82.
  Organic Content: AASHTO T267.

It is important to note that all samples may not have to be subjected to the full range of test procedures.

It should be noted also that ground thermal analysis and the engineering properties of permafrost unique to northern periglacial environments are taken into consideration in all situations.

1.3.3 Environments of Deposition

The properties of any granular material vary with its gradation, moisture content, vertical position in relation to the surface of the ground, and geographic location. Time and climate influence the weathering process of mechanical and chemical disintegration that breaks the material down into progressively smaller particles. The term gradation refers to the relative size of these particles in a deposit.

Size distribution is related to environments of deposition that indicate the texture and composition of a granular deposit. The amount of each size grouping in a deposit is one of the major tools used in judging, analyzing, and classifying a source for use as a construction material. Granular deposits contain particles ranging in size from boulders through clay, as indicated below.

	203.2 mm (8 in.)		71.6 mm (3 in.)		19 mm (0.75 in.)		4 mm (0.16 in.)		2 mm (0.08 in.)		0.42 mm (0.02 in.)		0.074 mm (0.003 in.)	
Boulders		Cobbles		Coarse Gravel		Fine Gravel		Coarse Sand		Medium Sand		Fine Sand		Silt & Clay (Fines)

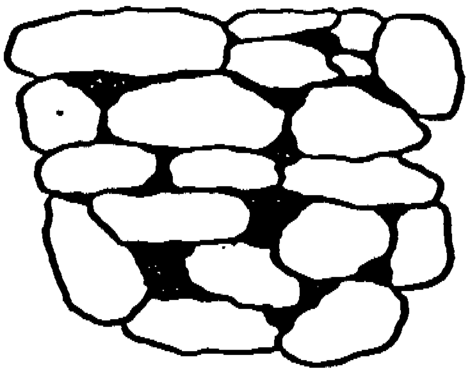
Gravel and sand particles are the most desireable and are found in glacio-fluvial deposits and post glacial beaches. Silt and clay particles, called 'fines', are undesirable over 15 percent because they tend to hold water which in periglacial environments, as in the N.W.T., results in high ice content and greater frost susceptibility. However, a lower limit of 5% is often acceptable to aid in compaction. Fines are often found in deltaic and lacrustine deposits, some fluvial sediments, and tidal flats. Post glacial/fluvial processes during the Quarternary period have also influenced the type of gradation in granular sources in the N.W.T.

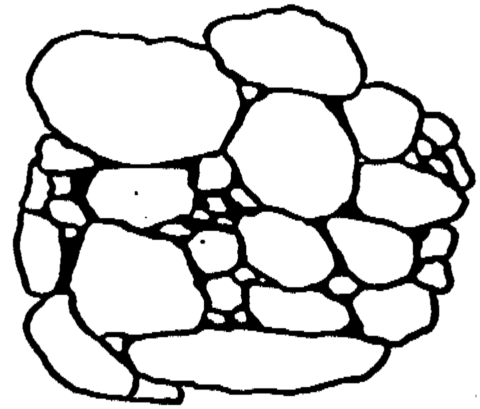
Mechanical weathering is the dominant process acting on the rock strata of the precambrian outcrops throughout the N.W.T. Since the regolith produced from the weathering process occur "in situ", most granular deposits in the N.W.T. are "poorly graded" with a high percentage of "oversized" particles.

The suitability of a deposit for construction purposes is directly related to the particle distribution or grain-size curve. This curve indicates if a deposit is "well-graded" or "poorly graded", two terms that are used extensively in this report.

A "well graded" granular deposit has an equal amount of each gravel and sand size and little or no fines. These deposits are referred to as "clean" and are excellent quality materials for "pitrun" construction purposes. Eskers and raised beaches are prime examples of "clean" deposits.

A "poorly graded" granular source has an excess of some particle sizes, a shortage or lack of others, or has nearly all particles the same size. These sources need processing to improve and upgrade their quality. Screening and washing can be used to remove undesirable particle sizes. Talus slopes, alluvial fans, and varved clays are prime examples of this type of deposit found in the N.W.T.





Poorly-graded materials with all particles the same size or with a lack of certain particle sizes (left drawing) have more voids and are less stable than well-graded materials where the voids are filled by the smaller particle (right drawing).

1.4 Volume Estimates

Volumes of granular material sources as described in this study are classified as being proven, probable, or prospective.

A **proven** volume is one where existence, extent, thickness and quality is supported by ground truth information such as a test-pitting, exposed stratigraphic sections, bore hole drilling, and aggressive sampling and ground truth reconnaissance.

A **probable** volume is one whose existence, extent, thickness and quality is inferred on the basis of direct and indirect evidence such as airphoto interpretation, geophysical data, terrain analysis, and limited sampling and ground truth reconnaissance.

A prospective volume is one whose existence, extent, thickness and quality is suspected on the basis of limited direct evidence, such as airphoto interpretation, remote sensing information, or imaging radar techniques. There is no sampling or ground truth reconnaissance.

1.5 Restoration and Regulations

Pit planning, design, and restoration are important aspects of granular resource development. Environmentally, the development of any granular sources offers the potential for drainage and erosion problems, habitat destruction, and the disturbance of wildlife. In many communities in the N.W.T., excessive scarring of the surrounding terrain is a major concern. These reports take into account the economic and environmental factors of pit abandonment and reclamation. Guidelines to minimize the impact of pit development and quarry operations are available in the INAC (1982) publication "Environmental Guidelines Pits and Quarries". At all stages of pit planning, design and operation, methods that ensure final pit restoration are stressed.

Permafrost can be expected throughout the N.W.T. and results in a variety of environmentally sensitive problems related to pit abandonment and restoration; thus pit development in permafrost environments must be planned well in advance and special techniques used during the extraction of material.

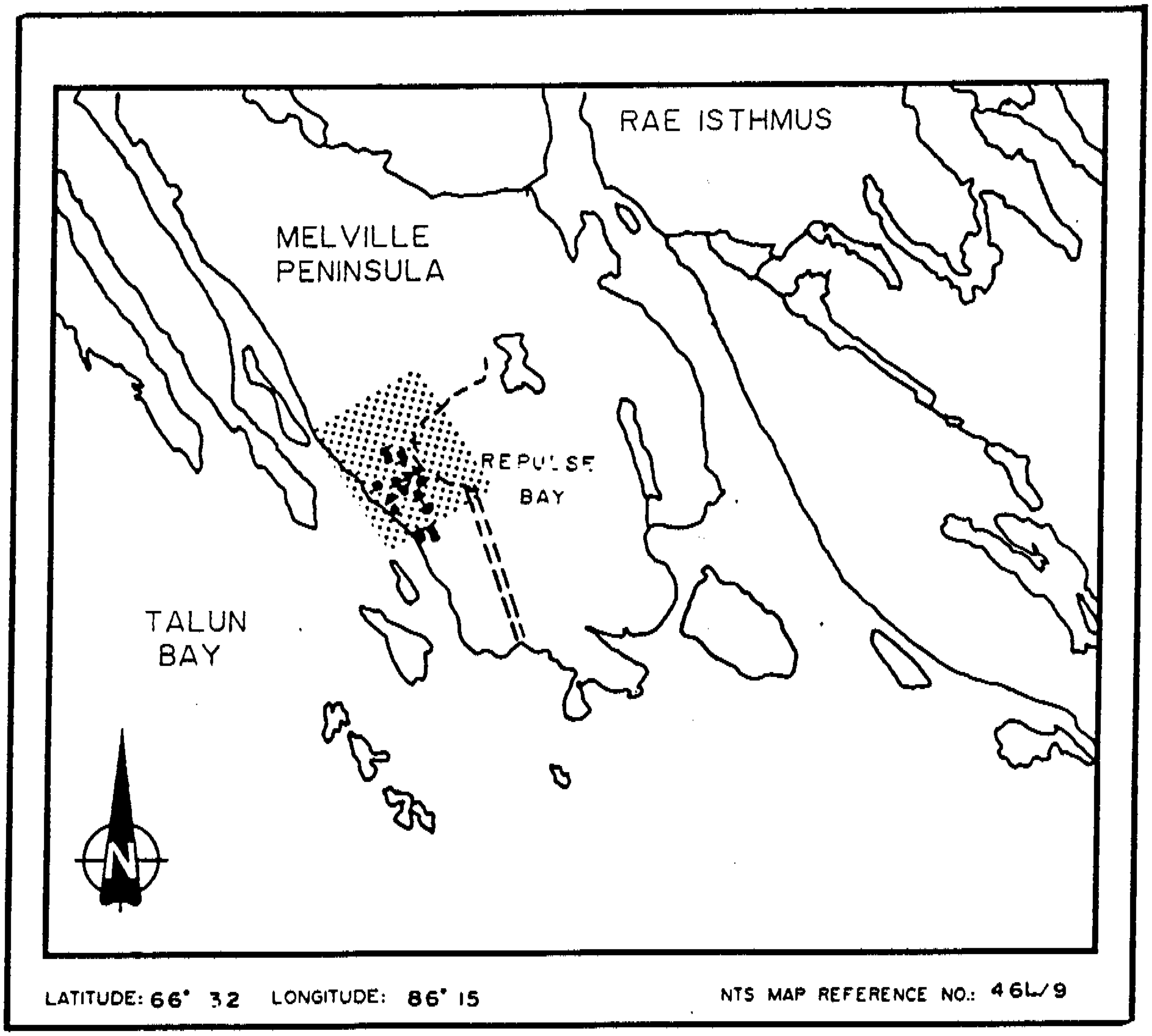
Territorial land use regulations are to be followed in all development plans, without exception, especially in the areas of land use permits, explosives, and pit abandonment.

2. TERRAIN ANALYSIS

2.1 Regional Setting

The community of Repulse Bay is located on the Rae Isthmus adjacent to the northeast shore of the inner harbour of Talun Bay between the Gulf of Bothia and Southampton Island. A site location map is displayed below with geographical co-ordinates and N.T.S. map reference as noted.

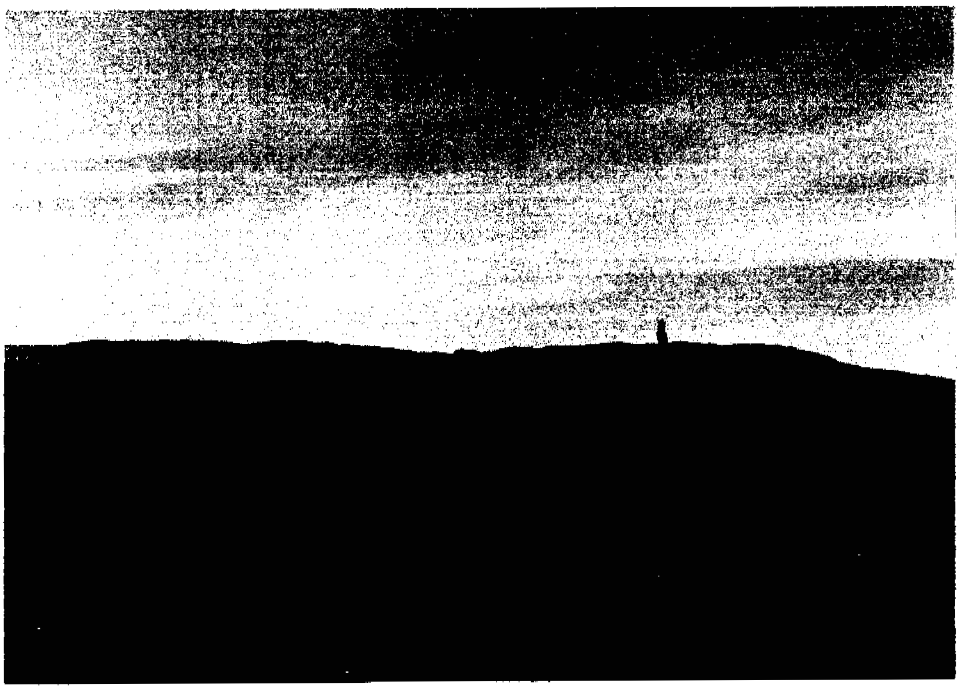
The community of 454 people is 1,424 km. northeast of Yellowknife, in the Keewatin Region of the N.W.T., with an elevation of approximately 24m.



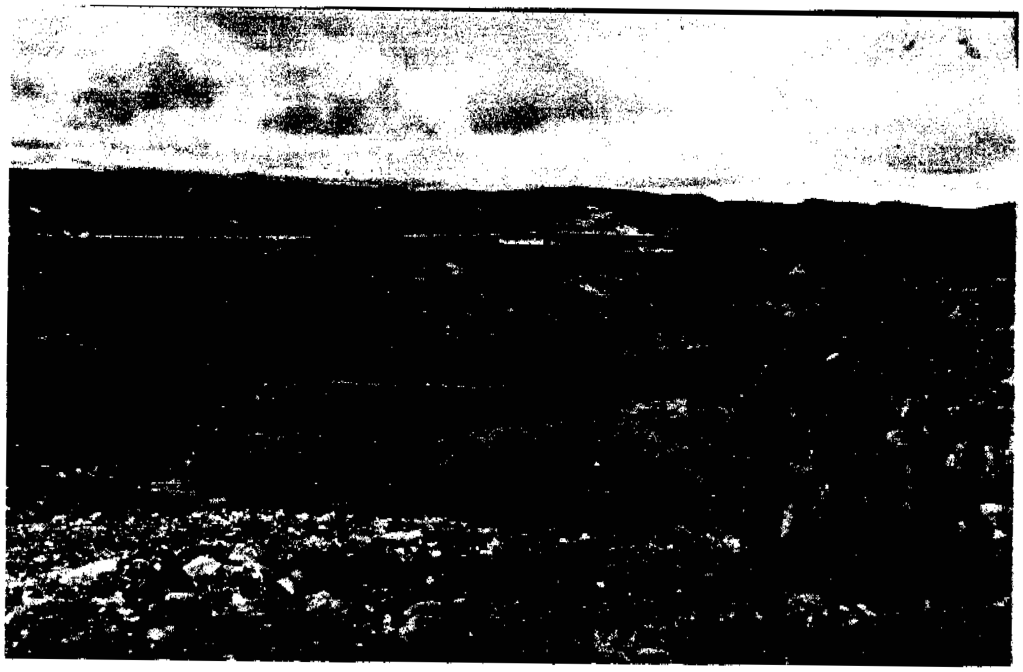
2.2 Geology and Geomorphology

The geology of the area is typical of the Rae Isthmus, which is a narrow neck of land 80 to 100 km. across and about 55 km. wide, that connects Melville Peninsula with the Keewatin bedrock.

The bedrock of the study area is situated within the Churchill structural province and is very old, the bedrock belonging to the Aphebian to Archean ages. Foliation and structural lineaments have a visible north-northwest trend. As seen below, extensive bedrock outcrops are exposed throughout the region in parallel linear ridges that trend in the north-northwest direction. The view is to the northwest.



The bedrock geology consists of granite gneiss. During the Pleistocene glaciation, structural lines of weakness within the granitic bedrock were eroded rapidly, and the land, which formerly may have been a relatively level plateau, was cut up into a series of blocks and knobs separated by steep-sided valleys. As viewed on the following page, blocks begin at the coast where they form narrow, deep, north-northwest trending fjords, and they project inland in the form of valleys.



The geomorphology of the area is extremely rugged and access inland is difficult. During deglaciation, the area was isostatically depressed and waters from Hudson Bay inundated coastal areas presently lying below approximately 125 m elevation. The glacial till was re-worked by wave and current action leaving little or no soil cover over bedrock ridges. Approximately 30 km. northwest of Repulse Bay, where the effect of the marine transgression was less than in coastal areas, glacial deposits are more extensive and landforms such as drumlins and eskers are noted. (Note Figure 2: Source Location Map).

The study area is situated well within the continuous permafrost zone (note Figure 1). Landforms created by permafrost processes were clearly visible during field reconnaissance and include patterned ground and solifluction lobes.

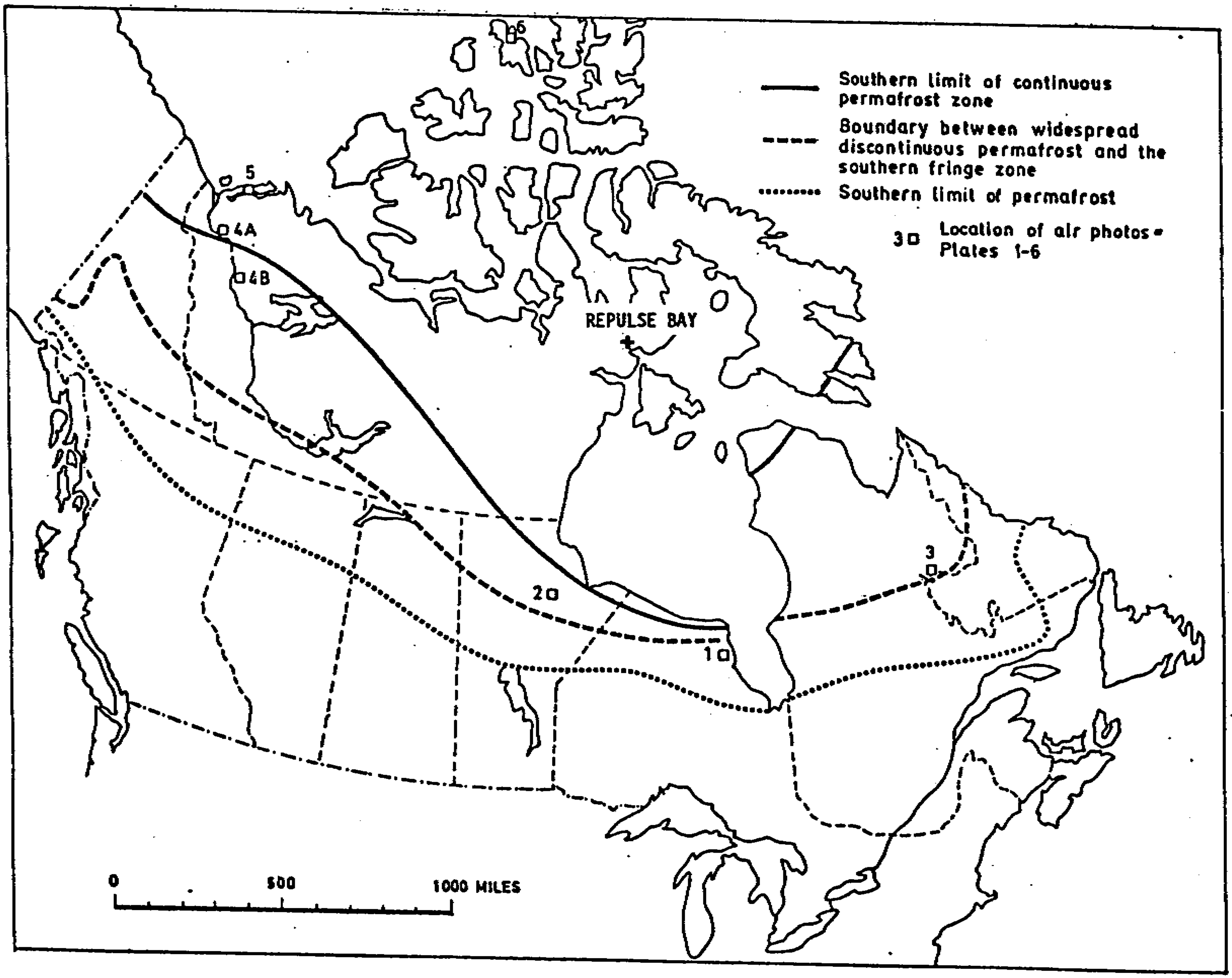
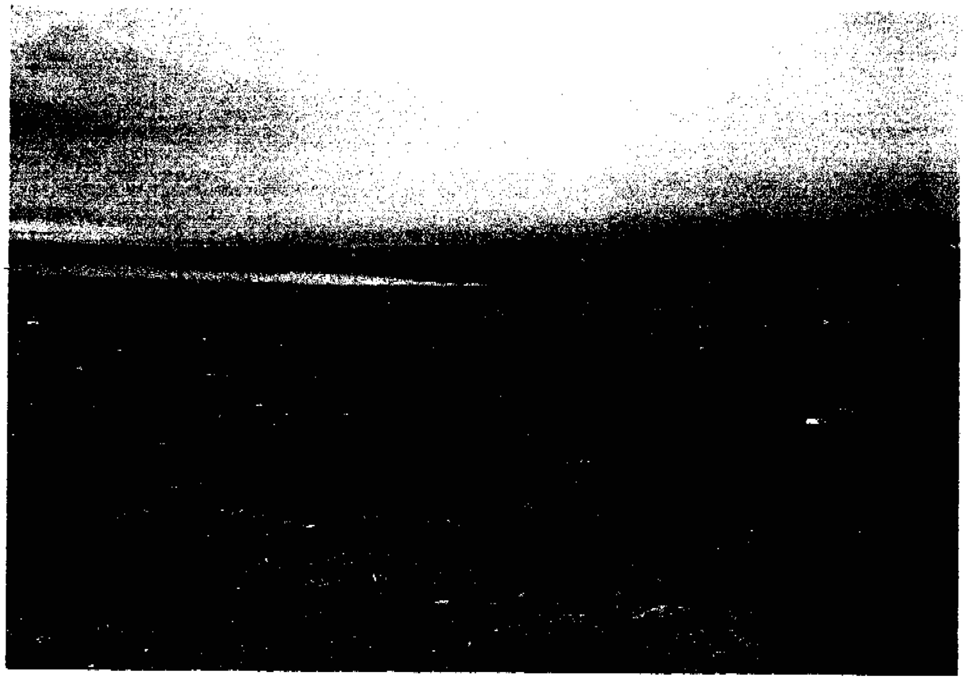


FIGURE 1 PERMAFROST DISTRIBUTION

2.3 Drainage

Surface drainage is controlled by the bedrock valleys. Sheet-like drainage occurs on bedrock knobs, but within the valleys drainage is poor. The valleys typically contain small lakes and ponds, as viewed below, which are rarely connected by well defined streams. Infiltration into the ground is restricted by the presence of well developed permafrost.

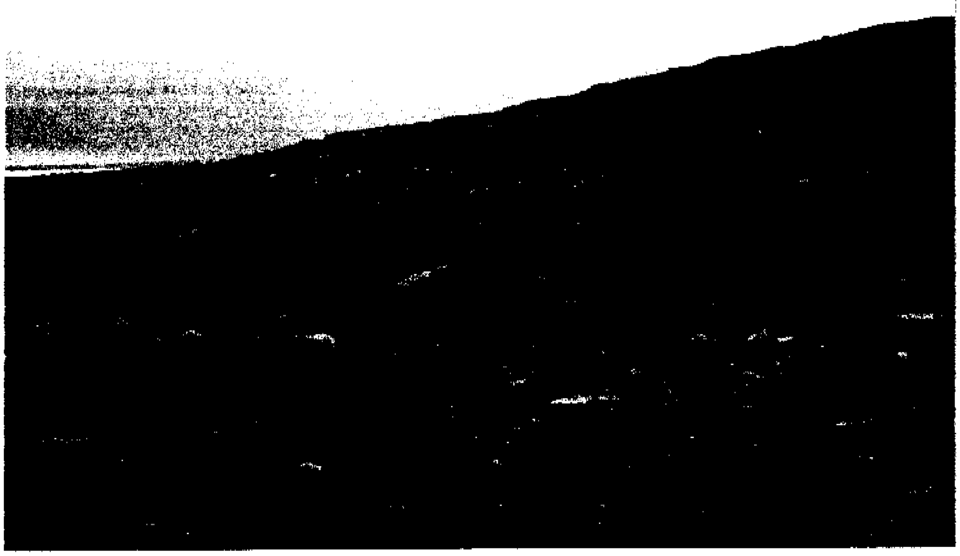


2.4 Environments of Deposition

To explain the existing borrow and potential sources of granular material in the immediate vicinity of Repulse Bay, or lack of it as is the case, the processes that have resulted in the accumulation of surficial deposits in the region need to be addressed. With respect to Repulse Bay, there are only two ways in which surficial granular materials are formed.

The most widespread type of granular source found in the region is related to post-Pleistocene beach ridge deposit. These sources have been nearly exhausted in the vicinity of Repulse Bay. These deposits represent numerous small remanent beaches that were formed at a time when ocean levels were much higher. As seen on the following page, deposits are typically found on gentle northeast facing slopes in association with bedrock outcrops. These sources consist of shallow, angular to subangular coarse sand and over-sized gravel. Often glacial till cover these abandoned beach ridges, increasing the percentage of over-sized material, ranging up to boulder size. (Note Appendix 2).

The second type of deposit widespread in the region is related to the mechanical breakdown of large rock masses in situ. The resulting material (referred to as detritus) contains large angular cobbles and gravels. As seen below, these deposits are related to the weathering of large granitic rock outcrops, are shallow, poorly graded, and consist mostly of angular gneiss fragments.



3. GRANULAR SOURCES AND ASSESSMENT

This section provides an overview of the various existing and potential granular sources within the study area. Each source is described in terms of location, genesis, volume, engineering properties, and development considerations. Test results are found in **Appendix 2**. Note the Granular Source Location Map in **Appendix 4**.

3.1 Existing Sources

At present, there are no existing granular sources in use in the vicinity of Repulse Bay. Beach ridges in and around the community have been stripped for use in the construction of the airstrip, roads, and building pads. As a result of this practice, the land around the community has been extensively scarred and local sources of granular material have been exhausted.

3.2 Potential Sources

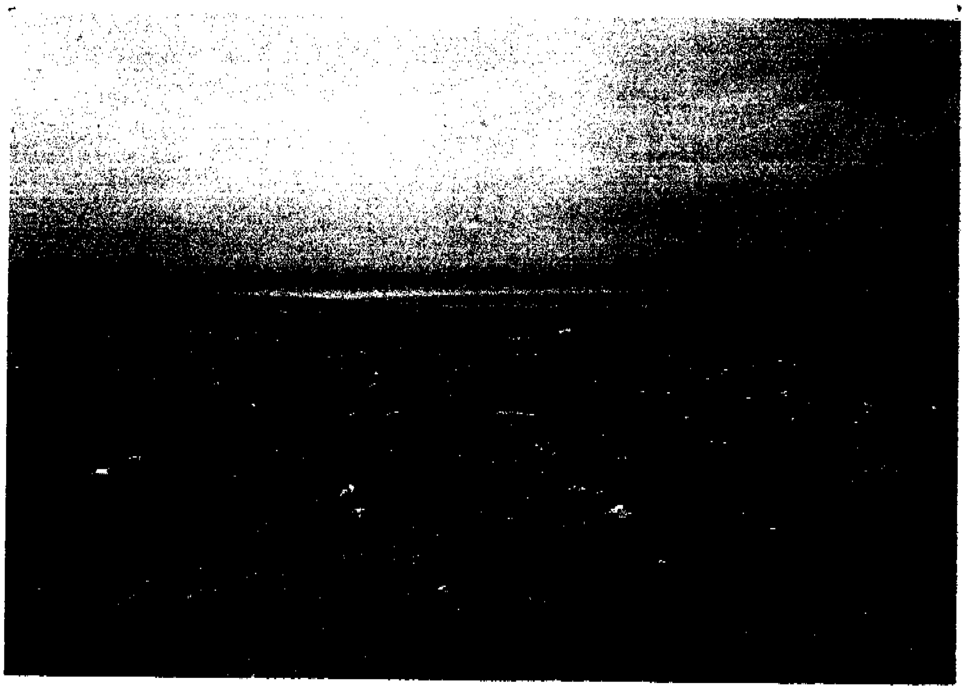
Potential sources of "pitrun" granular material in the vicinity of Repulse Bay are limited in volume, are of poor quality and are inaccessible The geological setting of the community is such that large volumes of quality pitrun granular material simply do not exist in close proximity to the community. As was mentioned, approximately 30 km. inland, glacial deposits are more extensive than in coastal areas; however, the extreme high costs to access, develop and transport the materials to Repulse Bay would normally exclude these sources.

3.2.1 Talun Bay

This deposit is discussed because it has been mentioned by the community and other departments within the G.N.W.T., as a possible potential source of granular material. In view of the urgent need for granular material and the lack of potential sources, a limited site investigation of this source was undertaken in July/1990 (note File 9170-607I-04).

Description/Genesis:

The Talun Bay deposit represents a large beach reach complex situated on the west side of Talun Bay and extends inland along AMITTUTJUAQ LAKE and adjacent valleys. The source is located approximately 5 km. across Talun Bay or 15 km. over land (note Source Location Map). As can be viewed in the photograph below, the source comprises an area of low lying coastal deposits that have been severely re-worked by wave and current action through numerous marine transgressions.



Quantity:

Talun Bay is a sizeable deposit, upwards of 300,000 m^3 perennially frozen embankment material. The deposit covers a large area but due to the frozen nature of the material, the stratigraphic thickness and lateral continuity of the source is difficult to access.

Test Results:

Sample RB-02 was obtained, with difficulty, along the coastal region of Talun Bay. Due to the shallow depth of the test hole, frozen ground was encountered at 0.6 meters; test results may not be truly indicative of the true composition of the material. Several test holes were attempted in various locations, with the same result. Sample RB-02 contained approximately 47% gravel, 50% coarse sand, and 3% fines.

Development Considerations:

Although this deposit is the largest potential source of general fill in the immediate vicinity of the community, transport of the materials to Repulse Bay would be the most significant factor affecting development. Transport alternatives include a travel haul over ice, a distance of 5 km. across Talun Bay, or the construction of an all road, approximately 20 km. across the structural trend of the land. Furthermore, the community does not have the necessary equipment to carry out a winter haul across Talun Bay. Even if the community could haul material from this source, the material would have to be "blasted" to create sufficient volumes for hauling which would only increase the already high cost of production. Another consideration is that this material is marginal at best even as a source of embankment, processing would still be necessary to produce the required volumes of "select" grades. (Note Section 6).

3.2.2 Depleted and Abandoned Sources - Site 1

Description/Genesis:

Site 1 is a representative location for the few remaining remanent beach ridge deposits within the immediate vicinity of the community. As Hudson Bay retreated during post-glacial activity and the land isostatically rebounded, these linear, shallow, beach ridges remained. Site 1 is covered by glacial till. The actual area of Site 1 is seen on the following page. This source represents a typical abandoned borrow deposit. A large number of abandoned and/or depleted beach ridge deposits now extend north and west of the community. This abandoned source is located approximately 3.5 km. northwest of the community.

Quantity:

Site 1 contains approximately 700 m^3 of coarse sand and pebbles. Small pockets of these deposits may contain another 500 m^3 of material.

Test Results:

Sample RB-1 contains approximately 52% gravel, 27% sand and 20% fines. However, frozen ground was encountered at a depth of 0.8 m. The high percentage of gravel is due to the coarse till that covers the site area.

Development Consideration:

These abandoned borrow sources are widespread in the Repulse Bay, especially evident on air photos. In general, individually these deposits no longer contain sufficient quantities for community projects. As additional work is necessary to restore and rehabilitate these sites, field observation indicate that approximately 1,200 m^3 of embankment material would be available to users as these borrow sources are collectively "cleaned-up" and restored. Site 1 is a representative example.

3.2.3 Esker Deposits

Several long esker ridges are located 25 - 30 km. northwest of the community. As these ridges would contain 700,000 m^3 of coarse sand and gravels, they do represent a large potential source of granular material. (Note Source Location Map). However, a 25 km. road would be required, across a series of rivers, bedrock ridges, and poorly drained valleys, to access the deposits from Repulse Bay. Again, the high cost to transport the materials to Repulse Bay would exclude these sources for development, as well, the volume of material needed to construct a 25 km. road is not available in the area between the community and the Esker deposits.

3.3 Quarry Ridges

There are a number of excellent quarry locations within the vicinity of Repulse Bay due to the numerous long, block-like north-south trending, bedrock ridges that exist throughout the study area.

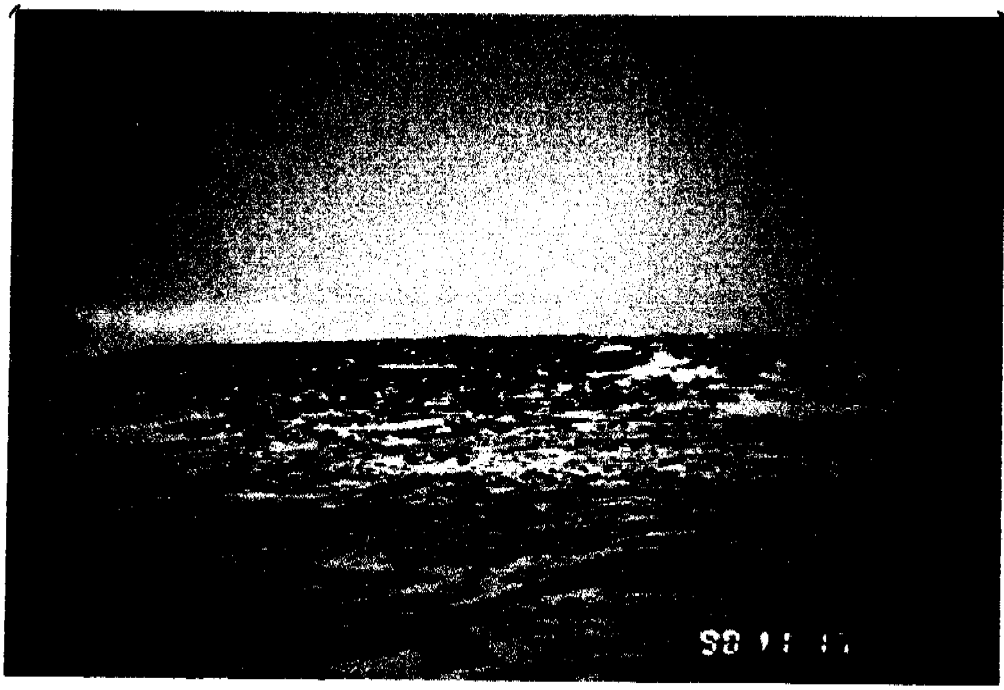
Five quarry sites were located, based on specific geotechnical criteria, within a 4 km. radius of the community. During the investigation, a tour was arranged with Sheldon Dorey (S.A.O.) to examine each of the sites (note Source Location Map). Q_2, approximately 1 km. from the airport, was approved for a "drill and blast" site by the community council on July 14, 1990.

As was mentioned, Q_2 consists of a hard granitic gneiss. Sample RB-03 was removed from the blasted backwall of Q_2; test results show that the rock has a very low abrasion and soundness weight loss indicating an ideal "crushing" rock. When crushed to 19mm, the material produced is approximately 73% gravel, 25% sand sizes, and 2% fines.

As viewed below, Q_2 is typical of the bedrock ridges that surround the community. The ridge is over 200 m. long, 65 m. wide, with an average blasting face of 4 m., and would produce over 50,000 m^3 of blasted material.

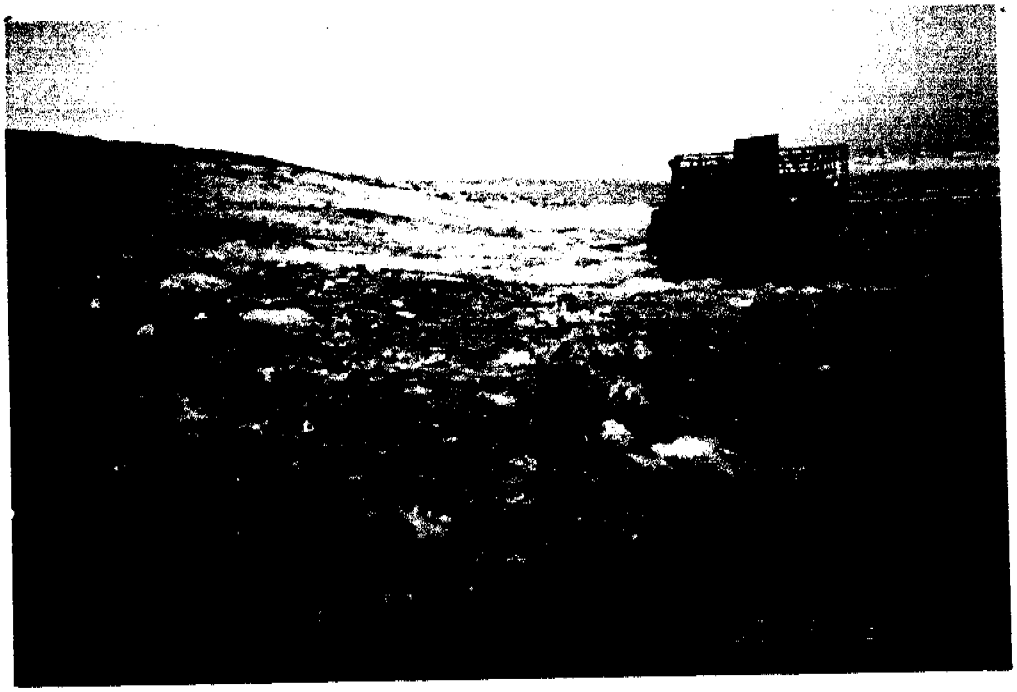
The "blasting" properties of gneiss are such that a tight blasting pattern is needed as the hardness and compressive strength co-efficients are high. Another factor is that owing to the presence of permafrost, the explosive would need to be water resistant.

A major recommendation will be to produce granular material of all grades, for the community, through a "blast/quarry and crush" operation of these gneissic bedrock ridges. A test operation to confirm the efficiency and cost of producing granular material from "drilling and blasting" the numerous bedrock ridges in the vicinity of Repulse Bay was implemented in November, 1990, with satisfactory results. (Note Appendix 3). The following photos represent the results of the initial blast as Q^2 was quarried to produce granular aggregate.

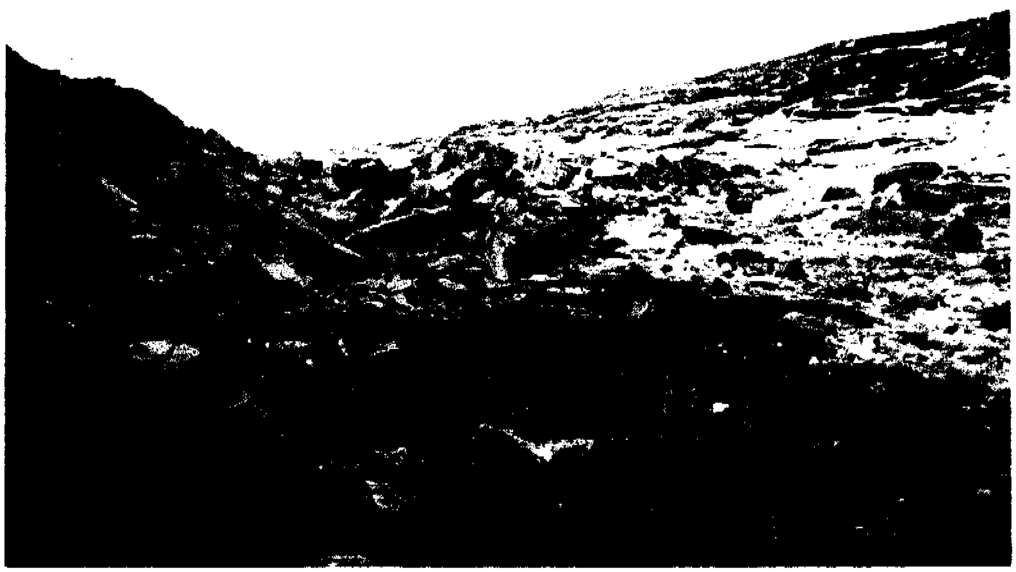


Q_2 - Panoramic view of quarry site, view looking directly south.

Q_2 - 800 cubic meters of fragmented rock produced from first blast, view from top of quarry looking northeast.



Q_2 - Preparing for "blast", view is of quarry floor, loading and stemming of bore holes in progress.



Q_2 - Back break on blast face, view is southeast along quarry face immediately after blast.

Q_2 - Varying grades of material produced from shock wave of blast.

Q_2 - Typical blasted rock, "spoil" will be "mucked" and "sized".

4. GRANULAR RESOURCE EVALUATION

4.1 Supply and Demand

A supply and demand analysis indicates that a significant discrepancy exists between the supply (availability) of naturally occurring granular material and the projected user demand over the next twenty years. (Note Appendix 1).

Just the short term granular need far exceeds existing sources. Of a total ten year forecast demand of approximately 49,000 m^3 of all grades of granular material, there is available less than 1,200 m^3 of marginal embankment and subbase and no select grades, as of November, 1990.

The "drill and blast" operation that was implemented between November 16 - December 4, 1990 will produce enough material to satisfy the highest priority granular needs of the community during the FY 91/92. However, future requirements of all grades of granular material beyond 91/92 will certainly have to be met by the development of potential sources, probably through a series of "drill, blast and screening" operations. The quarry sources will have to be adequate to provide for over 15,000 m^3 of embankment and subbase and 14,000 m^3 of select material between the years 1991 and 1995 just to satisfy the short term granular needs of the community, <u>if</u> the total needs are 100% realized.

4.2 Resource Assessment

As a basis for developing a strategy for future development and management of granular sources, all potential sources and prospective volumes have been mentioned as is required in a report of this nature.

Results indicate that, as naturally occurring "pitrun" sources in the immediate vicinity of Repulse Bay have been depleted, for the most part, and potential sources are practically inaccessible and too costly to develop, there are few options other than drilling and blasting available to produce the necessary granular aggregate.

The demand for granular material is projected to range from 29,000 m^3 by 1995 to as much as 49,000 m^3 by 1999. To meet this demand, a quarry and screening operation is the most cost-effective and efficient option for producing various grades of granular material. Background information concerning such an operation is contained in Appendix 3.

5. RESOURCE DEVELOPMENT

5.1 General

The following preliminary cost estimates are related to the production of granular material from bedrock and "pitrun" sources in the vicinity of Repulse Bay.

At present, there now exists a critical shortage of granular material at Repulse Bay. Thus, the cost to produce granular material, of all grades, becomes the controlling element in satisfying the short and long term granular needs of the community. The major factor that will influence the unit cost of material at Repulse Bay is the METHOD by which the grades of granular material can be produced.

Four methods of producing and/or processing granular material are mentioned below. The high cost of mobilization is a common cost related factor in producing granular material for the community. Accordingly, every effort must be made to minimize mobilization costs.

5.2 Drill, Blast, Crush and Stockpile

Public tenders for a multi-year contract to blast and crush 15,000 m^3 at Repulse Bay were called for by June 15, 1990. Based on the submitted tenders, the cost to crush and stockpile 15,000 m^3 of select grades at Repulse Bay was over \$80/m^3.

Gely Construction, of Montreal, submitted a tender price of \$83.20/m^3. In the bid, the mobilization costs alone were \$840,000 which already exceeded the 1990/91 capital funds that were available for Repulse Bay. This bid was regarded by DPW as unacceptably high but did clearly indicate the need to find alternate ways to economize the production of granular material.

5.3. Gravel Shipments to Repulse Bay

A preliminary estimate of the cost of shipping granular materials to Repulse Bay from Coral Harbour or Chesterfield Inlet was requested by MACA.

Northern Transportation Co. Ltd.'s (NTCL) rough price to load from a stockpile on the beach, transport and unload to a stockpile on the beach was

From Chesterfield Inlet	$275/m^3
From Coral Harbour	$295/m^3

These prices are obviously unacceptably high. Furthermore, the quantities (15,000 m^3) under discussion refer only to select grades. The community desperately needs quantities of embankment material that would still have to be produced locally.

5.4 Seasonal Load, Haul, and Stockpile Pitrun Material

The most critical aspect of producing quantities of pitrun granular material locally is the accessibility of an adequate source. The transport of the materials to Repulse Bay would be the most significant factor affecting the development of local sources.

The development of a quarry and haul operation from the large beach ridge on the west side of Talun Bay has been mentioned. Transport alternatives include a travel haul over ice, a distance of 5 kilometers across Talun Bay to Repulse Bay, or the construction of an all season road, a total distance of approximately 16 km. However, a large part of this road would have to cross the structural trend at the head of Talun Bay, making road construction difficult and expensive. (Note Source Location Map). As for a winter operation, the community does not have the necessary equipment to carry out a winter haul across Talun Bay. As of November, 1990, community equipment consisted of

1 -	D6 Dozer	
1 -	950B Loader*	
1 -	10 m^3 Truck*	
1 -	Grader	(*poor condition)

Another important consideration is that the material at Talun Bay is perennially frozen. Even in July, the material was predominately frozen with only a thawed layer of 0.5 meters. The material would have to be "blasted" to produce the required volume for hauling. This will increase the unit hauling price considerably.

A preliminary cost estimate to winter excavate, haul, and stockpile 15,000 m^3 of embankment material from Talun Bay is approximately \$56.32/m^3 or \$844,800.00. The haul would have to take place in winter and is based on the use of four (4) 10-metric trucks, a D7 dozer with ripper attachments, explosives, a haul time of 30 minutes and a 12 hour shift. All equipment would have to be mobilized and shipped by barge during summer. A summer haul would involve the construction of a 16 km. land route over the rugged, poorly drained terrain surrounding Talun Bay that would triple the per unit price.

Two other considerations are that the Talun Bay material is marginal at best and that even if the community could haul materials from this source, the material would still have to be processed to produce a select grade increasing the unit price even higher, over \$60 per cubic metre.

The esker ridges located 30 km. northwest of the community will contain large volumes of sands and gravel but the high cost of constructing a 30 km. all season road combined with high hauling and engineering costs to develop the source would not make this a cost-effective alternative. The terrain between the eskers and the community is extremely rugged with no sources of material available to construct the road.

5.5 Drill, Blast, and Screen

The feasibility of producing granular material by a "drill and blast" quarry method was confirmed in November, 1990. The quarry was located approximately one (1) km. from the Hamlet. The rock was blasted in a manner that was expected to produce approximately 5,000 m^3 of material that would be suitable for embankment use without further processing. This operation is considered a "test" prelude to producing a much larger volume of material in the future. The "test" operation involved drilling and blasting the bedrock using various blasting patterns (note Appendix 3) to produce different size material. All material greater than 6" (150mm) would be used for embankment. Lesser sizes would be used for select grades. To date, the cost to quarry the bedrock outcrop to produce granular material is approximately \$48.50/m^3. This price does not include the purchase, operating and mobilization costs of a screener; however, these costs would be deferred over a five-year period.

5.6 Cost Assessment

At the present time, a quarry operation to "drill and blast" bedrock to produce various grades of granular material appears to be the most economic and efficient manner of satisfying the granular needs of the community. This method maximizes the Department's Local Involvement initiatives and is "environmentally friendly".

6. RECOMMENDATIONS

It is recommended that, as soon as possible, the Municipality of Repulse Bay implement a Granular Resource Development and Management Plan based on this report and modified as is appropriate by legitimate local concerns that are properly beyond the scope of this report.

The specific technical recommendations of this report are:

1. The remaining granular material in abandoned and nearly depleted pits should be extracted during site clean-up as these pits are restored and rehabilitated. It is estimated that approximately 1,200 m^3 of embankment material would be readily available for use during grading, contouring and overburden replacement of abandoned sites.

2. Geotechnical tests and ground reconnaissance indicate that potential sources of naturally occurring granular "pitrun" in the vicinity of Repulse Bay are NOT cost-effective or efficient to develop, are limited in fines, are of marginal quality, are poorly drained, and for the most part, are inaccessible. As well, development of these deposits would have a negative environmental impact. Future development of these sources is <u>not</u> recommended.

3. The granular needs assessment tables in Appendix 1 give an overview of community granular requirements for specific fiscal years. However, total yearly material requirements are often NOT 100% realized as capital projects are deferred or cancelled, due to limited funding. Due to the severe critical shortage of granular material in the community, it is recommended that granular requirements in future fiscal years be updated and economized so that the highest priority granular needs are met with minimum quantities. In this way, important community capital projects will not be deferred because of a lack of granular aggregate.

4. The feasibility of quarrying bedrock sources in the vicinity of Repulse Bay, on an economic and efficient basis, to produce various grades of required granular material has been confirmed. It is recommended that, of the options available, the "drill and blast" quarry method of producing embankment material should be continued.

5. It is recommended that tenders be called in FY 1991/92 to drill and blast bedrock sources to produce 15,000 m^3 of granular material. A continuation of the rock quarry at Q_2 is recommended.

6. The mobilization of a screener to Repulse Bay in FY 1991/92 is recommended to process the blasted "spoil" so as to produce select grades of material as and when required.

7. Furthermore, hamlet equipment has to be upgraded if the community is to become self-sufficient in granular material. There are no local contractors and existing hamlet equipment is not adequate for most capital projects. One example is that if the "drilling and blasting" of bedrock sources continues, the contractor will need a "backhoe" to move, extract and "size" the blasted fragmented rock. Presently there is no "backhoe" in the community and existing equipment is not sufficient or designed for a major rock quarry operation.

REFERENCES

Annual Book of Standards, American Society for Testing and Materials, (ASTM), various rock and foundation tests and standards.

Department of Indian and Northern Affairs, 1982, Environmental Guidelines Pits and Quarries.

Department of Energy, Mines and Resources, 1970, Geology and Economic Minerals of Canada, Ottawa, Canada.

Department of Public Works, G.N.W.T., 1986, Community Granular Study on Repulse Bay, N.W.T., Yellowknife.

Department of Public Works, G.N.W.T., Soil Classification System, Yellowknife.

Dupont, Sales Department, 1980, Blasting Handbook, 16th Edition, Delaware, U.S.A.

Embleton and King, 1971, Glacial and Periglacial Geomorphology, London

Krynine and Judd, 1957, Principles of Engineering Geology and Geotechnics, McGraw-Hill Civil Engineering Series, Toronto.

Putman, Brian, Lands Officer, Department of Municipal and Community Affairs, G.N.W.T., Rankin Inlet.

Sowers, George F., 1979, Introductory Soil Mechanics and Foundations: Geotechnical Engineering, Fourth Edition, MACMILLAN Publishing Co. Inc., New York.

Thurber Consultants, 1981, Repulse Bay, Borrow Search, File 15-23-15, Calgary, Alberta.

GLOSSARY OF TERMS

Active layer:	the layer of ground in permafrost which thaws each summer and refreezes each fall.
Alluvial fan:	fan shaped mass of alluvial deposits shed by fluvial activity from mountain streams.
AASHTO:	American Association of State Highways and Transportation Officials, used almost exclusively by the several state Departments of Transportation and the Federal Highway Administration in earthwork specifications for transportation lines.
Archean:	a Precambrian time-strategraphic classification; the oldest eon within the Precambrian, 2,480 million years.
Blocked-drainage:	a distinct beaded or feathered drainage pattern due to the presence of poorly drained soils in permafrost regions.
Colluvial sediments:	sediments transported and deposited through the process of mass wasting (i.e. by gravity).
Continuous permafrost zone:	an area underlain by permanently frozen subsoil.
Crushed Rock:	is produced by passing blasted bedrock or pitrun through a mechanical crusher to produce angular fragments.
Deltaic deposits:	deposition of sediments by rivers in low energy environments, characterized by well-developed cross-bedding and sands, silts and clays.
Detritus:	the accumulation of non-stratified rock fragments through the weathering of large rock outcrops in situ.

Drumlin:	rounded streamline mounds of till.
Environment of deposition:	the lithology, composition, and diversity of all granular deposits are directly related to part and modern depositional and erosional environments.
Eskers:	a long narrow, winding ridge composed of stratified accumulations of sand and gravel produced from subglacial streams; eskers are aligned with the flow of retreating glaciers or ice sheets.
Frost Susceptible Soil:	soil in which significant ice-segregation will occur, resulting in frost heave, or heaving pressures, when requisite and freezing conditions exist.
Frost wedging:	water expanding as it freezes widens crevices in well-bedded or well-jointed rock and shatters it.
Glacial Till:	unstratified glacial drift deposited directly by the ice.
Ground-truth reconnaissance:	the physical act of acquiring data on the ground to prove geological assumptions.
In-situ:	the natural undisturbed soil or strata of weathered material in place.
Isostatic Rebound:	the upward movement of the earth's crust to achieve a general equilibrium as the great weight of the continental ice sheets decrease.
Kame Terrace:	a steep-side, constructional terrace consisting of stratified sand and gravel formed as a glacio-fluvial deposit between a melting glacier or a stagnant ice lobe and a higher valley wall or lateral moraine.

Pitrun:	unprocessed gravel containing a minimum of 35% coarse aggregate larger than #4 sieve.
Raised beaches:	beaches formed during times of high water level and then stranded by the lowering of the water level or by the elevation of the land.
Regolith:	unconsolidated mantle of weathered rock and soil material on the earth's surface.
Solifluction:	in subarctic regions, fine rock fragments when saturated with water, spread slowly down slope and along valley floors.
Syncline:	a trough or downfold in the rocks.
Talus slope:	the accumulation of small fragments (scree) in the millimeter-to-meter range from cliffs or steep walls that maintain a uniform slope (commonly about 30°) as it grows.
Territory Land Use Regulations:	provides regulatory control for maintaining sound environmental practice for any land use activity on all lands under Federal control in the territories.
USC:	United Soil Classification System, used for foundation engineering such as dams, buildings, road earthwork specifications, and airfield design.
Varved sediments:	distinct band representing the annual deposit in sedimentary materials.
Wisconsin glaciation:	the latest of the various ice sheets of the Pleistocene epoch, approximately 10,000 years ago.

APPENDIX 1

GRANULAR NEEDS ASSESSMENT TABLES

Based on the G.N.W.T. 5 Year Capital Plan

GRANULAR NEEDS ASSESSMENT

As previously indicated, the granular requirements for Repulse Bay have been developed from each G.N.W.T. Department's 5 year capital plan and 20 year capital needs assessment, as well as information from the NWTHC, Federal Agencies and the private sector. The various projects were analyzed for their granular requirements and this information was used as the basis for establishing a 20 year granular needs projection by the type of materials required.

The information upon which this report is based is as accurate as could be found in November, 1990. To revise it and the conclusions drawn from it to keep them up to date has been impossible. Therefore, comparison with the approved capital plan for 90/91 will certainly show differences. However, the objective was to make a reasonable assessment of needs for granular materials in Repulse Bay for the period noted. Since the changes brought about each year by the capital planning process will tend to reduce the quantities required and, to some extent the substitution of one project for another will probably have a relatively small effect on the totals, this approach is considered fair and reasonable. Furthermore, continual surveillance of the sources and the quantities extracted will show when additional sources must be developed.

The analysis shows that Repulse Bay requires approximately 56,000 m^3 of granular materials for fiscal years 1990/91 through 1998/99. This information is shown in part on the following pages, as is a summary of the projected requirements for fiscal years 1998/99 through 2000/2009. Detailed information for this later period is available from office files. If consulted, the data should be considered rather speculative at best.

For the purpose of this report, granular materials have been separated into five major types: embankment, subbase, base, surfacing and concrete aggregate. However, base, surfacing, and concrete aggregate are often referred to collectively as "select grades". The reason for this is that embankment and subbase materials are often used directly from a source as "pitrun" while select grades are obtained through the processing of the material by washing, screening or crushing.

Table 2 represents the granular material breakdown of capital projects that was used to develop this section of the report. This information was then used to derive the granular needs assessment tables for individual fiscal years displayed in Table 3.

5.1 TABLE 2: CAPITAL PROJECTS

Granular Material Breakdown
(in cubic metres)

Description	Embankment	Sub Base	Base	Surface Material	Concrete Aggregate	Riprap
Warehouse		900	450	300		
Group Home		500	175	300		
Solid Waste Facility	9000		3750	2250		
Solid Waste Facility/ Access (1 km.)	13900		1300	200		10
Solid Waste Improvements	6000		2500	1500		
Water Supply Improvements	6000		2500	1500		
Water Supply - Reservoir	30000	10000	10000			
WS-Facility Access	10000		5000	3000		
R/S/L - Lot Development (1 lot)		180	80	100		
R/S/L - New Road (1 km.)	4900		1300	1200		100
R/S/L - Resurfacing (l km.)	600		200	1200		50
R/S/L - Road Upgrade (l km.)				1000		
Staff Housing		400	175	200		
Single Unit (Satellite base)		300	100	200		
Duplex		500	175	200		
4-plex		675	225	200		

Description	Embankment	Sub Base	Base	Surface Material	Concrete Aggregate	Riprap
In town gas station		600	200	200	50	
Garage x 2 Bay x 3 Bay		600	200	200	50	
Firehall		350	100	200	50	
New School		400	100	200	200	
School Addition		200	50	100	100	
Museum - Low$		200	50	100	100	
Small Community Hall (250m2)		300	100	200		
Medium Community Hall (390m2)		500	175	200		
Large Community Hall (440m2)		675	225	200		
Hamlet Office		500	175	200		
Small Gym (250m2)		300	100	200		
Medium Gym (390m2)		500	175	200		
Large Gym (440m2)		675	225	200		
Medium Arena		675	225	200		
Trade Shop		300	100	200		
Small Arena		500	175	200	100	
Skating Rink		500	175	200	100	
Airstrip - New 60 x 900	81000		16200	5400		
Airstrip - Upgrade Maint/year				1700		
Airstrip - Resur-face 60 x 900				5400		

Description	Embankment	Sub Base	Base	Surface Material	Concrete Aggregate	Riprap
Tankfarm - new facility	3000		2000	3000		
Tankfarm - upgrade	300	300	300			
Tankfarm - facility & access	6000		2000	6000		
Increase capacities	6000		2000	6000		
Shoreline Protection				600	-	4000
Sewage Lagoon	100,000m^3					
Office - small	Duplex	500	175	200	(visitor centre)	
Office - large	4-plex	675	225	200		
Arena - large		850	275	200		
Park Development (Low$)	600		200	1200		50
(High$)	4900		1300	1200		100

TABLE 3
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
SUMMARY
(Volumes in cubic metres)

FISCAL YEAR	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP	ANNUAL TOTAL
1990 - 1991		3,615	1,515	1,700			6,830
1991 - 1992	2,100	2,600	1,800	1,500			8,000
1992 - 1993	4,500		3,000	3,050			10,550
1993 - 1994		1,200	400	800			2,400
1994 - 1995	1,200	3,700	1,800	2,300			9,000
1995 - 1999	5,823	4,240	3,341	6,301	150	14	19,869
1999 - 2009	7,470	4,600	4,840	4,360		15	21,285
20-YEAR TOTAL	**21,093**	**19,955**	**16,696**	**20,011**	**150**	**29**	**77,934**

TABLE 4
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1990 - 1991
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
MACA						
Medium Arena		675	225	200		
Residential Core		1,440	640	800		
RENEWABLE RESOURCES						
Office Warehouse		900	450	300		
HOUSING						
2 Units		600	200	400		
TOTAL REQUIREMENTS		**3,615**	**1,515**	**1,700**		

TABLE 5
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1991 - 1992
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
MACA						
Residential (Shoreline)	1,200	2,300	1,200	1,500		
HOUSING						
3 Units	900	300	600			
TOTAL REQUIREMENTS	**2,100**	**2,600**	**1,800**	**1,500**		

TABLE 6
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1992 - 1993
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
MACA Phase 4						
M.A.C.A. Solid Waste Improvements	3,000		2,500	1,250		
ECONOMIC DEVELOPMENT Historic Site and Trail	600		200	1,200		
HOUSING 3 Units	900		300	600		
TOTAL REQUIREMENTS	**4,500**		**3,000**	**3,050**		

TABLE 7
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1993 - 1994
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
HOUSING						
4 Units		1,200	400	800		
TOTAL REQUIREMENTS		**1,200**	**400**	**800**		

TABLE 8
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1994 - 1995
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
MACA						
Residential Core	1,200	2,500	1,400	1,500		
HOUSING						
4 Units		1,200	400	800		
TOTAL REQUIREMENTS	**1,200**	**3,700**	**1,800**	**2,300**		

TABLE 9
GRANULAR NEEDS ASSESSMENT
REPULSE BAY CAPITAL PROJECTS ESTIMATED MATERIAL REQUIREMENTS
1995 - 1996
(Volumes in cubic metres)

PROJECT	EMBANKMENT	SUBBASE	BASE	SURFACING MATERIAL	CONCRETE AGG.	RIPRAP
M.A.C.A.						
Residential Core	1,500	1,000	1,200	1,723		
HOUSING						
2 Units		600	200	400		
TOTAL REQUIREMENTS	**1,500**	**1,600**	**1,400**	**2,123**		

Northwest Territories Public Works

SAMPLE DATA SHEET

PROJECT REPULSE BAY GRANULAR INVESTIGATION	PROJECT NUMBER 90-9170-6071-04

PART 1 - COMPLETED IN THE FIELD

SAMPLE IDENTIFICATION RB - 02	METHOD OF SAMPLING Shovel	
LOCATION Talun Bay Coastal Area 5 km. Across Bay		
TEST HOLE NUMBER #2	DEPTH 0.65 meters	Permafrost encountered
FIELD DESCRIPTION Large cobbles on surface of frozen ground, snow in hollows, coarse sand, little "fines"		
LAB TESTS REQUIRED W.S.A., visual, Grain Curve, U.S.C.		
SAMPLED BY Fred Collins	DATE D/M/Y 15/07/90	SAMPLE DISCARDED RETAINED

PART 2 - COMPLETED IN THE LABORATORY

DATE RECEIVED	RECEIVED BY
REQUESTED COMPLETION DATE D/M/Y	RESULTS SUBMITTED TO

PART 3 - LABORATORY TEST RESULTS AND COMMENTS

Visual

Very coarse dark brown, poorly sorted, sand, with large cobbles and pebbles,subangular, little fines

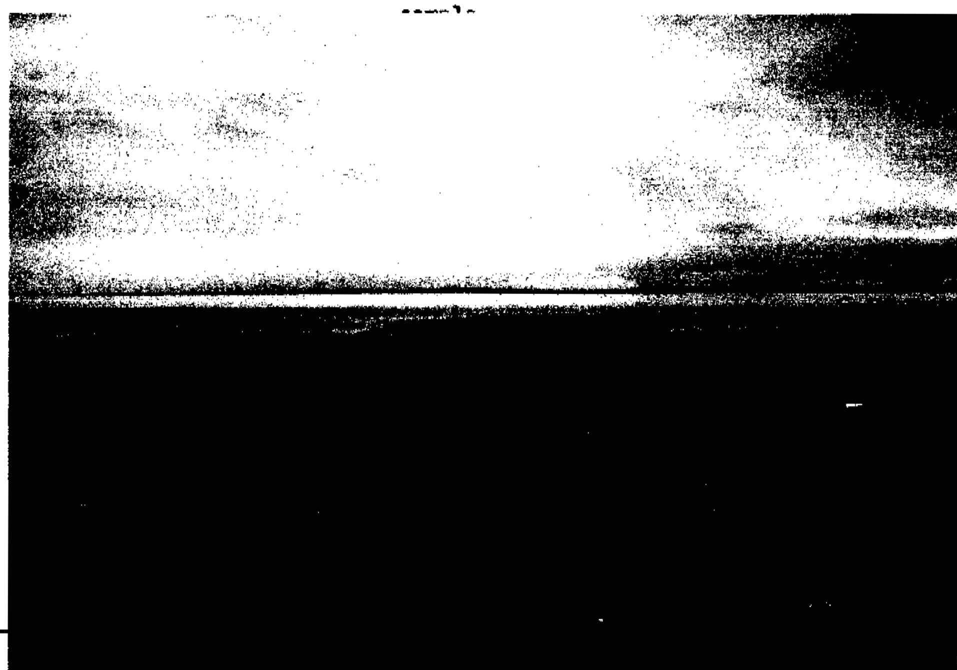
W.S.A.

Gravel	=	46.9%
Sand	=	50.1%
Fines	=	3.0%

* As the ground was frozen below 0.6 meters, it was difficult to obtain a truly representative sample.

U.S.C.

SP



COMPILED BY		
REVIEWED BY	DATE D/M/Y	ATTACHMENTS ____ PAGES

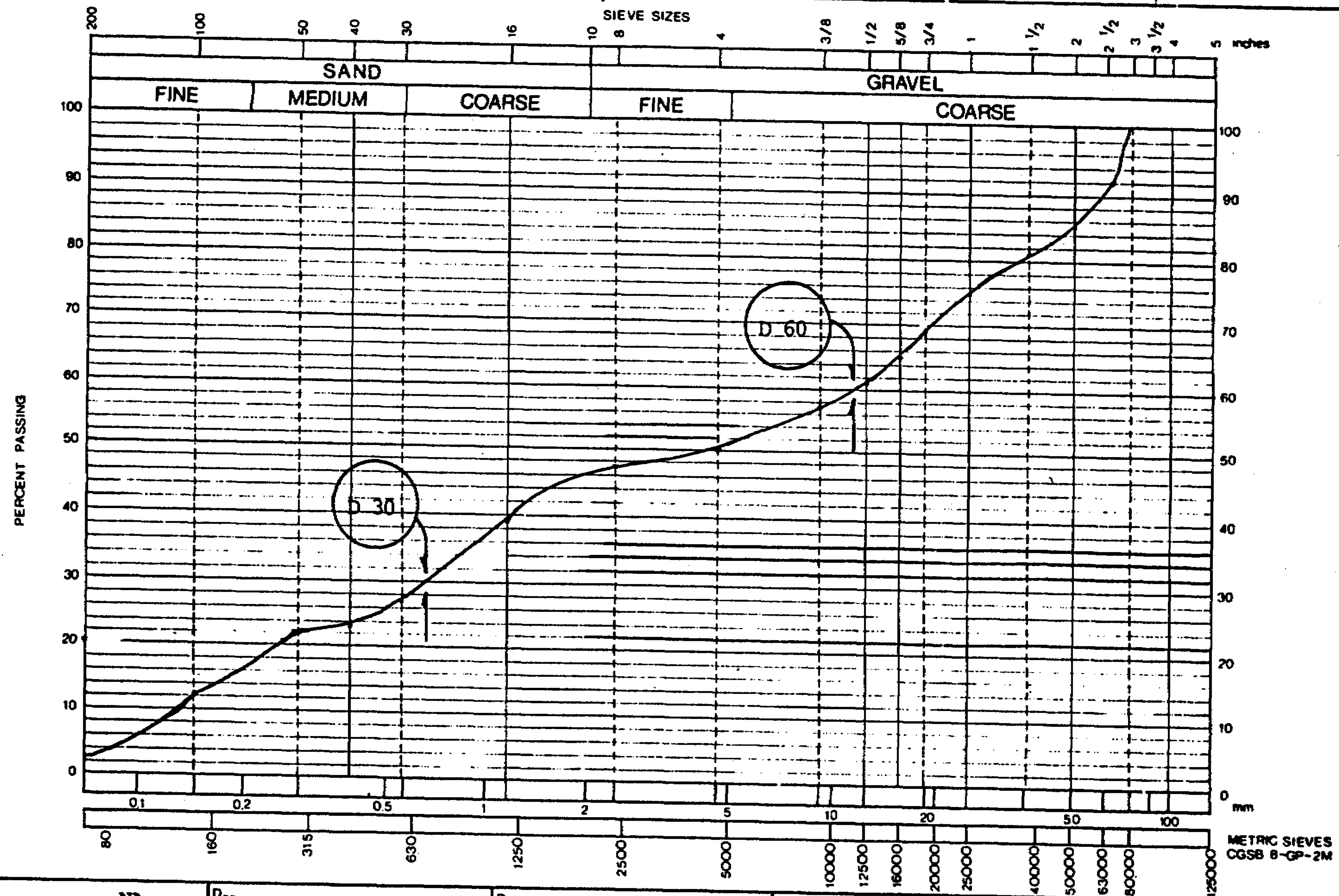
NWT 2601/0886

F-0486 - 016

Northwest Territories Canada

GRAIN SIZE CURVES

SAMPLE IDENTIFICATION	TESTED BY
AB-02 REPULSE BAY - Talun Bay	



D_{10}	D_{30}	D_{60}	C_u	C_c
NA	0.650	12.000	NA	NA

NWT 1785/0787

Northwest Territories Public Works

SAMPLE DATA SHEET

PROJECT REPULSE BAY GRANULAR INVESTIGATION	PROJECT NUMBER 90-9170-6071-04

PART 1 - COMPLETED IN THE FIELD

SAMPLE IDENTIFICATION RB-03	METHOD OF SAMPLING Quarry Wall	
LOCATION Q_2 - 1 kilometer west of airport		
TEST HOLE NUMBER #3	DEPTH Surface	
FIELD DESCRIPTION From proposed Quarry - #2 front face		
LAB TESTS REQUIRED Crush to 19mm, U.S.C., W.S.A., Soundness, L. A. Abrasion.		
SAMPLED BY Fred Collins	DATE D/M/Y 16 / 07 / 90	SAMPLE DISCARDED RETAINED

PART 2 - COMPLETED IN THE LABORATORY

DATE RECEIVED	RECEIVED BY
REQUESTED COMPLETION DATE D/M/Y	RESULTS SUBMITTED TO

PART 3 - LABORATORY TEST RESULTS AND COMMENTS

Quarry Sample Crushed to Minus 19mm.

W.S.A.

Gravel	=	73.2%
Sand	=	25.2%
Fines	=	1.6%

U.S.C.

GW

L. A. Abrasion

1.45% weight loss

Soundness

2.17% weight loss

COMPILED BY		
REVIEWED BY	DATE D/M/Y	ATTACHMENTS ______ PAGES

NWT 2601/0886

F-0486 - 016

Northwest Territories Public Works

WASHED SIEVE WORK SHEET

PROJECT	Quarry Rock
SAMPLE IDENTIFICATION	Repulse Bay
SAMPLE DESCRIPTION	

A) MASS BEFORE WASHING 18674.1 grams
B) MASS AFTER WASHING 18418.0 grams
C) MASS PASSING No. 200 256.1 grams

TESTED BY HBT - MS & VC
DATE D-M-Y 08-09-89

SIEVE SIZES U.S.	SIEVE SIZES Metric	MASS RETAINED	MULTIPLY BY FACTOR	MASS RETAINED	PERCENT RETAINED	PERCENT PASSING		FACTOR
3"	75						X	△ PAN X / AMOUNT for Y
2 1/2"	67						X	
2"	50						X	
1 1/2"	37.5						X	
1"	25					100	X	
3/4"	19	451.0	△		2.4	97.6	Y	
5/8"	16	1864.4	△		10.0	87.6	Y	
1/2"	12.5	4076.0	△		21.8	65.8	Y	
3/8"	9.5	3877.4	△		20.8	45.0	Y	
No. 4	4.75	3690.6	△		19.8	25.2	Y	
No. 8	2.36	1417.2	▲		7.6	17.6	Z	▲ PAN Y x △ / AMOUNT for Z
No. 10	2	189.6	▲		1.0	16.6	Z	
No. 16	1.18	629.5	▲		3.4	13.2	Z	
No. 30	0.600	653.7	▲		3.5	9.7	Z	
No. 40	0.425	321.8	▲		1.7	8.0	Z	
No. 50	0.300	350.3	▲		1.9	6.1	Z	
No. 100	0.150	516.4	▲		2.8	3.3	Z	
No. 200	0.075	326.4	▲		1.7	1.6	Z	
PAN		50.3+256.1	▲		1.6			AASHTO T-11 and 27
MATERIAL WASHED PASSING No. 200			C	256.1				
TOTAL RETAINED		18670.7		D				

COMMENTS Crush count - 100.0%
A.S.T.M. C-88 Coarse Aggregate Weight Loss - 1.46%
Fine Aggregate Weight Loss - 2.17%
(Sulfate soundness)

$$\text{ERROR} = \frac{A\ 18674.1 - D\ 18670.7}{A\ 18674.1} \times 100 = 0.02\ \%$$

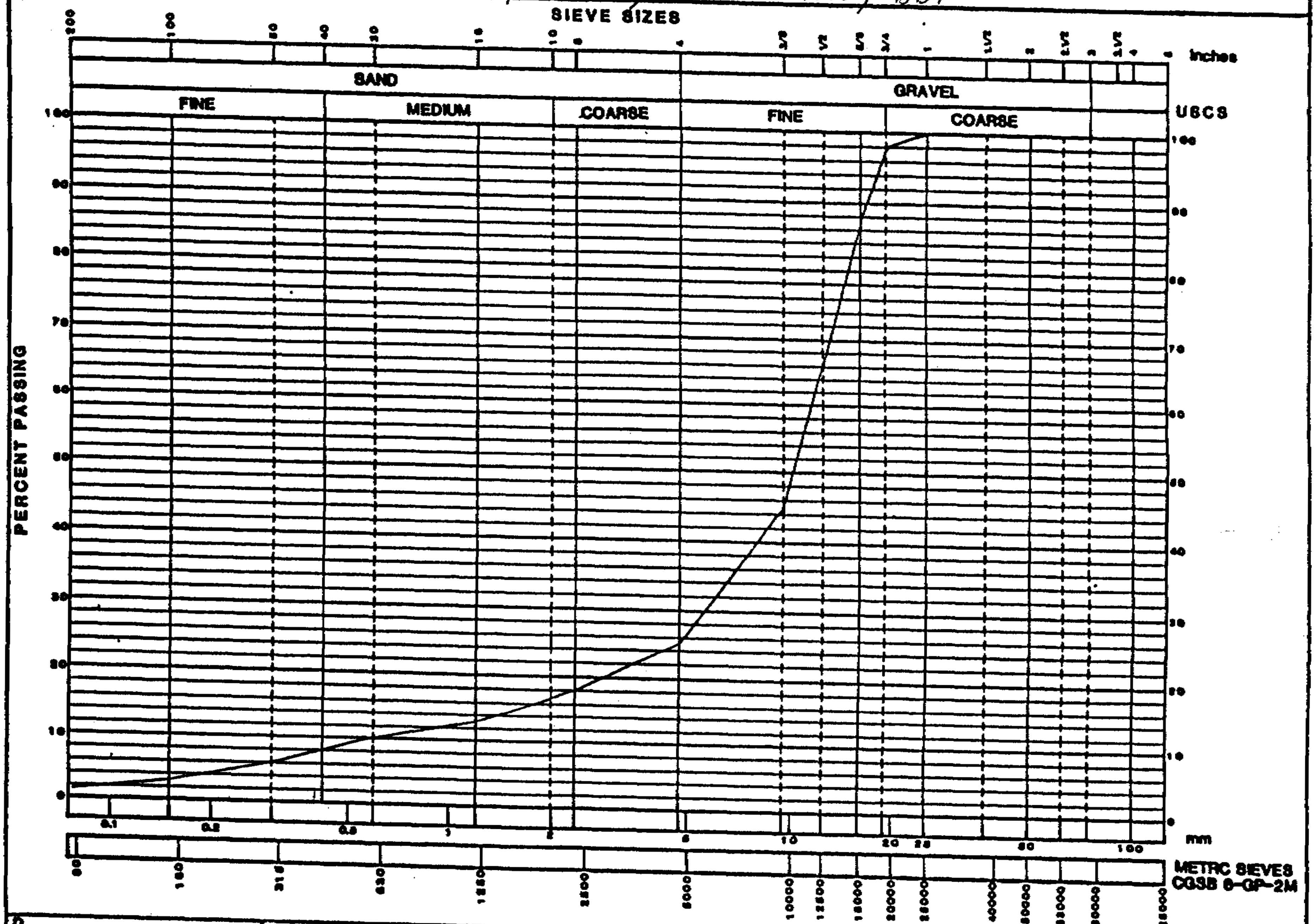
COMPILED BY HBT - VC	DATE D-M-Y 10-10-89
REVIEWED BY	DATE D-M-Y

F-077

GRAIN SIZE CURVES

SAMPLE IDENTIFICATION Q2 - RB-03 Repulse Bay

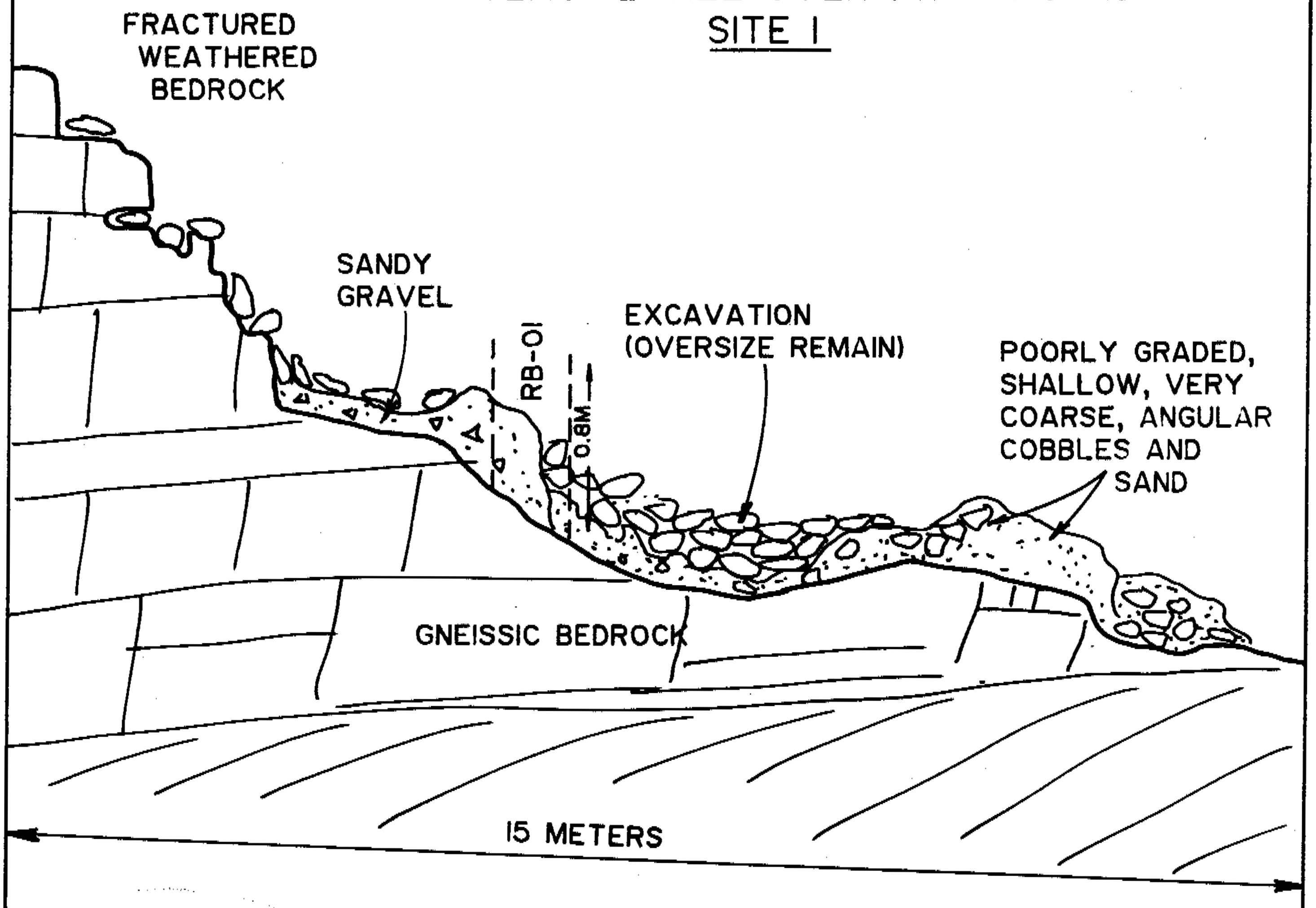
TESTED BY Hardy BBT



D_{10}	D_{30}	D_{60}	C_u	C_c

TYPICAL BEACH RIDGE DEPOSIT
TEST HOLE PROFILE RB-01
(ABANDONED SOURCE)

GLACIAL TILL OVER BEACH SAND
SITE 1



Northwest Territories Public Works

Checked by
Approved by
REVISIONS

Date	By

COMMUNITY PROGRAMS SECTION
ENGINEERING DIVISION

REPRESENTATIVE CROSS SECTIONS
REPULSE BAY - SITE 1

Drawn by	Date	Scale	Dwg. No.
B. ROCHON	FEB./91	N.T.S..	

APPENDIX 2

GEOTECHNICAL DATA 1990

Laboratory Test Results
Grain Size Curves
Cross Sections

SAMPLE DATA SHEET

TEST RESULT '3'

PROJECT Repulse Bay Granular Study	**PROJECT NUMBER** -9170

PART 1 – COMPLETED IN THE FIELD

SAMPLE IDENTIFICATION Site #1	**METHOD OF SAMPLING** Hand Shovel
LOCATION 3.5 Km from Hanlet, North Side	
TEST HOLE NUMBER #3	**DEPTH** .8-1.2 m

FIELD DESCRIPTION Gravelly Sand, high % oversize, re-worked till, no fines, very coarse

LAB TESTS REQUIRED U.S.C., Visual, Grain Curve,

SAMPLED BY F. Collins	**DATE D/M/Y**	**SAMPLE DISCARDED** XX	**RETAINED**

PART 2 – COMPLETED IN THE LABORATORY

DATE RECEIVED	**RECEIVED BY** T. Robson
REQUESTED COMPLETION DATE D/M/Y	**RESULTS SUBMITTED TO**

PART 3 – LABORATORY TEST RESULTS AND COMMENTS

VISUAL DESCRIPTION: Gravelly Sand - Angular to sub angular aggregates
- Max. Size - 70 mm X 34 mm
Nominal Size - 34 mm

Composition - Rose Granites; Granite Gneiss with Fracture lines showing Iron deposits Carbonates - Calcium; Dolomite

Fines - Composition; pebbles-sub-angular to sub-rounded, sand-medium to fine, greyish brown with trace silt and clays.

DRY SIEVE ANALYSIS: Gravelly sand with 25.8% coarse fraction retained on 4.75 sieve and 0.4% passing 0.075 sieve.

CLASSIFICATION: SP - Poorly graded sands, gravelly sands little or no fines.

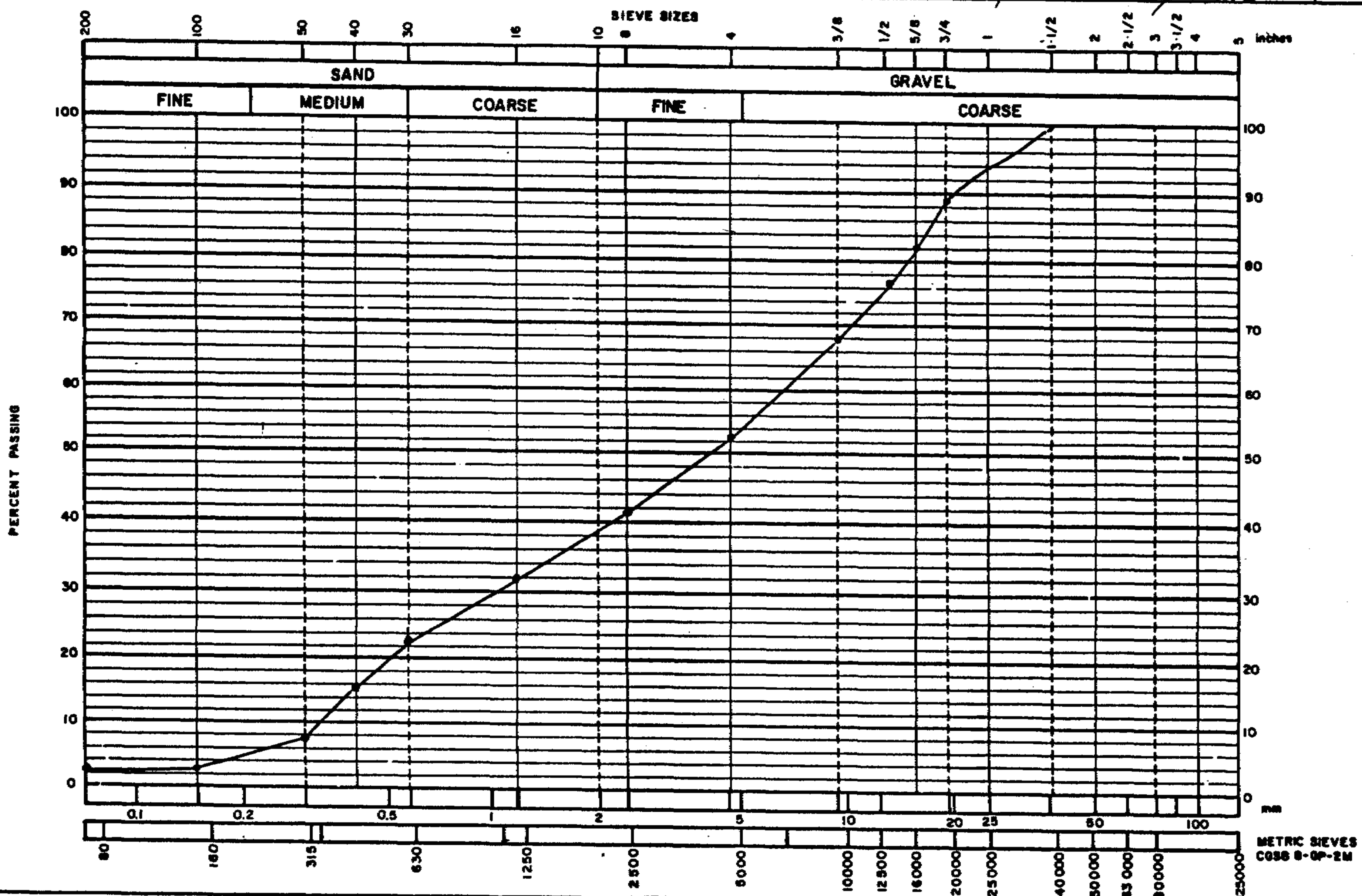
COMPILED BY T. Robson

REVIEWED BY	**DATE D/M/Y**	**ATTACHMENTS** ______ **PAGES**

Northwest Territories Public Works and Highways

GRAIN SIZE CURVES

SAMPLE IDENTIFICATION	TESTED BY
Site 1 - Abandoned - RB-01	EBA Repulse Bay RB-01



D_{10}	D_{30}	D_{60}	C_u	C_c
.375	1.15	7.25	19.3	.49

NWT 1786/0886

APPENDIX 3

Test Blast Results

Repulse Bay, N.W.T.
Nov 16 - Dec 04 1990

REPULSE BAY - DECEMBER/90

(A) Drill Patterns Used

1. 4' x 4' on short holes less than 8'
2. 5' x 5' on holes 8' to 15'
3. 6' x 6' on holes 15' plus.

(B) Product Produced (estimated)

		Produced
1.	1" minus 20%	160 m^3
2.	6" minus 40%	320 m^3
3.	12" minus 60%	480 m^3
4.	Under 10% scattered	<80 m^3
5.	Large 12" plus	320 m^3

(C) Stemming and Capping

1. No holes were stemmed.
2. All caps were one meter.

(D) Production

3" holes using carbide button bits (total of 2 bites used) (400 to 500) feet per 12 hour days (winter) 1,140 c.yds. produced or 800 m^3.

(E) Powder factor 1.7 lb/c.y. full column loaded.

(F) Powder Used

Amex II
Power Frac (75%)
Primachord

(G) Winter Problems

1. Transportation on site.
2. Equipment freezing.
3. Powder freezing.
4. Moral.

(H) CONCLUSIONS

1. The drill pattern used is not producing much smaller sizes, but is making good general fill and rip-rap sizes.

2. We must use smaller pattern to get smaller sizes. Suggest 4' x 4' pattern on the 8' to 15' holes and probably 4' x 4' on the 15' plus holes?

3. The small amount of scatter indicates a well controlled blast.

Note:

1. At this point the contractor has completed 17% of job and used 10% of the powder he proposed he would need. It would appear that the contractor had envisioned a tighter pattern and his site people used a larger pattern.

2. The quarry has been properly daylighted to allow good drainage for future operations.

3. It is anticipated that ammonium nitrate explosives can be utilized here summer or winter as well as primachord. (This is the cheapest possible alternate).

APPENDIX 4

SOURCE LOCATION MAP

Repulse Bay, N.W.T.