GRANULAR SOURCE SURVEY AND SPILL CONTINGENCY PLAN

MUNICIPALITY OF IGLOOLIK, NUNAVUT

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December 14th, 2011

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Privileged and Confidential

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December 14th, 2011

Mr. Jon Cooper
Government of Nunavut
Community and Government Services - Baffin Region
2nd Floor, GNO 1045
P.O. Box 379
Pond Inlet, Nunavut
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Dear Mr. Cooper

RE: GRANULAR SOURCE SURVEY AND SPILL CONTINGENCY PLAN

ARKTIS Piusitippaa Inc. is pleased to provide the Government of Nunavut, Department of Community Government and Services with a report for the above referenced project. We trust the information presented in this report satisfies the requirements of the project. Please do not hesitate to contact the undersigned if there are any questions or comments.

Sincerely,

ARKTIS PIUSITIPPAA INC.

Greg Fairthorne, P.Eng.
VP, Infrastructure Engineering

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Letter of Transmittal

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1.0 INTRODUCTION

1.1 Terms of Reference

ARKTIS Piusitippaa Inc. (ARKTIS) was retained by the Government of Nunavut – Department of Community and Government Services (GN-CGS) to complete a Granular Source Survey as part of the project entitled Improvement of Water Supply System for the Municipality of Igloolik, Baffin Region, Nunavut, under Phase 15 of the proposal submitted by ARKTIS.

As part of the requirements for Phase 15 of the project, a granular source survey was to be completed through a review of existing documentation; however, the only source of information available to estimate current potential borrow source locations in the municipality of Igloolik was a granular source survey completed in 1993 (provided by the GN-CGS). After an initial evaluation of the report, ARKTIS determined that a new study could not rely only on a study completed approximately 18 years ago as there was no information regarding the current conditions of the potential borrow areas identified in the past, and no information of other areas that were developed and areas that remain undeveloped. In order to allow the GN-CGS to properly identify borrow areas for future exploration of granular materials, ARKTIS recommended a field investigation to assess the current condition of areas identified in 1993; the GN-CGS agreed with this recommendation, and the project scope of work was subsequently expanded to encompass a field investigation.

A site investigation was conducted by ARKTIS technical staff in June 2011. This report presents the results of the field investigation along with an evaluation of the condition, material characteristics and estimated volumes of granular material in the existing and new potential borrow source locations identified near the Municipality of Igloolik.

1.2 Objectives and Goals

The main objective of this report is to present the results of a field investigation completed by ARKTIS staff to assess granular source locations in the Municipality of Igloolik in Nunavut along with an overall evaluation of existing and new potential borrow areas.

The key specific objectives of the granular source survey study are listed below:

- Review information from the 1993 granular source survey made available by the GN-CGS RFP regarding location of existing and new sources of granular material including material quality, quantity and site plan;
- Present results of a field investigation completed by ARKTIS to assess the current condition of sources of granular material (if developed after 1993 or not);
- Summarize results of the test pit program completed to allow sampling of soils for laboratory analyses including water content and grain size distribution;
- Present an estimation of available volumes with a discussion of the development potential of each identified borrow area;
- Present a summary and evaluation of all granular borrow sources investigated during this study;

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- Present and discuss the characteristics of each granular borrow source investigated, including an overall description of each area, its topography, surface and groundwater considerations, site access, potential environmental impacts resulting from the exploration of the area and requirements for closure and reclamation after exploration;
- Present a spill contingency plan for the operation of granular sources in the Municipality of Igloolik.

1.3 Report Outline

In order to address the main and specific key objectives of the granular source survey, this report is segmented into nine sections as follows:

- Section 1 presents terms of reference, main and key objectives of this report and report outline.
- Section 2 presents an overview of site location, including the Municipality of Igloolik and the existing and new potential granular source areas identified in 1993 by NWT.
- Section 3 presents the methodology adopted for the field investigation completed by ARKTIS staff including procedure and methods used to estimate volumes, material quality and characteristics including laboratory soil analyses.
- Section 4 of this report presents the findings of the field investigation and evaluation completed in existing granular sources with potential for continuous exploration with overall significant remaining volume of granular soils to be extracted.
- Section 5 of this report presents the findings of the field investigation and evaluation completed for new granular sources previously identified by the 1993 NWT study and that have not been explored until the completion of the 2011 granular source survey.
- Section 6 presents a summary of sources of granular materials assessed as part of this study, including existing and new sources, including an overall evaluation of the areas.
- Section 7 presents a spill contingency plan for the continuous exploration of existing granular source areas and for future exploration of new granular sources in the Municipality of Igloolik.
- Section 8 presents the limitations of liability.
- Section 9 presents report closure.

2.0 BACKGROUND INFORMATION

2.1 Igloolik, Nunavut

The Municipality of Igloolik (69°23′ N latitude and 81°46′ W longitude) is located in the northwest region of the Foxe Basin within the Qikiqtaaluk Region of Nunavut, approximately 860 km northwest of Iqaluit, as illustrated in **Figure 1**. The population of Igloolik in 2010 was estimated in 1736 according to the Government of Nunavut[1].

[1] Government of Nunavut (2011). http://stats.gov.nu.ca/statistics%20documents/pop_projections_by_comm.pdf

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2.2 Granular Source Survey

2.2.1 Introduction

Several existing and new areas were identified in the Municipality of Igloolik in 19931 as sources of granular materials for the development of the community. These areas were re-evaluated in 2011 by ARKTIS' staff in two stages as follows:

- Completion of a desktop review of the document produced by GWT (1993)[2]; and
- Assessment of the current condition of the areas reported by GWT (1993)[2] and new potential granular source areas in the Municipality of Igloolik, including completion of test pits to assess depths of granular layers, estimation of the footprint of the areas, and laboratory analyses to assess material properties. The methodology for the estimation of available volumes and for completing test pits is described in greater detail in **Section 3**.

2.2.2 Granular Source Areas

This section presents a summary of the granular source areas discussed in this report, including the majority of the areas identified by GWT (1993)[2] and new potential areas identified by ARKTIS' staff. These areas are discussed in greater detail in **Section 4** for areas already under exploration and **Section 5** for new potential areas.

A summary of the areas discussed in **Section 4** and **Section 5** of this report is provided in **Table 1**. A map of the location of these areas is presented on **Drawing 01**.

Table 1 – Granular source areas investigated in the survey.

Granular Source ID	Condition	Location	Description
E1	Existing granular source area partially exploited	Approximately 2.0 km N of the community, NW from the existing sewage lagoons, N of existing access road.	This area was partially developed for the construction of the berms of the sewage lagoons.
E2	Existing granular source area partially exploited	Approximately 700 m north of the community, immediately south from the municipal solid waste disposal facility.	This area was partially developed by the community with limited available granular material for future explorations.
E3	Existing granular source area partially exploited	Located immediately west of the community and west from the hamlet garage.	This area is the main current granular source for the community.
E4	Existing granular source area partially exploited	Located approximately 2.7 km southwest from the community, south from the existing runway.	This area was initially developed as used as the main source of granular soil for the construction and maintenance of the existing

[2] NWT (1993). Granular Source Evaluation. Department of Government Services and Public Works. January, 1993

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Granular Source ID	Condition	Location	Description
			runway.
E5	Existing waste rock pile apparently not used since its deposition	Approximately 2.7 km southwest of the community (between existing potable water reservoir and South Lake)	Existing waste rock pile from the construction of the existing potable water reservoir
N1	New potential granular source area	Located approximately 1.0 km north of the community and immediately south from the community sewage lagoons.	Unexplored area with potential to be developed and used as a future source of granular material for the community
N2	New potential granular source area	Located approximately 800 m southwest from the community, immediately east from the access road to the airport	Unexplored area with potential to be developed and used as a future source of granular material for the community
N3	New potential granular source area	Located approximately 1.0 km southwest from the community, immediately east from the access road to the airport and east from the fuel storage facility.	Unexplored area with potential to be developed and used as a future source of granular material for the community
N4	New potential granular source area	Located approximately 4.0 km south from the community, and south from the runway.	Unexplored area with potential to be developed and used as a future source of granular material for the community (continuation of source E4).

3.0 METHODOLOGY

The municipality of Igloolik has several areas where granular materials may be developed for the development of the community in the future. The granular source areas were investigated by ARKTIS' staff based on several elements that characterize each source. This section describes the methodology for estimating areas of existing and potential granular source locations, the assessment of the volumes of material for exploration, and the methodology for completing test pits at select locations.

3.1 Footprint

The footprint of the existing and new potential sources of granular materials was initially assessed through a desktop review of the GWT (1993)[1] study followed by an evaluation of available aerial photographs. The second stage for determining the footprint of the areas was through a site visit where key coordinates were recorded with the assistance of a handheld GPS.

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3.2 Volumes

The estimated volumes of available granular materials at each existing and new potential granular source area were assessed by considering the footprint of the area and average thickness of layer of granular materials above frozen soils. The thickness of the granular materials layer was assessed by excavating test pits (discussed in **Section 3.3**).

3.3 Test Pit Investigation and Sampling

Test pits were completed by ARKTIS' staff with the assistance of a Cat 315C excavator. The locations for the completion of test pits were determined in the field based on site conditions and accessibility. The test pits were considered ended when refusal was encountered in either bedrock or frozen soils.

Representative soil samples were collected from the majority of the test pit locations to allow laboratory analyses to be completed. Samples were stored in sealed plastic bags to maintain the water content. Procedures for laboratory analyses are discussed in **Section 3.1.4**.

3.4 Results of Laboratory Analyses

Samples collected during the test pit investigation were submitted for laboratory analyses including water content and grain size distribution. Due to the granular nature of the samples and visible low fines content, the grain size distribution of the samples was determined by sieving only without the need to complete a hydrometer analysis.

4.0 GRANULAR SOURCE SURVEY – EXISTING BORROW AREAS

4.1 Granular Source # E1

4.1.1 Overall Description

Granular source E1 (Existing 1) is located immediately northwest of the existing community sewage lagoons as shown on **Drawing 01**. As informed by a hamlet staff, this borrow area was developed for the construction of the sewage lagoon berms.

The soil type observed in granular source E1 is mostly sandy gravel with some cobbles. This area has been developed, but not in its totality, which makes this borrow source still an alternative for exploitation for works that do not require large volumes of sandy gravel. The potential use of the remaining available granular material from this area is in the maintenance of the sewage lagoons and solid waste disposal facility.

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4.1.2 Topography

The overall topography of the granular source E1 area is typically formatted by gently slopes that allow surface water to flow northeast towards the ocean. It was observed the existence of slopes as steep as 1V:4H in the limit between the E1 area and the access road, becoming flatter towards the northeast end of the source area.

4.1.3 Surface and Groundwater Considerations

The topography of the area is well-drained without any visible surface water ponds during the time of the site inspection. Frozen soils are suspected to be near ground surface according to a hamlet operator, which suggests that groundwater may not be an issue in case of continuous operations of this granular source.

4.1.4 Site Access

Access to the granular source E1 is facilitated by an all-season road, which connects the community to the solid waste disposal facility and sewage lagoons. No additional site access roads are required for the continuing exploration of the E1 area.

4.1.5 Environmental Impact Associated with Development

The physical environment of the location of borrow source E1 is a typical northern climate oriented eco-system, located approximately 500 m southwest from the shoreline of the ocean. The soils in this area are mostly comprised of sand with some small sized vegetation (predominantly moss-like) at undeveloped locations. Based on available information, this area is generally not considered to be overly inhabited by wildlife whether migratory, aquatic, spawning, nesting or unusual species, except for ravens that are seen around the landfill area and sporadically around borrow source E1.

Except for the removal of additional topsoil from undisturbed areas and additional exposure of frozen soils, no significant environmental impacts are anticipated from continuous exploration of borrow source E1. Corrective actions are recommended for closure and reclamation of E1 after the cessation of exploration activities, as discussed in **Section 4.1.9**.

Development may cause permafrost exposure and consequent degradation, which should be monitored and minimized as much as possible.

Noise and dust are not anticipated to be an environmental concern with the development of this area.

4.1.6 Results of Laboratory Analyses

Samples collected from the E1 area were logged by visual classification. No samples were collected from area E1 for further laboratory analyses.

4.1.7 Footprint and Available Volumes

The footprint of granular source E1 is estimated to be 130,000 m^2, as illustrated on **Drawing 01**, with an approximate length of 1,900 m and approximate width of 60 m.

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The depth of available granular materials in granular source E1 (above frozen soils or bedrock) is estimated in 0.4 m on average, considering the current stage of development of this area.

The estimated volume of granular materials available for extraction from source E1 is 52,000 m^3.

4.1.8 Methods for Future Development

- The first stage to be considered for continuous operations of granular source E1 is the removal of topsoil and organics from undeveloped areas. Topsoil should be stockpiled for closure activities;
- The method to be used to excavate granular material from area E1 should be based on direct removal of loose granular material with the assistance of a loader. Assistance from a dozer may be required to stockpile material;
- Granular materials should be excavated until refusal in frozen soils or bedrock. No excavations should be completed below the water table due to safety concerns, additional water handling and concerns with permafrost degradation;
- Excavated material contains ground-ice, it should be stored at a location within the pit where it can thaw and drain. Small stockpiles allow frozen material to thaw and drain, as a large surface area is exposed to heating. Melt water from thawing stockpiles may have high fines content, and require inspection of the seepage before discharge to downstream areas.

4.1.9 Overview of Requirements for Closure and Reclamation

The final phase of pit and quarry development is reclamation. Reclamation objectives are influenced by site conditions and future land-use, and must be satisfactory to regulatory authorities and key stakeholders. Proponents may suggest future uses for the site, but the land use regulator will make the determination. Specifics for closure and reclamation are discussed below:

- Cleanup
    - Once operations are completed, all provisional structures, machinery and parts, garbage and material stockpiles should be removed.
- Landscape reconstruction
    - Coarse material, overburden, and topsoil stockpiled in the pit or quarry during operations should be used for reclamation of the site upon project completion. Use of frozen materials for reconstruction activities is not recommended as ground-ice may melt and cause subsidence.
    - Coarse material should be used for slope reconstruction. Overburden should then be used for site grading and contouring.
    - Once site contouring is completed and the ground surface has stabilized, stored topsoil (if any) should be placed on areas from which the soil was stripped. The ground surface should be roughened to improve conditions for revegetation.

- Drainage and erosion control
    - Successful reclamation involves proper surface drainage. Contouring will assist in re-establishing natural drainage patterns on the site. If necessary, diversion ditches should be constructed to facilitate surface water drainage and prevent surface water accumulation in reclaimed areas and thereby reduce the potential for erosion.

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- Revegetation:
    - Attempts to restore the natural vegetation in the area should be completed by placing excavated overburden and topsoil back to the area. Salvaged topsoil often contains seeds from native plants and organic matter that aid in vegetation re-establishment. The main objectives of revegetation are to prevent soil erosion, and improve the appearance of the reclaimed site.
- Monitoring:
    - Post-closure monitoring may be required to verify if drainage elements are functional and if erosion effects are within acceptable limits. Post-closure maintenance may also be required to limit erosion and the accumulation of surface water ponds in the reclaimed area.

4.2 Granular Source # E2

4.2.1 Overall Description

Granular source E2 (Existing 2) is located immediately west of the existing community landfill, as shown on **Drawing 01**.

The soil type observed in granular source E2 was observed to be gravels with some cobbles and some sand. This area has been developed by the community but not to its totality. Potential for continued development of source E2 is considered viable, from its southwest end to the north end. Due to its proximity to the municipal landfill, an alternative to be considered by the community is to preserve the remaining volumes of granular soils from source E2 for maintenance and closure activities.

4.2.2 Topography

The topography of granular source E2 is typically comprised of slopes that vary from steep along its western side (within the immediate vicinity of a bedrock ridge) to gently sloping ground that allows surface water to flow east and south towards the existing access road. Due to removal of granular materials from source E2, relatively flat areas are observed within its footprint.

4.2.3 Surface and Groundwater Considerations

Source E2 is relatively well drained along its eastern and southeast sections. Snow accumulation was observed during the time of the inspection along the western boundary of the area (delimited by the bedrock ridge). Snow melt has caused surface water to accumulate and form ponds and surface soils to become wet in the vicinity of the snow packs. Frozen soils are suspected to be near ground surface according to a hamlet operator, becoming deeper towards the existing access road.

4.2.4 Site Access

Access to granular source E2 is facilitated by an all-season road, which also connects the community to the solid waste disposal facility and sewage lagoons. No additional site access roads are required for the continuing exploration of this source.

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4.2.5 Environmental Impacts Associated with Development

No additional environmental impacts are expected to occur in the area of source E2 due to continued development. Existing environmental impacts from the initial exploitation may include, and is not limited to, some degree of permafrost degradation and the accumulation of surface water due to uneven development of the area over the years.

4.2.6 Results of Laboratory Analyses

Due to the limited remaining volume of granular materials at source E2, representative samples were collected for visual classification only. No samples were collected from source E2 for further laboratory analyses.

4.2.7 Footprint and Available Volumes

The footprint of granular source E2 is estimated to be 32,000 m^2, as illustrated on **Drawing 01**, with an approximate length of 500 m and approximate width of 60 m.

The depth of available granular materials in granular source E2 (above frozen soils or bedrock) is estimated to be approximately 0.4 m on average, considering the current stage of development of the area.

The estimated volume of granular materials available for extraction from source E2 is 12,800 m^3.

4.2.8 Methods for Future Development

- The continued development of source E2 may require the removal of topsoil and organics from unexploited areas. The stockpiling of topsoil should be considered for use in the progressive reclamation of areas within source E2;
- The method to be used to excavate granular material from area E2 should be based on direct removal of loose granular material with the assistance of a loader. Assistance from a dozer may be required to stockpile material (blasting is not required);
- Granular materials should be excavated until refusal in frozen soils or bedrock. No excavations should be completed below the water table due to safety concerns, additional water handling and concerns with permafrost degradation;
- In the scenario where excavated material contains ground-ice, it should be stored at a location within the boundaries of source E2 to allow it to thaw and drain. Melt water from thawing stockpiles may have high fines content, and require inspection of the seepage before discharge to downstream areas.

4.2.9 Overview of Requirements for Closure and Reclamation

- Cleanup
    - Once operations are completed, all provisional structures, machinery and parts, garbage and material stockpiles should be removed.
- Landscape reconstruction
    - Coarse material, overburden, and topsoil stockpiled in the area during operations should preferentially be used for reclamation of the site upon project completion.

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  - Coarse material should be used for slope reconstruction. Overburden should then be used for site grading and contouring.
  - The ground surface should be roughened to provide micro-sites suitable for revegetation.
- Drainage and erosion control
  - Contouring should be completed as required to optimize surface water flow in the reclaimed area and to minimize erosion. The existing access road may be used to divert water off the area with the assistance of culverts (if needed).
- Revegetation:
  - Attempts to restore the natural vegetation in the area should be completed by placing excavated overburden and topsoil back to the area.
- Monitoring:
  - Post-closure monitoring may be required to verify if drainage elements are functional and if erosion effects are within acceptable limits. Post-closure maintenance may also be required to limit erosion and the accumulation of surface water ponds in the reclaimed area.

4.3 Granular Source # E3

4.3.1 Overall Description

Source E3 is a large deposit located directly west of the settlement of Igloolik, adjacent to the airport road, and for several years has been extensively used by the community as a source of granular material. The deposit is bounded to the north by a standing body of water and peaty terrain, to the east by the elevated airport pad, and to the west and south by near surface bedrock and poorly-drained, low-lying terrain.

Granular source E3 is the current main source of granular materials for the community of Igloolik. Source E3 is located immediately west of the Hamlet garage as shown on **Drawing 01**. The southwest section remains undeveloped (southwest from TP-11-20 and TP-11-22).

The deposit covers an area 600 meters long varying in width between 250 and 400 meters. The deposit varies in thickness, typically in the range of 0.9 to 1.4 m becoming shallow and discontinuous to the south and west. The northern section of source E3 is near depletion with very limited available granular material for extraction. The southern section of source E3 was developed in the past but not to the same extent as the northern section.

4.3.2 Topography

The deposit is a raised marine beach ridge that lies adjacent to the western slope of the airport road and continues westward eventually merging into the peat and bog terrain of the coastal plain. E3 is an elongated ridge, typically flat, narrower to the south and slopes northwest leading down to a standing body of water marking the northern most boundary of the source.

4.3.3 Surface and Groundwater Considerations

The area encompassing source E3 is poorly-drained. The groundwater table was observed to be approximately 0.8 to 1.1 m below ground surface in the southern area of E3. Groundwater was observed to be at ground surface at the northern section of E3, which suggests that the area is no longer suitable for development.

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Frozen soils were observed to be approximately 0.9 to 1.4 m below ground surface.

4.3.4 Site Access

Site access is considered excellent due to the proximity to the community. No additional access roads or improvement to the existing roads are anticipated to be required for continuous development of granular source E3.

4.3.5 Environmental Impacts Associated with Development

The physical environment within the locality of borrow source E3 is similar to the other borrow locations. The vegetation in the overburden of undisturbed areas is mostly composed of small sized vegetation (predominantly moss-like). Due to its proximity to the settlement, this area is not considered to be overly inhabited by wildlife whether migratory, aquatic, spawning, nesting or unusual species.

The major environmental impacts with the continuing development of source E3 are:

- Removal of topsoil from areas along the southern end of the source. Topsoil should be either stockpiled or used for closure and reclamation of the northern sections of the borrow area;
- Noise and dust may adversely affect the residents near the source during operations;
- Permafrost degradation and exposure, and potential for the accumulation of water in ponds and seeping into main roads immediately east from E3.

4.3.6 Results of Laboratory Analyses

Three representative samples were collected from test pits excavated within the footprint of source E3 (sample G19 from TP-11-20; sample G20 from TP-11-21; and sample G21 from TP-11-22). The Water Content from the samples ranged from 5 to 15 %. The grain size distribution analysis indicated that the soils at source E3 are typically comprised of sandy gravel sized particles, with cobble content of up to 10 % and fines content typically lower than 5 %.

4.3.7 Footprint and Available Volumes

The footprint of granular source E3 is estimated to be 170,000 m^2, as illustrated on Drawing 01, with an approximate length of 600 m and approximate width of 250 m. The northern section of the source is near depletion of granular resources and has not been included in the calculation of remaining available volumes, which represents an area of approximately 75,000 m^2 from the total footprint of source E3.

The remaining 95,000 m^2 of the remaining area encompassed by source E3 has an approximate depth of granular soils that range from 0.9 to 1.4 m and decreases laterally to the south and west.

An average of 0.7 m was adopted for the estimation of available volumes of granular materials at source E3, for the remaining 95,000 m^2 of the area. Therefore, it is estimated that approximately 66,500 m^3 of granular material remain at source E3 for future extraction.

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4.3.8 Methods for Future Development

- The first stage to be considered for continuous operations of granular source E3 is the removal of topsoil and organics from undeveloped areas. Topsoil should be stockpiled for closure activities, preferentially along the northern section of the source where there are indications of permafrost degradation and water accumulated in ponds;
- The method to be used to excavate granular material from source E3 should be based on direct removal of loose granular material with the assistance of a loader. Assistance from a dozer may be required to stockpile material;
- Granular materials should be excavated until refusal in frozen soils or bedrock. No excavations should be completed below the water table due to safety concerns, additional water handling and concerns with permafrost degradation. During the test pit investigation, ice-rich soils were encountered at a depth of approximately 1.0 m below ground surface along the southern section of the source. Operations should avoid exposing ice-rich soils;
- Excavated material containing ground-ice (e.g. seasonal ice in soil)should be stored at a location within the source boundaries where it can thaw and drain. Small stockpiles allow frozen material to thaw and drain as a large surface area will be exposed to heating. Melt water from thawing stockpiles may have high silt content, and require control and treatment before being discharged to surface water.

4.3.9 Overview of Requirements for Closure and Reclamation

- Cleanup
    - Once operations are completed, all provisional structures, machinery and parts, garbage and any material stockpiles at source E3 should be removed from the site.
- Landscape reconstruction
    - Coarse material, overburden, and topsoil stockpiled in the pit or quarry during operations should be used for reclamation of the site upon project completion. Progressive reclamation of the northern sections of source E3 is recommended with excavated overburden excavated from the southern section of source E3 during future development.
    - Once site contouring is completed and the ground surface has stabilized, stored topsoil (if any) should be placed on areas from which the soil was stripped. The ground surface should be roughened to improve potential for revegetation.
- Drainage and erosion control
    - Grading and contouring is to be completed to minimize the potential for the accumulation of surface water in ponds and erosion in the reclaimed areas.
- Revegetation:
    - Attempts to restore the natural vegetation in the area should be completed by placing excavated overburden and topsoil back to the area.
- Monitoring:
    - Regular inspections are to be completed and maintenance completed as required.

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4.4 Granular Source # E4

4.4.1 Overall Description

Source E4 is a large granular deposit located south of the existing runway and potable water reservoir, as shown on **Drawing 01**. This deposit was developed by the community for the construction of the existing runway and is currently used as the source of granular material for the maintenance of the runway. Some areas within source E4 have been extensively used; however, based on visual observations and the results of the test pit investigation, significant amounts of materials remain in the area for extraction. The deposit covers an area 1200 m long varying in width between 250 and 600 m.

The deposit is bounded to the north by elevated land and airport land, to the east by an area believed to be airport land and relatively flat, to the west by an access road that connects South Lake to the existing potable water reservoir and the community, and to the south by poorly drained low-lying land and few small water bodies.

Ground conditions were assessed by means of a test pit investigation to allow soil sampling and estimation of available quantities of granular materials for extraction. TP-11-12 to TP-11-15 were completed within the footprint of source E4. The thickness of granular materials with potential to be developed ranged from 0.7 to 1.1 m.

4.4.2 Topography

The northern section of granular source E4 is typically higher in elevation compared to the south sections. The elevation of the northern sections is typically around 45 m above sea level, decreasing to approximately elevation 32 m along the southern edge of the area (~5 % slopes). Overall, source E4 is well drained with no visible surface water ponds or wet areas observed during field investigation.

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4.4.3 Surface and Groundwater Considerations

Source E4 is located in an area with slopes of approximately 5 % grade from north to south, which allows surface water to flow towards low-lying terrain and small water bodies located south of the source.

During the test pit investigation, no seepage or wet soils were observed from ground surface to refusal.

4.4.4 Site Access

Access to the western area of granular source E4 is facilitated by an all-season road, which connects the community of Igloolik to South Lake, as shown on Drawing 01. A trail crosses the southern edge of granular source E4, connecting the western section of the area to the eastern section and to granular source N4. Improvements may be required for the trail in case of further development of granular source E4 or development of source N4.

4.4.5 Environmental Impacts Associated with Development

The physical environment of the location of borrow source E4 is similar to the other borrow locations, being a typical northern climate oriented eco-system with shallow vegetation at sporadic locations. As the

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area has been used for the development and maintenance of the existing runway, the majority of the vegetation was removed.

The environmental impacts that are anticipated with the continued exploration of source E4 are:

- Removal of topsoil from the southeast area of source E4;
- Permafrost degradation and exposure, and potential for surface water accumulation; this is not considered permanent damage, as correctional closure and reclamation activities may reduce or eliminate long-term effects regarding permafrost degradation.
- Proper closure and reclamation of the site after its use will allow environmental impacts to be mitigated and arctic vegetation to establish itself in the area with time.
- This area is not considered to be overly inhabited by wildlife whether migratory, aquatic, spawning, nesting or unusual species.

4.4.6 Results of Laboratory Analyses

Four representative samples were collected from test pits completed within the footprint of source E4 (sample G11 from TP-11-12; sample G12 from TP-11-13; sample G13 from TP-11-14; and sample G14 from TP-11-15). Regarding water content from samples collected during investigation, it was observed that granular materials were dry to moist, with water content ranging from 2 to 5 %. The grain size distribution analyses indicated that the soils at source E4 are mostly comprised of gravels with up to 10 % cobbles, 0 to 20 % sand and up to 10% fines.

4.4.7 Footprint and Available Volumes

The footprint of granular source E4 is estimated to be 480,000 m^2, as illustrated on **Drawing 01**, with an approximate length of 1,100 m and approximate width of 350 m.

The thickness of granular materials observed during the test pit investigation ranged from 0.7 to 1.1 m. For estimation of available volume of granular materials that have the potential to be extracted from source E4, a thickness of 0.7 m was adopted. The rationale for adopting the lowest thickness of granular materials observed during the test pit investigation is that a few locations within the footprint of source E4 are near depletion and further extraction from these areas may not be possible or may not yield significant volumes of granular materials. By adopting an area of 480,000 m^2 and thickness of 0.7 m, it is estimated that a total of 336,000 m^3 of granular materials have the potential to be extracted from source E4.

4.4.8 Methods for Future Development

- Removal of some shallow vegetation from selected areas may be required for continued development; topsoil should be stockpiled if possible, to be used for closure activities;
- The method to be used to excavate granular material from source E4 should be based on direct removal of loose granular material with the assistance of a loader. Assistance from a dozer may be required to stockpile material;
- Granular materials should be excavated until refusal in frozen soils or bedrock. Operations should avoid exposing ice-rich soils if encountered during excavation.

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4.4.9 Overview of Requirements for Closure and Reclamation

- Cleanup
  - Once operations are completed, all machinery and parts, garbage and any material stockpiled in the area must be removed from site.
- Landscape reconstruction
  - Exposed permafrost should be covered to prevent post-closure degradation.
  - Progressive reclamation is recommended with excavated overburden being used for the reclamation of pre-developed areas.
  - Ground surface should be roughened to improve re-establishment of vegetation.
- Drainage and erosion control
  - Grading and contouring should be completed to minimize the potential for surface water accumulating in ponds and erosion in the reclaimed areas.
- Revegetation:
  - Attempts to restore the natural vegetation in the area should be completed by placing excavated overburden and topsoil back to the area.
- Monitoring:
  - Regular inspections should be completed and maintenance completed as required.

4.5 Granular Source # E5

4.5.1 Overall Description

Granular source E5 corresponds to a granular stockpile located approximately 2.7 km southwest of the community. ARKTIS' staff was informed that this stockpile was produced from the excavation and blasting of the current potable water reservoir, which is located approximately 450 m northeast from the stockpile. Based on visual inspection, the stockpile does not appear to have been used by the community since its deposition in the early 1990s.

The granular material at source E5 ranges from fine gravels to cobbles and boulders, covering an area of approximately 7,200 m^2 (80 x 90 m). The stockpile has a maximum height of approximately 6 m at its south end and near to ground surface at its north end.

4.5.2 Topography

The topography in the vicinity of granular source E5 is characterized by well drained soils becoming poorly drained towards the south (towards South Lake). Source E5 is located on an approximate 1V:3H slope with the northern section of the stockpile located at a higher elevation than the southern section.

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4.5.3 Surface and Groundwater Considerations

Source E5 is located near steep slopes compared to the other existing granular sources described in this report. It allows surface water to flow south towards a boggy area where groundwater is observed to be near or at ground surface. Removal of available granular materials from source E5 should not impact surface and groundwater regimes considering it is not a natural occurrence. Grading of the area during and after removal of the granular stockpile should assist in restoring natural surface water flow.

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4.5.4 Site Access

Access to source E5 is very good as it is located immediately west of the access road to South Lake and cabins located southwest of the island. No additional access roads are required to allow the development of source E5.

4.5.5 Environmental Impacts Associated with Development

It is not anticipated that exploration of source E5 will result in any environmental impacts as it is not a natural occurrence.

4.5.6 Results of Laboratory Analyses

Samples collected from source E5 were logged by visual classification. No samples were collected from area E1 for further laboratory analyses.

4.5.7 Footprint and Available Volumes

The footprint of granular source E5 is estimated to be 7,200 m^2, as illustrated on **Drawing 01**, with an approximate length of 90 m and approximate width of 80 m.

It is estimated that approximately 18,000 m3 of granular material is available for removal from the source E5 granular stockpile (based on thicknesses discussed in **Section 4.5.1**).

4.5.8 Methods for Future Development

For the removal of the available granular material at source E5, no additional efforts such as excavation and/or basting are anticipated. Due to this reason, exploration may be completed only with the assistance of an excavator and dump trucks for transport. For extraction, it is recommended to remove granular material in layers from source E5 to reduce the potential for instabilities.

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4.5.9 Overview of Requirements for Closure and Reclamation

Based on the fact that source E5 is an existing stockpile, closure and reclamation of this area should be limited to removing the available granular source available and restoring surface water flow towards the boggy area located south from the stockpile. Erosion should be monitored during the post-closure period and maintenance completed as required.

5.0 GRANULAR SOURCE SURVEY – NEW POTENTIAL BORROW AREAS

5.1 Granular Source # N1

5.1.1 Overall Description

Granular source N1 is a large potential source located approximately 1.0 km north of the community of Igloolik and immediately west of the sewage lagoons, as shown on **Drawing 01**. The majority of source N1 is comprised of cobble and gravel sized soils. As illustrated in **Appendix C**, this granular source is

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bounded to the south by a bedrock escarpment, to the north by an all-season road, to the east by an access road and to the west by low-lying terrain that eventually merges with a peat covered area near the former community runway.

The depth of granular materials (from ground surface to refusal in frozen soils or bedrock) was assessed through the test pit investigation. Depths of 1.2, 1.2 and 1.4 m to frozen soils were observed during the site investigation. Peat was observed to overly the granular deposit, with thickness between 0.1 and 0.3 m.

5.1.2 Topography

Average slopes of over 10 % were observed in the area of source N1. The southern perimeter of source N1 is at about 40 m above sea level (asl) diminishing to about elevation 30 m asl along the northern perimeter of the area. Slopes become gentle towards the northern perimeter of the area. Plateaus were observed at about elevation 33 to 37 m asl which may facilitate extraction of granular materials from this potential source.

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5.1.3 Surface and Groundwater Considerations

Source N1 is well drained along its south-western perimeter, where steep slopes exist. Test pits excavated in this area revealed that the granular materials are moist with no free water present. The north-eastern section of the area is made up of gently sloping land. Along this section, select peaty terrain with groundwater near ground surface was observed during the field investigation. Excess water in these areas may be related to late snow melt.

Development of source N1 may cause some level of permafrost degradation with the removal of peat from the area, which may cause excess water in the area as a consequence of permafrost degradation.

5.1.4 Site Access

Site access to the source N1 is facilitated by an all-season road considered in very good conditions. It is not anticipated the need of additional access roads for the exploration of source N1.

5.1.5 Environmental Impacts Associated with Development

The environmental impacts that are anticipated with the development and exploration of area N1 are:

- Removal of peat from the area;
- Permafrost degradation and exposure, and potential for surface water accumulation along the north-eastern section of source N1;
- Proper closure and reclamation of the site after its use will allow environmental impacts to be mitigated and arctic vegetation to establish itself in the area with time.
- This area is not considered to be overly inhabited by wildlife whether migratory, aquatic, spawning, nesting or unusual species.

5.1.6 Results of Laboratory Analyses

Three test pits were excavated within the footprint of source N1 (TP-11-23 to TP-11-25). Representative samples were collected and submitted for laboratory analyses to assess grain size distribution and water

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content. The results of laboratory analyses show that the granular material from source N1 is composed of well graded gravel with sand content ranging from 10 to 20 %, cobble content ranging from 10 to 20 %, and typically less than 10 % of fines (silt and clay).

The measured water content of samples was in the range of 7 to 8 % (moist).

5.1.7 Footprint and Available Volumes

The footprint of source N1 (illustrated on **Drawing 01**) is estimated to be approximately 100,000 m^2, with approximate length of 1,000 m and approximate width of 85 m.

It is estimated that approximately 100,000 m^3 of granular material is available for removal from granular source N1, assuming average thickness of 1.0 m for granular materials (based on thicknesses discussed in **Section 5.1.1**).

5.1.8 Methods for Future Development

The extraction of granular materials from source N1 should be initiated at the north-eastern perimeter of the area where the ground is gently sloping. With continued development of this area, excavations should move towards the south-western section of the area. Proper management of site slopes including stability and seepage control should be completed to maintain overall stability of site slopes.

For the removal of the granular material from source N1, it is anticipated that extraction can be completed with the assistance of an excavator, loader, dozer and dump truck.

Topsoil should be stockpiled and used for progressive reclamation and closure of the area.
Granular materials should be excavated until refusal in frozen soils or bedrock. No excavations should be completed below the water table (if encountered).

If excavated material contains ground-ice, it should be stored at a location within the boundaries of the source area where it can thaw and drain. Small stockpiles are preferred rather than large stockpiles.
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5.1.9 Overview of Requirements for Closure and Reclamation

- Cleanup
    - As part of the closure and reclamation activities, all provisional structures, machinery, parts, garbage and any material stockpiles at source N1 should be removed and disposed of off-site.
- Landscape reconstruction
    - The landscape should be reconstructed to reduce the potential for instability, surface water accumulation and permafrost degradation.
    - Peat removed during the preparation of the site for exploration should be reused as part of the progressive reclamation or site closure. Progressive reclamation of explored sections is recommended with excavated overburden excavated from new areas used for covering and recontouring.
    - The ground surface should be roughened to improve potential for revegetation.
- Drainage and erosion control

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- Grading and contouring is to be completed to minimize the potential for surface water accumulation and erosion in the reclaimed areas. Culverts may have to be installed to allow surface water to flow northeast towards the ocean.

- Revegetation:
  - Attempts to restore the natural vegetation in the area should be completed by placing excavated overburden and topsoil back to the area.
- Monitoring:
  - Regular inspections are to be completed and maintenance completed as required. The overall stability of the slopes at closure should be assessed by a geotechnical engineer.

5.2 Granular Source # N2

5.2.1 Overall Description

Granular source N2 is located immediately southwest of the community of Igloolik, east of the road to the airport and fuel station, as shown on **Drawing 01**. During the field investigation completed by ARKTIS' staff, a predominance of weak (i.e. broken with hands), flat, cobble sized particles was observed on the surface layer of source N2. Due to the coarse grain size of the granular material and possibility of the existence of buried utilities in the area, test pits were not excavated within the footprint of source N2.

Granular source N2 has an approximate area of 90,000 m^2, roughly 400 m in length and 200 m in width. Source N2 is a well drained location with average elevation of 46 m asl, and is bounded by the community of Igloolik to the east, by the access road to the airport and fuel station to the west, to a flat terrain (source N3) to the south and by an access road to the community to the north.

5.2.2 Topography

Source N2 is well drained with elevation in the range of 38 to 48 m asl. The majority of source N2 gently slopes (approximately 2 %) to the east. Steeper slopes are observed along the eastern perimeter of the area, with declivity of up to 1V:5H.

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5.2.3 Surface and Groundwater Considerations

During the field investigation completed in the area, there was no wet ground observed within the footprint of source N2. Although the area is well drained, there are a few sections along the northern perimeter of source N2 that may present groundwater near ground surface or surface water accumulation; these sections may require proper management during the development and operations of the source.

5.2.4 Site Access

Access to the potential granular source N2 is facilitated by an all season road that connects the community of Igloolik to the airport and fuel station. The area can also be accessed by a road along the eastern perimeter of the area. It is not anticipated that additional access roads will be required for the development of this potential source.

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5.2.5 Environmental Impacts Associated with Development

The main environmental impacts that are anticipated with the development of the potential granular source N2 are as follows:

- Potential for generation of dust with the development and operations, which may impact the community located immediately east of the area;
- Removal of peat from selected areas;
- Exposure of permafrost which may result in potential degradation;
- Due to its proximity to the community, this area is not considered to be overly inhabited by wildlife whether migratory, aquatic, spawning, nesting or unusual species.

5.2.6 Results of Laboratory Analyses

Samples from the potential granular source N2 were not collected for laboratory analyses due to the occurrence of an excessive quantity of large sized materials (i.e. cobbles and boulders) in the area.

5.2.7 Footprint and Available Volumes

The footprint of potential source N2 is estimated to be approximately 90,000 m^2. The depth of cobbles and gravels in the potential granular source is estimated to be 0.7 m based on the drilling investigation completed in this vicinity at the time of the investigation. It is estimated that a total volume of 63,000 m^3 of cobbles and gravels could be extracted from source N2.

5.2.8 Methods for Future Development

A large quantity of oversize rock (i.e. coarse cobbles) was observed in this potential granular source. The method that is indicated for the development of this area is the removal of granular materials in layers with thickness of less than 0.5 m to prevent surface water accumulation, physical instabilities and risk to the community as the area is frequently traversed by community members to reduce the distance from community to the fuel station. Maximum slopes of 1V:3H must be maintained to reduce overall risk.

Minimum removal of peat must be ensured during the development of this potential source.

Removal of materials should be completed by an excavator and transport completed by dump trucks. Stockpiles of granular materials should be avoided in this area due its proximity to the community and risks associated to this practice.

5.2.9 Overview of Requirements for Closure and Reclamation

Closure and reclamation of this potential granular source should be completed in a way to reduce or eliminate any impacts to the community and to the environment. As this area is very close to the community, the following items must be considered for closure and reclamation after exploration:

- Grading and recontouring of the area after exploration to reduce the potential for surface water accumulation and to prevent permafrost exposure;
- Construction of diversion ditches or other drainage structures to reduce the potential for surface water and snow melt to flow east towards the community; and
- Discuss with community members potential future uses for the area to set closure and reclamation objectives and criteria based on community needs. Regular inspections are to be completed and

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maintenance completed as required. The overall stability of the slopes at closure should be assessed by a geotechnical engineer.

5.3 Granular Source # N3

5.3.1 Overall Description

Granular source N3 is located immediately southwest of the community of Igloolik, east of the road to the airport and fuel station, and south of the granular source N2, as shown on **Drawing 01**. The general characteristics of this potential granular source are similar to source N2. The predominant granular material available in source N3 is cobble sized rock with trace to some boulders and some gravel, with fines content typically less than 10 % based on visual inspection. Cobbles from this area are elongated and broken by hand with medium effort. Due to the coarse grain size of the granular material in this area, possibility of the existence of buried utilities and proximity to the fuel station, test pits were not excavated within the footprint of source N3.

Granular source N3 is a well drained location with an approximate area of 70,000 m^2, roughly 450 m in length and 150 m in width. The elevation of source N3 is in the range of 32 to 45 m asl, and is bounded by the community of Igloolik to the east, by the access road to the airport and fuel station to the west, to what is believed to be airport land to the south and by potential source N2 to the north.

5.3.2 Topography

The topography of the western half section of potential source N3 is characterized by gentle slopes with average declivity of around 4 % to the east. The slopes become steeper along the eastern half section of the area where slopes over 8 % in declivity to the east can be observed.

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5.3.3 Surface and Groundwater Considerations

Based on visual observations, no wet areas or signs of surface water accumulation were observed within the footprint of source N3. The area is characterized by the existence of slopes that allow surface water to flow east of the area. There is no indication that groundwater will impact or be impacted by the exploration of granular materials from this location.

5.3.4 Site Access

Site access to the potential granular source N3 is good. Access to the area is possible by an existing access road that connects the community to the fuel station. Alternatively, a trail along the eastern perimeter of the area can be upgraded and used as the main access to the area.

5.3.5 Environmental Impacts Associated with Development

- Similar to the environmental impacts with the exploration of granular materials from source N2, the potential impacts due to the exploration of source N3 are anticipated to result from the following main elements:
- Generation of dust related to development and operations;
- Removal of peat from selected areas which may result in additional permafrost degradation in the area and vicinity;

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- Exposure of permafrost which may result in potential degradation;
- No anticipated impacts to migratory, aquatic, spawning, nesting or unusual wildlife species.

5.3.6 Results of Laboratory Analyses

Samples from potential granular source N3 were not collected for laboratory analyses as granular materials from this area are oversized which does not make laboratory analysis possible. Due to this reason, material grain size was logged by visual inspection only.

5.3.7 Footprint and Available Volumes

The footprint of potential granular source N3 is estimated to be approximately 70,000 m^2. As adopted for potential granular source N2, the depth of cobbles and gravels in source N3 is estimated to be 0.7 m based on the drilling investigation completed in this locality. Therefore, it is estimated that up to 49,000 m^3 of cobbles and gravels can be extracted from source N3.

5.3.8 Methods for Future Development

Following the concept for development of source N2 discussed in **Section 5.2.8**, the method that is indicated for removal is the excavation of granular materials in layers with thickness of less than 0.5 m to prevent water accumulating to form ponds, physical instabilities and risk to the community as the area is frequently traversed by community members to reduce the distance from the community to the fuel station. Maximum slopes of 1V:3H must be maintained to reduce overall risk and large boulders safely placed in flat areas.

For the development and exploration of this area, an excavator should be used for the removal of granular materials. Stockpiling of material is not recommended for this area due to potential risks to frequent traffic of snowmobiles and ATVs (all-terrain vehicles) in the area.

5.3.9 Overview of Requirements for Closure and Reclamation

Requirements for closure and reclamation of source N3 are similar to the requirements for closure of source N2 due to the similarity of their general characteristics. Closure and reclamation of this area may require additional criteria, including specific goals and objectives, if compared to other areas due to its proximity to the community of Igloolik. Preliminary elements to be considered for closure and reclamation are summarized below:

- Surface water accumulation and permafrost degradation must be limited or prevented by completing grading and contouring of the area after extraction of materials. Specific requirements for grading involve the regular and frequent placement of granular material cover over areas of exposed permafrost during excavation activities to reduce exposure time and thereby minimize potential permafrost degradation;
- Drainage elements, such as ditches, dykes, culverts, and swales, may be required to collect and divert excess surface water runoff from the reclaimed area and prevent excessive flow towards the community;
- Closure and reclamation of this source should include community input and future land uses. An assessment of this area should be completed to evaluate impacts and allow design to address all concerns and impacts in the area due to operations.

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5.4 Granular Source # N4

5.4.1 Overall Description

The potential granular source N4 is located approximately 4.0 km from the community, south of the airport, east of granular source E4, and north and west of low-lying boggy areas, as shown on **Drawing 01**.

Gravel is the predominant granular material available in source N4. Some cobbles are present in the eastern half of source N4 and were observed to be elongated and broken by hand with medium effort. Granular source N4 is a well drained location with an approximate area of 390,000 m^2, roughly 800 m in length and 450 m in width. The elevation of source N4 is in the range of 18 to 36 m asl. The elevation of the area decreases towards the southeast section.

Four test pits were excavated within the footprint of potential source N4 (TP-11-16 to TP-11-19). The depth of granular materials to refusal was measured to be in the range of 0.6 to 1.2 m.

5.4.2 Topography

The topography of the area is characterized by up to 4 % slopes to the southeast. The slopes become slightly steeper downgrade of this area where wet areas and surface water accumulation can be observed.

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5.4.3 Surface and Groundwater Considerations

Source N4 is considered mostly well drained. No surface water accumulation was observed within the footprint of the area. Free water was observed in two of the four test pits excavated in the area, at about 0.6 m below ground surface. Refusal of test pits occurred in ice or ice-rich soils, which may cause seepage and excess soil pore water in case of permafrost degradation.

5.4.4 Site Access

Access to granular source N4 is facilitated by an all season road that connects the community to granular source E4, followed by an ATV trail that allows access to granular source N4 through the southern perimeter of source E4.

For the development of granular source N4, upgrades are required to the ATV trail to allow access to the area. Upgrade activities may include site grading, placement of fill and drainage elements such as diversion ditches and culverts.

5.4.5 Environmental Impacts Associated with Development

The environmental impacts that are anticipated with the development of source N4 are:

- Removal of sporadic topsoil from the area;
- Permafrost degradation and exposure, and potential for surface water accumulation;
- It is unlikely that development of this area as a granular source will impact wildlife whether migratory, aquatic, spawning, nesting or unusual species.

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5.4.6 Results of Laboratory Analyses

Four representative samples were collected from test pits excavated within the footprint of source N4 (sample G15 from TP-11-16; sample G16 from TP-11-17; sample G17 from TP-11-18; and sample G18 from TP-11-19).

The water content of samples collected during the investigation was measured to be in the range of 2 to 12 %. The grain size distribution analyses indicated that the soils at source N4 are mostly comprised of gravels with up to 10 % cobbles, 0 to 20 % sand and up to 10 % fines.

5.4.7 Footprint and Available Volumes

The footprint of potential granular source N4 is estimated to be in excess of 390,000 m^2. Based on the results of the test pit investigation, an average depth of 0.7 m of granular materials was considered appropriate. Therefore, it is estimated that up to 273,000 m^3 of granular materials can be extracted from source N4.

5.4.8 Methods for Future Development

- Remove peat and organics (if any);
- Directly remove granular materials from the source with the assistance of an excavator, loaders and/or dozers;
- Excavated material contains ground-ice (e.g. seasonal ice in soil), it should be stored at a location within the boundaries of the source area where it can thaw and drain.
- Granular materials should be excavated until refusal in frozen soils or bedrock;
- No excavations should be completed below the water table;

5.4.9 Overview of Requirements for Closure and Reclamation

- Cleanup
    - All provisional structures, machinery and parts, garbage and any material stockpiles should be removed from the site for closure.
- Landscape reconstruction
    - Grading and recontouring should be completed as part of closure activities, covering exposed permafrost and placing fill in areas where surface water accumulation may occur.
    - The ground surface should be roughened to improve potential for revegetation.
- Erosion control
    - Grading and contouring is to be completed to minimize the potential for surface water accumulation and erosion in the reclaimed areas.
- Revegetation:
    - Attempts to restore the natural vegetation in the area should be one of the goals of the closure and reclamation of the area.
- Monitoring:
    - Regular inspections are to be completed and maintenance completed as required.

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6.0 EVALUATION OF AVAILABLE GRANULAR SOURCES

6.1 Evaluation

This section presents an overall evaluation of the existing and potential granular source areas. The following elements are discussed separately for each area identified in **Section 4** and **Section 5** of this report:

- Available/remaining volumes of granular materials
- Site access
- Surface and groundwater
- Environmental impacts associated with development
- Topography
- Closure requirements

The evaluation system adopted in this report is described below:

- Available/remaining volumes of granular materials:
    - High: more than 150,000 m3 of granular materials available for exploration..
    - Moderate: 50,000 to 150,000 m3 of granular materials available for exploration.
    - Low: less than 50,000 m3 of granular materials available for exploration.

- Site access:
    - Very Good: well maintained existing access roads exist in the area where no or minimum upgrades are required. No additional roads are required for the exploration of the granular source area.
    - Good: access road to the granular source area is in good condition requiring minor upgrades. Construction of sections of new access roads within the footprint of the granular source area may be required to optimize exploration and facilitate removal of granular materials from the area.
    - Fair: existing access road to the granular source requires significant upgrades or access roads within the footprint of the granular source area need to be constructed involving significant challenges.
    - Poor: access to the area requires the construction of roads and/or significant upgrades to existing access roads in poor condition.

- Surface and groundwater:
    - Very good: exploration is not expected to affect the surface and groundwater system in the area based on visual observations and the results of the test pit investigation. The area is well drained and there is no to minimum impact from surface water. Groundwater is not a concern related to development.
    - Good: development affects the surface and/or the groundwater system in the area to a low degree. Preventive actions may be required such as the excavation of ditches to divert surface water off-site and prevent surface water accumulation. The groundwater may become a concern with extraction of granular materials to depths greater than 1.0 m depth.

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  - Fair: development affects the surface and/or the groundwater system in the area to a moderate degree. Continuous efforts to divert surface water off-site and groundwater control measures may be required. Groundwater may become a significant concern with excavation of granular materials in the area at shallow depths (i.e. less than 1.0 m).
  - Poor: development affects the surface and/or the groundwater system in the area to a high degree. The area has the potential for surface water accumulation due to a shallow groundwater system (typically near ground surface) and uncontrolled surface water runoff. Challenges in operating the granular source area are anticipated from a surface/groundwater effects perspective.

- Environmental impacts associated with development:
  - High: elevated environmental impacts are anticipated to occur with the development of the granular source area, which may include permanent damage to wildlife habitat and vegetation in the footprint of the granular source area and/or areas in the immediate vicinity. Closure activities may not rehabilitate the site to pre-development conditions due to the severity of environmental impacts caused during operations.
  - Moderate: some damage is anticipated to occur with the development of the granular source area, which may include temporary damage to wildlife habitat and local vegetation. Environmental impacts are considered temporary and may be rehabilitated during closure of the area. No or low environmental impacts remain after site closure.
  - Low: no or low adverse environmental impacts are anticipated with the development of the granular source area based on visual inspection completed in the area. Development is not expected to generate significant damage to wildlife and local vegetation within the footprint of the area and immediate vicinity.

- Topography:
  - Good: the topography of the area is overall flat and facilitates extraction of granular materials from the area. No steep slopes are observed in the area.
  - Fair: the topography of the area includes some slopes which can be managed to limit their impact in the overall development of the granular source area. Limited areas of the granular source location have steep slopes but no challenges or concerns exist with operations from a topography standpoint.
  - Poor: the topography of the area is anticipated to be a challenge for the development of the granular source area. Steep slopes are encountered within the footprint of the area which may require additional efforts to extract granular materials.

- Closure requirements:
  - High: significant efforts are required to close and rehabilitate the area after the granular source is exhausted. Closure activities may require management of significant permafrost degradation or require soil cover in the majority of the area.
  - Moderate: some challenges are anticipated for the closure of the area, which may include the construction of diversion ditches to facilitate surface water drainage and reduce post-closure erosion, and placement of a cover system in part of the footprint of the area and other activities.

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- Low: no significant efforts are anticipated to be needed for closure, which may only require overall site grading and recontouring to facilitate surface water drainage.

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Table 2 – Comparison table for granular source areas in Igloolik, Nunavut

Granular source ID	Distance from the community	Estimate volume available	Predominant Grain Size	Site access	Surface and groundwater considerations	Environmental impacts associated with development	Topography	Closure Requirements
E1	2.7 km	Moderate (52,000 m^3)	Sandy gravels	Very good	Good	Low	Good	Low
E2	0.7 km	Low (12,800 m^3)	Gravels	Very good	Fair to Good	Low	Fair to Good	Low
E3	0 km	Moderate (66,500 m^3)	Gravels	Very good	Fair to Good	Low	Good	Low to Moderate
E4	2.7 km	High (336,000 m^3)	Cobbles and gravels	Good	Good	Low	Good	Low
E5	2.7 km	Low (18,000 m^3)	Boulders, cobbles and gravels	Very good	Very Good	Low	Fair	Low
N1	1.0 km	High (100,000 m^3)	Sandy gravels	Very good	Moderate	Moderate	Poor to Fair	Moderate to High
N2	0.8 km	Moderate (63,000 m^3)	Cobbles and gravels	Very good	Moderate	Low to Moderate	Fair	Moderate to High
N3	1.0 km	Low (49,000 m^3)	Cobbles and gravels	Very good	Moderate	Low to Moderate	Fair	Moderate to High
N4	4.0 km	High (273,000 m^3)	Gravels	Fair	Fair to Good	Low to Moderate	Good	Low

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6.2 Advantages and Disadvantages

The key advantages and disadvantages related to the development of each granular source location identified in this report are discussed below.

- Source E1
    - Advantages:
        - Easy access to the area
        - Availability of well graded sands for extraction
        - Most organics were already removed from the area
    - Disadvantages:
        - Reduced volume of available granular materials remaining in the area

- Source E2
    - Advantages:
        - Adequate proximity to the community
        - Easy access to the area
        - Proximity to the existing sewage lagoons and landfill with potential for available granular material to be used for maintenance and closure activities
    - Disadvantages:
        - Low volume of available granular materials remaining in the area
        - Late snow melt during spring which may cause surface water accumulation and excess water within the granular material during summer

- Source E3
    - Advantages:
        - Proximity to the community and hamlet garage
        - Easy access to the area
        - Moderate remaining volume of granular material for extraction
    - Disadvantages:
        - Exposed permafrost is degrading along the northern area of the source causing surface water to accumulate and form ponds. Continued exploitation may cause additional degradation
        - Risk of dust and noise generation and subsequent impact to the community

- Source E4
    - Advantages:
        - Large volume of granular materials available for extraction
        - Easy access
        - Low risk to generate dust and noise in the community
        - The area is well drained with potential for impact to surface water and groundwater system due to higher ground elevation
        - Uniform and well graded materials available
        - Favourable topography and gentle slopes which facilitates operations
    - Disadvantages:
        - Proximity to runway and potential restrictions due to airport operations

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- Source E5
    - Advantages
        - Use of an existing stockpile with grain size from sand to large boulders
        - Removal of material from this area will allow the surface water pathways to be restored in the area
        - Easy access
        - Availability of large boulders for armouring
    - Disadvantages
        - No disadvantages with the development of this area as it is an existing stockpile placed during the construction of the existing potable water reservoir

- Source N1
    - Advantages
        - Large volume of granular materials available for extraction
        - Easy access
        - Proximity to the community
        - Proximity to the existing sewage lagoons and landfill with potential for available granular material to be used for maintenance and closure activities
    - Disadvantages
        - Potential for seepage and physical instabilities as a result of permafrost degradation and potential poor practices during operations
        - Potential for seepage resulting from permafrost degradation may increase volume of water flowing towards the access road located north of the area

- Source N2
    - Advantages
        - Easy access to the area
        - The area is well drained with low potential for surface water accumulation during operations
    - Disadvantages
        - Proximity to the community and potential for excess dust and noise generation affecting the community during operations
        - Irregular form and low strength of cobbles (flat and weak)
        - Potential permafrost degradation in the immediate vicinity of the community

- Source N3
    - Advantages
        - Easy access to the area
        - The area is well drained with low potential for surface water accumulation during operations
    - Disadvantages
        - Proximity to the community and potential for excess dust and noise generation affecting the community during operations
        - Irregular form and low strength of cobbles (flat and weak)

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- Potential permafrost degradation in the immediate vicinity of the community
- Proximity to the fuel station

- Source N4
  - Advantages
    - Large volume of granular materials available for extraction
    - Low risk for dust and noise to reach the community
    - Closure and reclamation may only require grading and recontouring considering that the area is well drained and has relatively high elevation
    - Uniform and well graded materials available
    - Favourable topography and gentle slopes which facilitates operations
  - Disadvantages
    - Access to the area requires improvement of existing ATV trails
    - Proximity to runway and potential restrictions due to airport operations

7.0 SPILL CONTINGENCY PLAN

This section presents a spill contingency plan that should be followed during operations of the quarries in the Municipality of Igloolik, Nunavut. The contents of this section are based on recommendations from the Environmental Protection Service – Department of Sustainable Development guide[3].

7.1 Definition

A spill contingency plan is a set of procedures to be followed to minimize the effects of an abnormal event such as a spill, serving as a guide or reminder of the steps to take during response to a spill and identified personnel, responsibilities and location of equipment, and individuals who should be notified. All personnel working on the granular source areas should be aware of and understand the plan so that they can respond effectively to a spill.

A spill is defined as the discharge of petroleum products or other dangerous substances into the environment. Potential hazards created by any spill may affect humans, vegetation, water resources, fish and wildlife with intensity that may range from low to severe, depending on volumes and types of dangerous substances discharged into the environment.

7.2 Management, Control and 24h Contact Information

The overall management and control of the activities in the Municipality of Igloolik is the responsibility of the Senior Administrative Officer (SAO) or staff designated for the management of spills during operation of the borrow source areas.

The contact information of the SAO is below including phone number:

[3] Environmental Protection Service – Department of Sustainable Development. Contingency Planning and Spill Reporting in Nunavut. A Guide to the New Regulations. File assessed on August 31, 2011 on http://env.gov.nu.ca/sites/default/files/Spill%20Planning%20and%20Reporting%20Guide.pdf

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- SAO: Brian Fleming
- Phone: 867.934.8940

7.3 Description of the Facilities

This spill contingency plan was prepared for the granular source areas that will require approval from the Nunavut Impact Review Board (NIRB) for exploration of granular materials. The characteristics and descriptions of the granular source areas are discussed in **Section 4** and **Section 5** of this report, specifically for each area, including an overall description, topography and surface and groundwater characteristics.

7.4 Storage of Contaminants in Granular Areas

It is not anticipated that any contaminants will be stored at any granular source area in the Municipality of Igloolik. The only source of potential contaminants that is anticipated in these areas is petroleum products originating from leaks and drips from machinery, pumps, motors and other equipment involved in the development of these areas. Refuelling of vehicles and equipment will be completed at the hamlet garage or in an area designated by contractor, which will not occur at the granular source areas; this will eliminate the need to store fuel at the granular source areas. For contamination where spills of contaminants are in excess of specified quantities presented in **Table 3**, the incident must be reported following recommendations from the Spill Contingency Planning and Reporting Regulations for Nunavut.

7.5 Response Action by Steps

The following response actions are to be taken when facing a spill at the granular source areas:

- Immediately clean up minor spills;
- Use the available spill kits to limit the impact of any spills, following the REACT methodology presented below;
- If the individual is unsure of what to do with the spill and response procedures, he/she should immediately call for help to deal with any incident;
- Individuals in the spill area are to maintain their safety first and protect untrained personnel from interacting with the contamination. Prevent personnel from approaching the site and keep them at a distance considered safe that they will not be injured, or cause a fire or explosion;

The response methodology adopted for this spill contingency plan is the REACT model, as described below:

1. Remove the source that is causing the spill. Actions such as stop the drip, plug the leak, tighten the joint, replace a part, etc may be necessary.
2. Envelope the spill. The spill should be controlled by preventing the spread of the spill, keeping it localized to minimize potential impact.
3. Absorb/Accumulate the hazardous from the spill. The use of absorbent materials should assist in removing liquid contaminants from the ground. It is recommended the use of spill kits which should be provided by elements to allow the control and absorption of spills.
4. Containerise/Clean up the spill. Whenever possible, the contaminated soil and/or water should be collected and stored for later treatment. It is recommended the use of buckets or drums with the

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assistance of shovels or excavators to containerise the impacted soil/water and to remove the contamination from the environment.

5. Transmit a report detailing the spill, including information such as location of the spill, name of polluter, type and amount of material spilled, date and time of the spill and any perceived threat to human health or environment.

Additional information on response to spills is provided below for spills on land, water and snow and ice.

7.5.1 Spill on Land

The response to spills will include the REACT procedures described above including the steps below if necessary and applicable:

- Identify the source of the spill (equipment, motor, pump, etc);
- Contain the spill at the source whenever possible;
- Place containers or plastic sheets at the foot of the leak to minimize the potential for the contaminant to spread;
- Place a soil berm downslope of the seeping fuel. Plastic tarps can be used at the foot and over the berm to allow the fuel to pool on the plastic liner for easy capture. Berms can also be made of snow and lined with plastic in the winter;
- Absorbent sheeting can be used to soak up the fuel. The fuel can be then squeezed from the pads into plastic pails or other containers. Larger pools of fuel can be pumped if necessary. The overall goal should be prevent fuel from entering a body of water where it can have a significant environmental impact;
- Everyone in contact with fuel should wear appropriate equipment to prevent direct contact (e.g. gloves);
- Contaminated soils and absorbent sheets are to be removed from the spill area and stored in containers for later treatment and/or incineration.

7.5.2 Spill on Water

The likelihood of a spill on or over water is considered very remote as the existing and new potential granular source areas are not located in the immediately vicinity of lakes or the ocean. Due to this reason, a response plan for spills on water is not considered in this contingency plan.

7.5.3 Spill on Snow and Ice

Where a spill occurs on ice, it is recommended to compact snow around the edge of the spill and line the compacted zone with plastic sheeting to serve as a berm, which should prevent seepage of fuel into the water. Contaminated snow and ice must be scraped up immediately. The contaminated snow can then be placed in drums or on plastic and within plastic lined berms on land.

7.6 Site Map

A site map showing the location of all existing and new potential sources of granular material for the community of Igloolik is presented on **Drawing 01**.

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7.7 Training Required

All field personnel should receive training on what to do in case of a spill and in taking preventative measures to mitigate potential spills. This plan should be made available to staff to review and to become familiar with its contents and what to do in case of a spill, including reporting requirements.

To ensure that all individuals remain aware and cognisant of this document, refresher training and safety debriefing meetings should occur at regular and random intervals, especially before activities at the granular source locations identified in this report in **Section 4** and **Section 5**.

7.8 Inventory and Location of Response and Clean-up Equipment

The equipment that will potentially be used for clean-up activities should be similar to the equipment used by the Municipality of Igloolik for the development of the granular source areas, including as a minimum:

- One excavator
- One dump truck

All vehicles and machinery should be equipped with spill response kits and drip trays.

7.9 Spill Reporting

Internal reporting will occur directly to the staff manager and to the SAO. Internal reporting is required for minor spills and incidents.

For incidents where spills of contaminants are in excess of specified quantities (see **Table 3**), the incident will be reported following recommendations from the Spill Contingency Planning and Reporting Regulations for Nunavut (Government of Nunavut, 2011)[4]. Where there is a reasonable likelihood of a spill in an amount equal to or greater than the amount set out in **Table 3**, the owner or person in charge, management or control of the contaminants shall immediately report the potential spill following specifications described in the Spill Contingency Planning and Reporting Regulations for Nunavut and Environmental Protection Act[5].

[4] Government of Nunavut (2011). Spill Contingency Planning and Reporting Regulations for Nunavut. Available on: http://env.gov.nu.ca/sites/default/files/Spill%20Planning%20and%20Reporting%20Guide_0.pdf

[5] Environmental Protection Act (1999). Consolidation of spill contingency planning and reporting regulations.

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Table 3 – Criteria for external reporting of spills[5].

Item No.	TDGA Class	Description of Contaminant	Amount Spilled
1	1	Explosives	Any amount
2	2.1	Compressed gas (flammable)	Any amount of gas from containers with a capacity greater than 100 litres
3	2.2	Compressed gas (non-corrosive, non flammable)	Any amount of gas from containers with a capacity greater than 100 litres
4	2.3	Compressed gas (toxic)	Any amount
5	2.4	Compressed gas (corrosive)	Any amount
6	3.1, 3.2, 3.3	Flammable liquid	100 litres
7	4.1	Flammable solid	25 kg
8	4.2	Spontaneously combustible Solids	25 kg
9	4.3	Water reactant solids	25 kg
10	5.1	Oxidizing substances	50 litres or 50 kg
11	5.2	Organic peroxides	1 litre or 1 kg
12	6.1	Poisonous substances	5 litres or 5 kg
13	6.2	Infectious substances	Any amount
14	7	Radioactive	Any amount
15	8	Corrosive substances	5 litres or 5 kg
16	9.1 in part	Miscellaneous products or substances, excluding PCB mixtures	50 litres or 50 kg
17	9.2	Environmentally hazardous	1 litre or 1 kg
18	9.3	Dangerous wastes	5 litres or 5 kg
19	9.1 in part	PCB mixtures of 5 or more parts per million	0.5 litres or 0.5 kg
20	None	Other contaminants	100 litres or 100 kg

A person reporting a spill shall give as much of the following information as possible:

a) Date and time of spill;
b) Location of spill;
c) Direction spill is moving
d) Name and phone number of a contact person close to the location of spill;
e) Type of contaminant spilled and quantity spilled;
f) Cause of spill;
g) Whether spill is continuing or has stopped;
h) Description of existing containment;
i) Action taken to contain, recover, cleanup and dispose of spilled contaminant;
j) Name, address and phone number of person reporting spill;
k) Name of person in charge, management or control of contaminants at time of spill.

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7.10 Spill Prevention

Hydrocarbon spills are a major source of contamination at northern pit and quarry operations. Proper fuel storage and handling can help to prevent spills. Refuelling of equipment and vehicles should be completed in the proper area in the hamlet garage or under the responsibility of a contractor (if the case), and not at the granular source areas.

8.0 LIMITATIONS OF LIABILITY

This report has been prepared exclusively for the use of the Government of Nunavut – Department of Government Services, for the specific application described in **Section 1** of the report. The information and recommendations contained in this report should not be used for any other purpose, at another location, or by any other parties. Any use of, or reliance on this report by any third party is at that party's sole risk. The contents of this report were prepared in accordance with generally accepted principles, ethics and practices. No other warranty, expressed or implied, is given.

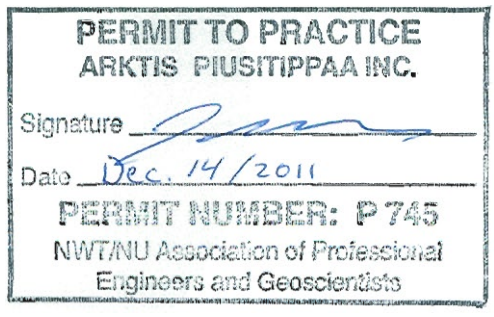
For further limitations, reference should be made to the General Terms and Conditions in **Appendix D**.

9.0 CLOSURE

We trust that this report meets your present requirements. Please contact the undersigned should there be any questions.

ARKTIS SOLUTIONS INC.

Prepared by:



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