GRANULAR AGGREGATE ASSESSMENT SURVEY
IQALUIT, NUNAVUT

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INTRODUCTION

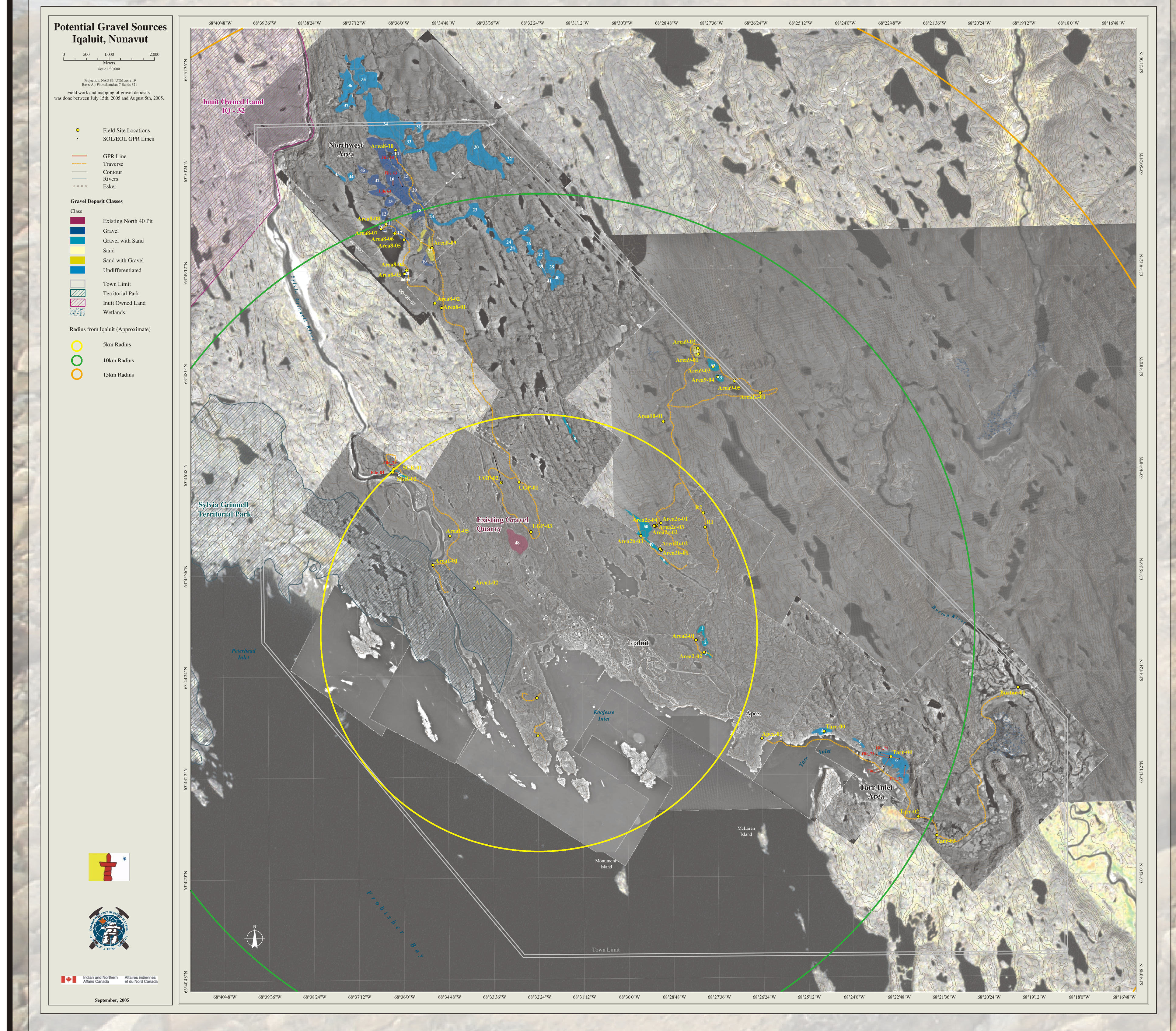
In 2005, an assessment of granular aggregate resources was conducted in the area around the city of Iqaluit. The survey was carried out to address immediate concerns regarding depletion of existing granular aggregate resources at the current source of aggregate for Iqaluit, the North 40 Pit. Alternate sources of aggregate are needed to address critical infrastructure needs.

To carry out the survey, all potential areas of aggregate were identified through air-photo interpretation. This information, combined with a review of previous assessment reports, provided a focus on which to base follow-up field work. Target areas with the best potential to yield aggregate resources were visited in the field, and basic information was gathered regarding the nature, extent and volume of the deposits. In addition, physiography of each of the areas was examined. A minor amount of Ground Penetrating Radar (GPR) data was collected to image the subsurface character of deposits, and depth to the bedrock contact.

The results of the assessment identified two areas having the best potential for follow-up work and possible development. The first area, informally named the Northwest Area, contains good-quality gravel, including high-quality gravel. Potential volumes contained in the Northwest area include: 1 000 000m³ of gravel and 4 000 000m³ of combined sand and gravel (minimum estimates based on a consistent depth of 1 m). Total potential aggregate may be > 14 000 000m³ for the Northwest Area. The second area, near Tarr Inlet, contains undifferentiated sand and gravel deposits. The total volume of undifferentiated sediments (minimum volume estimate based on a consistent depth of 1 m) for the Tarr Inlet area is approximately 300 000m³. Gravel in the Tarr Inlet area is thought to compose less than half of the total aggregate volume.

The Northwest Area has significant potential to be a long-term aggregate supply.

The gravel deposits in the Niaqunguk River Valley are small, sandy gravel deposits occurring as gravel bars along the river and may have potential to meet some short-term aggregate demands. Deposits adjacent to the Sylvia Grinnell River are composed of gravel and sand in varying amounts, however the quantities of gravel are neither abundant nor clean. The Northeast Area, in the Burton River Valley, contains varying amounts of sand and gravel, although sand is inferred to be more abundant than gravel.



1. Map of gravel deposits near Iqaluit. The sediments of most significance to an aggregate assessment include glaciomarine, glaciofluvial, and fluvial deposits. These deposits are mainly characterized by variable amounts of sand, gravel, boulders, and having variable degrees of sorting. They are normally well drained and contain minimal amounts of silt, unless overbank or marine sediments are associated with the deposits. Sediments suitable for potential aggregate resources are concentrated proximal to the modern-day shoreline, along sub-glacial and pro-glacial drainage pathways within the Frobisher Bay Moraine System, and along modern drainage systems.

BACKGROUND

Iqaluit is located at the head of Frobisher Bay and is underlain by Precambrian rocks of the Cumberland batholith. As the primary source of aggregate in glaciated terrains is normally the product of glacial and post-glacial processes, it is imperative to understand the Quaternary geology. The most comprehensive study of the Quaternary geology of the Iqaluit area was completed by Hodgson (2003, 2005).

The main area of interest is located between the Sylvia Grinnell River to the west of Iqaluit and Burton River to the east. Late Wisconsinan (Foxe) Glaciation was the glacial episode most responsible for the surficial deposits around Iqaluit (Hodgson, 2005). Ice-flow within this domain, was predominantly eastwards and discordant with flow distal to the Frobisher Bay Moraine System, thus indicating that the Frobisher Bay Moraine System represents a readvance of ice (Hodgson, 2005).

Within the confines of the two rivers, the terrain is dominated by deposits of till blanket and till veneer. The till is characterized as clast to matrix supported. Clasts are subangular, boulder and cobble, and mainly consist of Precambrian rocks of local origin. Only one till unit was identified (Hodgson, 2005). Till veneer is dominant towards the south, and till blanket is more dominant in the north and east of the area. The eastern portion of the area is characterized by the thickest till deposits occurring in a series of linear and convoluted ridges interpreted as multiple end-moraine ridges of the Frobisher Bay Moraine System. Glaciofluvial deposits occur as patches and are concentrated along drainage channels now occupied by modern rivers and streams including the Sylvia Grinnell, Niaqunguk, and Burton rivers, and an unnamed creek draining into the North 40 Pit. In the eastern part of the area, and bounding the Burton River valley, is a significant topographic high trending northwest to southeast, and dominated by exposed bedrock. This ridge makes a topographic barrier to the Burton River valley from the west. Modern day fluvial deposits occur in significant quantities along the Sylvia Grennell and Burton river valleys, and to a lesser degree along Niaqunguk River.

Iqaluit and Apex are mainly built on massive to cross-bedded glaciomarine delta deposits including sand, silt, boulders, and gravel that coarsen upwards. The current source of aggregate at the North 40 Pit and the abandoned pit at Apex are composed of such deposits. Deltas also exist at the head of Burton River, and perched ice-contact deltas exist at the head of Tarr Inlet and Apex Hill (Hodgson, 2005). Patches of exposed bedrock outcrop are concentrated along the shoreline and just inland of the glaciomarine deposits.

Figure 1 shows details of the 2005 survey with the objective of identifying gravel deposits. Figure 2 shows a summary of previous aggregate assessment surveys. Accurate air-photo interpretation is critical to obtaining good results and for forming a basis for follow-up investigations.

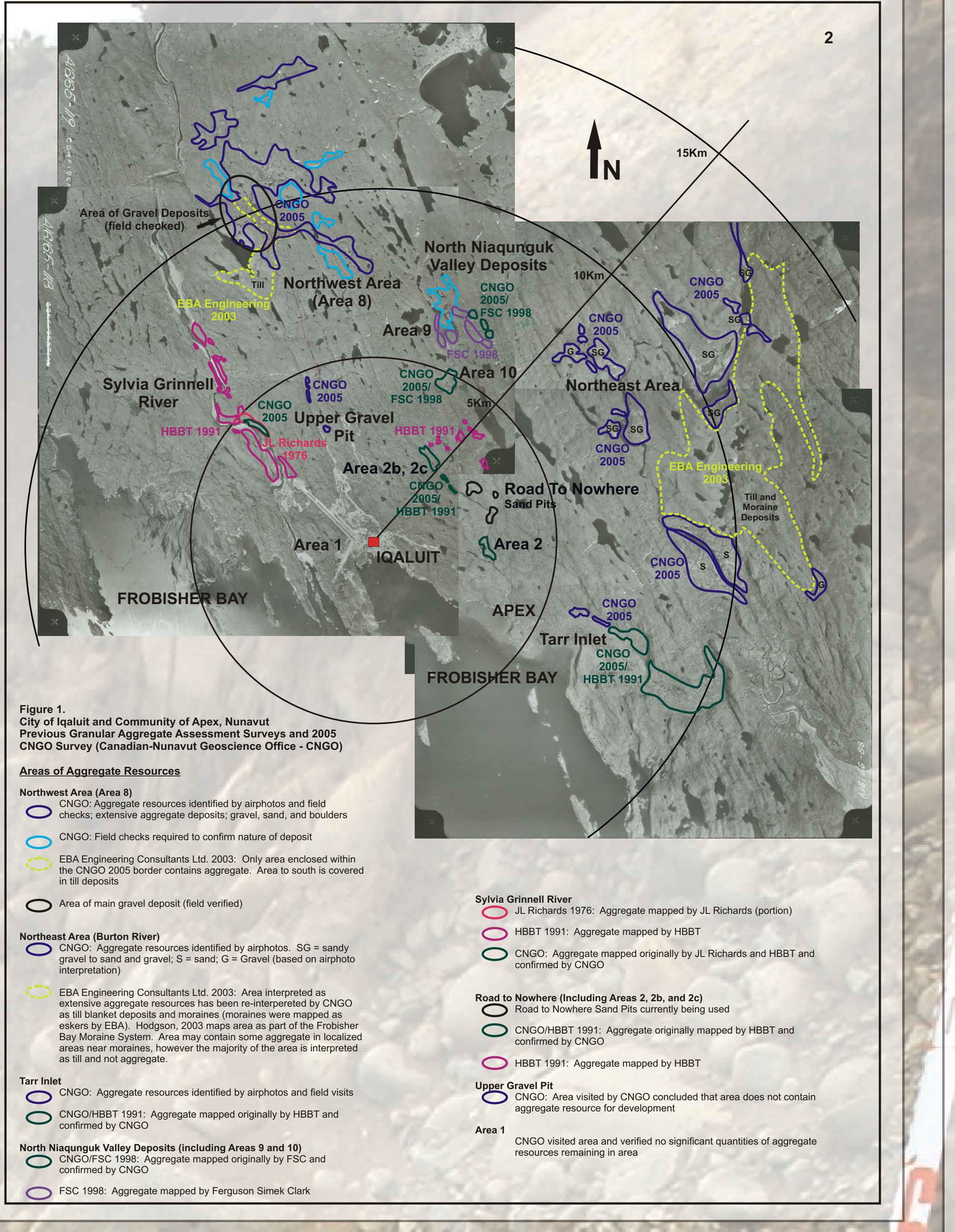


Figure 2
City of Iqaluit and Community of Apex, Nunavut
Previous Granular Aggregate Assessment Surveys and 2005 CNGO Survey (Canadian-Nunavut Geoscience Office – CNGO)

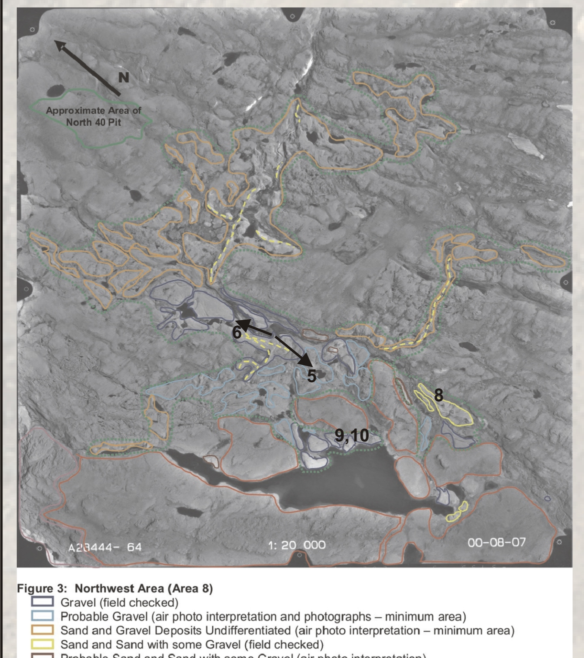


Figure 3: Northwest Area (Area 8)

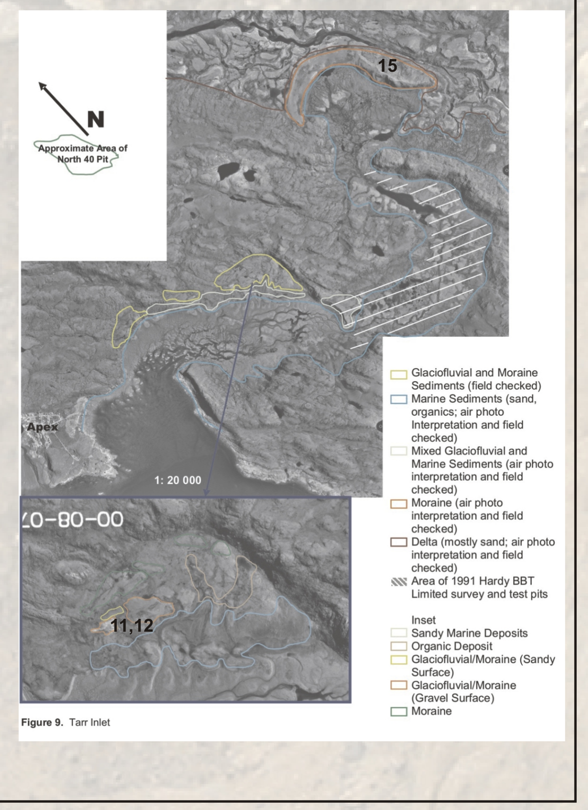


Figure 5: Tarr Inlet

SUMMARY OF RESULTS

Gravel resources within a 5-km radius of the centre of Iqaluit occur along the Niaqunguk Valley (1, 2) and the Sylvia Grinnell River. Limited time was spent at these sites due to the thorough nature of the previous work and/or the lack of a substantial gravel components to the deposits. The other sites visited include the deposits in the Northwest Area and near Tarr Inlet. The latter two areas were the focus for this assessment due to the high potential for gravel resources and the fact that gravel was not identified in these areas during previous assessments. The Tarr Inlet area deposits are less than 10 kilometres southeast of Iqaluit, and 5 kilometres east of Apex. The Northwest Area is 7 to 14 kilometres from Iqaluit, and is an extensive area comprising several concentrated gravel deposits.

Polygons around the deposit areas of interest were mapped in ArcView (1), and from this, the approximate corresponding area was calculated. This allowed for general estimates of potential volume to be calculated for each area of interest. Table 1 presents approximate minimum volumes for each area based on a uniform, 1-metre thick deposit. Table 2 presents approximate volumes for each area based on estimated (visula and GPR estimations,) average thickness for each deposit. Field investigations and detailed air-photo analysis allowed for further refinement of the volume estimates for the Northwest Area (see Table 3). The results presented in tables 1 and 2 demonstrate that the Northwest Area contains significantly more potential gravel than the other areas.

TABLE 1

Location	Min. Volume (m³)
Northwest Area	3,767,040
Tarr Inlet	295,069
Area 2	55,628
Area 2b	138,579
Area 9	102,209
Sylvia Grinnell	21,954
Total	4,380,483

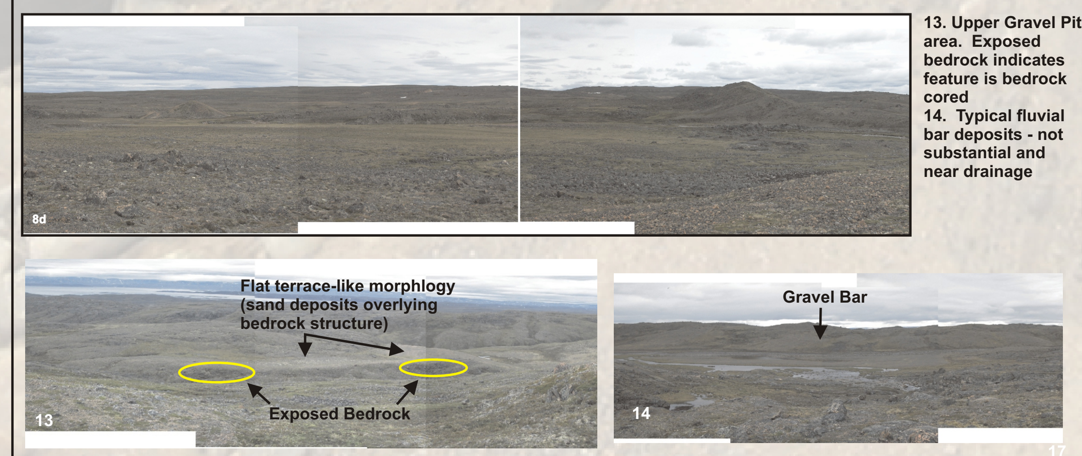
TABLE 2

Location	Avg. Volume (m³)
Northwest Area	13,939,742
Tarr Inlet	762,289
Area 2	55,628
Area 2b	138,579
Area 9	371,731
Sylvia Grinnell	175,637
Total	15,443,608

TABLE 3
Northwest Area Volumes (m³)

Deposit type	Minimum	Estimated Average
Gravel	1,053,857	3,754,927
Undifferentiated	2,612,057	9,530,073
Sand with Gravel	92,556	637,602
Sand	8,569	17,139
Total	3,767,040	13,939,742

Northwest Area
Figure 8a. Panorama view eskers in polygon 16 looking northward along GPR line File_63 . Note sediments become sandier at distal end of esker ridge near person (photos A0805_48 to 51; includes area of two GPR lines (File_63 in foreground and File_64 in background).
Figure 8b. GPR equipment (dismantled) at end of line File_64 (photos A0805_53-54)



13. Upper Gravel Pit area. Exposed bedrock indicates feature is bedrock cored
14. Typical fluvial bar deposits - not substantial and near drainage

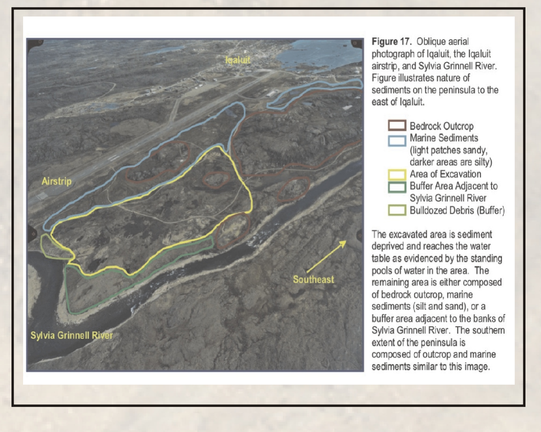


Figure 17. Oblique aerial photograph of Iqaluit, the Iqaluit airstrip, and Sylvia Grinnell River. Figure illustrates nature of sediments on the peninsula to the east of Iqaluit.

Bedrock Outcrop
Marine Sediments (light patches sandy, darker areas are silty)
Area of Excavation
Buffer Area Adjacent to Sylvia Grinnell River
Bulldozed Debris (Buffer)

The excavated area is sediment deprived and reaches the water table as evidenced by the standing pools of water in the area. The remaining area is either composed of bedrock outcrop, marine sediments (silt and sand), or a buffer area adjacent to the banks of Sylvia Grinnell River. The southern extent of the peninsula is composed of outcrop and marine sediments similar to this image.

8. Simple test pits give an indication of the nature of the surficial deposits.
9. Geomorphic features give insight to deposits. (Lake waters removed the fines leaving a spit showing the gravel size at this location.)
10. Close-up of 9.
11. Tarr Inlet lag gravels on surface.
12. Small natural exposure reveals sand underlies the lag gravel.

CONCLUSIONS

Drainage systems dissecting the area surrounding Iqaluit are oriented in a northwest to southeast direction following the 'bedrock grain'. These systems were utilized by both glacial and post-glacial drainage, so it is not surprising that the main concentration of aggregate deposits occurs in these northwest- to southeast-trending drainage systems. Where glacial drainage met the sea, glaciomarine deltas were deposited. In addition, other areas of concentrated aggregate deposits occur as patches along the modern shoreline.

Detailed aerial photographic interpretation and field visits to high priority areas resulted in a good synopsis of the various potential sources of aggregate in the Iqaluit area. GPR data was collected and provides insight for potential applications towards aggregate assessments. Based on this work, a proposed methodology is presented that could assist in carrying out future aggregate assessment surveys.

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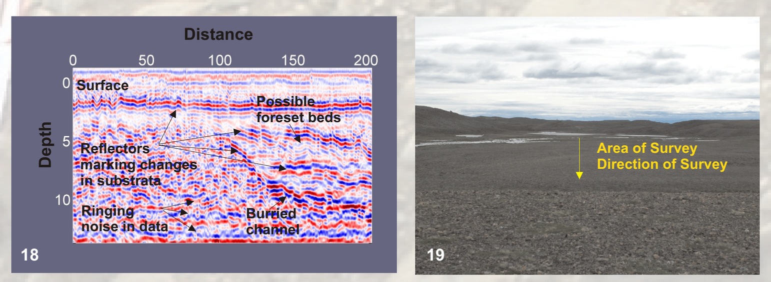
GROUND PENETRATING RADAR (GPR)

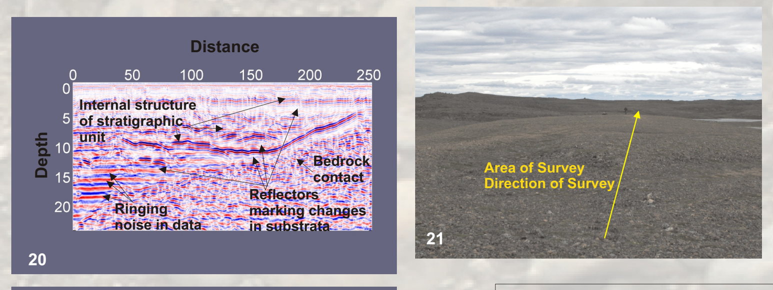
Ground Penetrating Radar is a high-resolution survey tool that emits electromagnetic waves into the subsurface to image subsurface features. A transmitter antenna emits a signal to the subsurface, which is then reflected at structural interfaces and detected by a receiver antenna. By moving the antenna pair along a survey line, an image of the subsurface structure can be determined. Contrasting dielectrical impedances are detected and recorded as reflected amplitudes/energies, as well as the time it takes the signal to reach the interface and return to the receiver. Depth of penetration into the subsurface depends on the choice of frequency (high frequency gives higher resolution, but less depth penetration; low frequency gives lower resolution, but greater depth penetration). The geophysical properties of the subsurface material also affects the return signal and resolution of the data. Velocity of the subsurface sediments can be variable and will partly depend on material type, moisture content and the presence of permafrost. In permafrost areas, velocities may be twice as high as those in non-unfrozen ground. This, combined with different velocities of the unexposed subsurface sediments makes calculating a velocity profile extremely tenuous.

GPR does not produce a section through the ground, rather it produces a representation of structural discontinuities such as geological interfaces, which must be interpreted. Without borehole data or exposed cross sections to verify the GPR data, only broad assumptions can be made. However, these assumptions are helpful for determining the subsurface morphology of sedimentary deposits. These data can help with subsequent planning for any borehole study, verifying where there may be a change in stratigraphy, and the possible depth to the bedrock contacts.

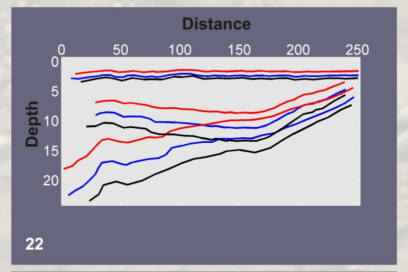
For this study, an antenna GPR system with an unshielded 100MHz antenna was used to produce profiles in high priority areas.



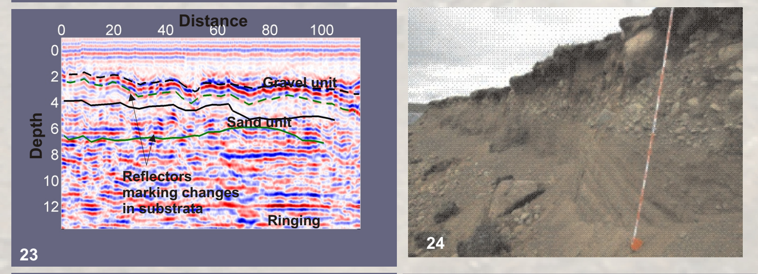
18. GPR profile File_60 (see 1 Northwest Area) depth axis is 8x exaggerated, '0' depth is centred on direct wave, velocity 0.15m/ns used for processing.
19. Gravel bar on which data for File_60 was collected.
Note the survey was taken on a flat portion of the gravel bar where the surface expression is consistent. The profile reveals significant difference in the thickness of the underlying sediments and the possibility of a buried channel.



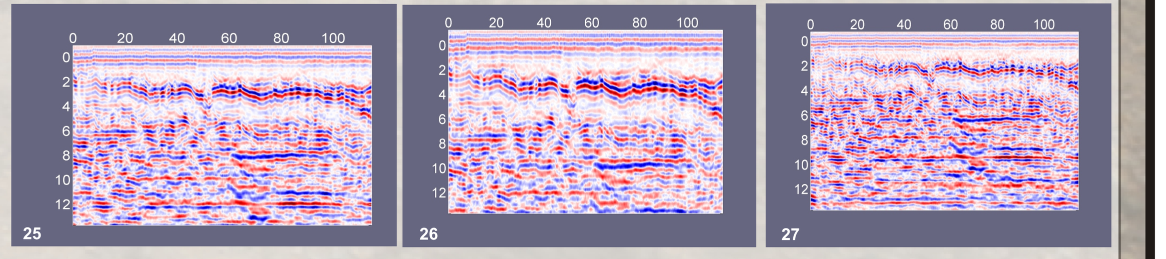
20. GPR profile File_63 (see 1 Northwest Area) depth axis is 5x exaggerated, '0' depth is centred on direct wave, velocity 0.15m/ns used for processing.
21. Location of data collection for File_63.
Survey was taken on the crest of a ridge. Note the surface sediments become finer and thinner with distance, and the feature appears to have a bedrock core.



22. GPR profile File_63 (see 1) depth axis is 5x exaggerated, '0' depth is centred on direct wave. This image shows the results of migration processing using three different velocities. Lines mark distinct contacts.
Red lines: lower than normal velocity (v=0.12 m/ns).
Blue lines: normal velocity (v=0.15 m/ns).
Black lines: higher than normal velocity (v=0.18 m/ns).
The important thing to notice here is the change in apparent layer thickness when increasing the migration velocity. This will have a significant effect on the estimation of gravel and/or sand volume. Digging test pits and/or drilling will be necessary to constrain the depth of the interfaces.



23. GPR profile for File_84 (see 1, Sylvia Grinnell area) depth axis is 5x exaggerated, '0' depth is centred on direct wave, processed using normal velocity (v=0.15 m/ns).
24. Survey was carried out above this section along the Sylvia Grinnell River bank to provide control. Gravel unit is 1m at location of tape measure.



25. GPR profile for File_84 (see 1, Sylvia Grinnell area) depth axis is 5x exaggerated, '0' depth is centred on direct wave processed using lower than normal velocity (v=0.12 m/ns).
26. GPR profile for File_84 processed using higher than normal velocity (v=0.18 m/ns).
27. GPR profile for File_84 processed at norlam velocity with interpretation for lower and higher overlayed

The results of the GPR survey show that GPR data can provide some useful information on locating subsurface boundaries and detecting contact interfaces. However, processing at various velocities shows that control through observed sections, digging test pits, and/or drilling is necessary for accurately interpreting the data. Velocities can also vary with depth, and the permafrost table will further complicate this issue.

PROPOSED METHODOLOGY FOR AGGREGATE ASSESSMENT SURVEYS

Phase I: Background Work

1. Airphoto analysis and review of previous studies. Using available airphotos, target areas for potential aggregate resources should be chosen for future follow-up and planning of fieldwork. It is crucial that an individual with experience in airphoto interpretation and an understanding of surficial geology reviews the airphotos to ensure mapping is as accurate as possible.

2. Communicate. Network with communities to obtain information regarding aggregate needs and environmental concerns.

Phase II: Reconnaissance Fieldwork

3. Visit target areas. This phase should involve reconnaissance ground-truthing of airphoto interpretations. Once suitable aggregate areas having potential as a resource are identified, follow-up work including more detailed descriptions, small easily excavated test pits to assess sediments (not sampling) and ground-truthing should be carried out. GPR studies can be performed at this phase to attempt to gain an understanding of subsurface morphology. A basic idea of potential access routes can be established at this time. To most productively utilize time and provide the maximum information and aerial coverage, excavation of large scale test-pits and sampling should be reserved for Phase II. However based on Phase II studies, recommendations for areas where detailed field work should be carried out can be made.

4. Present preliminary findings.
Note: It is recommended that a local guide be used for Phase II work. A local guide will have knowledge on gaining easy access to areas of interest, and also may have knowledge of deposits. Such assistance is invaluable for completing fieldwork. Depending on budgets and the amount of ground to be covered, helicopter support may be of assistance.

Phase III: Detailed Field-Work

5. Once priority sites for potential development have been selected, detailed fieldwork to address geotechnical issues can be carried out. This would include digging test pits in order to carry out laboratory analysis of the aggregate, detailed GPR surveys, choosing locations for possible drill testing and/or excavation to ground-truth with GPR data. Detailed surveying of the morphology to gain more accurate volume estimates can also be carried out during this phase.

6. Based on the discovery of suitable development sites, cost assessments and access routes can be assessed.