AGGREGATE RESOURCE STUDY
RANKIN INLET, NUNAVUT

Report No. L-15-1860
November 23, 2016


Sand stockpiles at the Meliadine sand pit

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.
801 Bancroft Pointe-Claire, QC H9R 4L6
T (514) 630-4997 F (514) 630-8937

EXECUTIVE SUMMARY

On behalf of the Hamlet of Rankin Inlet and the Government of Nunavut Department of Community and Government Services, JOURNEAUX ASSOC. conducted a desktop study and field investigation program to determine the Hamlet's aggregate needs for the next 20 years and to identify, evaluate and recommend specific new aggregate source to meet those needs.

Based on short, medium and long-term infrastructure needs identified by the Hamlet, an estimated total of close to 640,000 m^3 of aggregate may be required over the 20 year period, of which approximately 75,000 m^3 needs to meet select-grade crushed gravel specifications. Current aggregate borrow sources are nearing depletion. A desktop review of previous aggregate studies, satellite imagery and geological surface mapping provided context for the current aggregate study and identified numerous new prospective borrow sources and drill/blast/crush quarry sites.

During a July, 2016 field investigation, JOURNEAUX ASSOC. investigated seven (7) prospective new borrow sources, three (3) active borrow sources, and four (4) potential quarry sites including an existing quarry at the harbour. All but two of the sites were within Hamlet Municipal Boundaries which allows the hamlet to manage the quarries and borrow-pits through the existing Quarry Administration Agreement and to issue permits to contractors to extract materials from the sites. All existing and prospective sites were identified by their distance from the hamlet along the main Diane River Road to the west and the Agnico-Eagle Meliadine Mine Road to the northeast. These prospective aggregate sources, along with the type and estimated volume of available material, are summarized in the table below.

SOURCE	HAMLET DISTANCE	ESTIMATED VOLUME	MATERIAL TYPE & DETAILS
Diane Pit	6.5 km	126,000 m^3	Active pit with remaining material in recently opened area of gravel and sand north of road (WSP Site 'A') and excellent gravel around and beneath small lake
Meliadine Pit	7.5 km	170,000 m^3	Active sand pit with significant remaining sandy material in ridge to the south (WSP Site 'D') suitable for sand fill and general subbase fill applications.
Agnico-Eagle Pit	17.0 km	50,000 m^3	Active existing pit on Meliadine Mine Road used for road maintenance. Estimated volume in stockpiles and ground.
Journeaux-3 (Diane RR)	8.0 km	70,000 m^3	Raised beach with coarse gravel/cobble at ridgetop transitioning to clean sand at lower elevation. No shale. Mixing/crushing req'd. Cabins and grave site nearby.
Journeaux-4 (Diane RR)	16.0 km & 15.0+1.0 km	150,000 m^3 + 150,000m^3	Two deposits, one on the road and one accessible with 1.0km new road. Excellent source of coarse cobble & gravel (20-40% shale/slate), sand and binder material, with potential small thermokarst lakes on northern deposit.
KM 18 (Diane RR)	18.0 km	140,000 m^3	High, dry ridge with excellent gravel and sand suitable for crushing and/or screening. 10-20% shale/slate component
Journeaux-5 (Diane RR)	18.5 – 21.0 km	800,000 m^3	Complex deposit with some thermokarst lakes and variable material of which ~200,000 m^3 is expected to be coarse cobble and gravel (10-20% shale/slate) near ridgetop.
Journeaux-1 (Meliadine Mine Road)	10.5+2.5 km	800,000 m^3	Extensive area east of the Meliadine River (outside municipal boundary) accessible by 2.5km new road. Coarse beaches against bedrock outcrops and large gravel/sand area surrounding small lake.
Journeaux-2 (Meliadine Mine Road)	15.0 km	1,200,000 m^3	Massive area east of the Meliadine River (outside municipal boundary) roughly 3 square km in size. Investigated by helicopter only. Poorly drained. Volume roughly estimated.
Harbour Quarry	-	450,000 m^3	Existing quarry at harbour.
Diane Quarry Outcrop	6.5 km	110,000 m^3	Moderate-sized outcrop in existing pit
New Dump Outcrop	7.5 km	140,000 m^3	Long, high outcrop next to new landfill site
KM 13.0 Outcrop	13.0 km	90,000 m^3+	Broad outcrop traversed by Diane River Rd at KM 13

From the table, it is easy to see that sufficient aggregate sources are available on the existing road network to meet community needs for the next 20 years. The numerous contractors in the community engaged with the Hamlet to extract aggregate material have the local capacity to develop, manage and maintain the prospective borrow sources. Outside expertise would be required to conduct blasting operations if a quarry was developed, after which the existing contractors could crush, screen and haul the produced blast rock.

Each of the existing and potential borrow source and quarry sites were thoroughly evaluated and analyzed in terms of type, quantity and quality of material, processing required, and suitability for different applications as well as environmental compliance and operational feasibility. Class D cost estimates were used to recommend particular sites for development.

It is expected that the currently active Diane Pit including WSP Site A, and the Meliadine Pit, will meet both common pit-run and select-grade gravel needs for the next 3-5 years, after which upgrading the Diane River Road between KM 5 – 20 and developing the aggregate borrow sources at KM 16, 18 and ultimately KM 18.5 – 20 is recommended to supplement the supply of coarse aggregate for crushing and screening. The increased haul distance and associated road construction and maintenance costs to access the deposits will likely increase the cost of acquiring pit-run aggregate by about $20 per cubic metre over the life-cycle of the deposits which will supply the hamlet well beyond 20 years. Alternatively, higher-cost quarry operation at the existing harbour or the Diane Pit outcrop can produced sufficient select-grade crushed gravel to meet 20 year needs, which will extend the life of the Diane Pit and Meliadine Pit for providing common pit-run materials.

TABLE OF CONTENTS

Tables and Figures

Appendices

1 INTRODUCTION

JOURNEAUX ASSOC., a division of LAB JOURNEAUX INC., was retained by the GOVERNMENT OF NUNAVUT (Department of Community and Government Services, Kivalliq Region) to conduct an Aggregate Resource Study for the Hamlet of Rankin Inlet, Nunavut. Existing aggregate sources currently being extracted are expected to meet short-term needs, but with a rapidly growing population, the development of a sustainable, long-term plan including new aggregate sources is required to meet the Hamlet needs over the next 20 years.

The Aggregate Resource Study included a desktop study of prior aggregate quantity evaluations, projected Hamlet needs over a 20 year period, and potential new aggregate sources. A field investigation was carried out to confirm the identified sources and evaluate the Hamlet's capacities to develop and manage the sources. Both natural deposit (borrow site) exploitation and drill/blast/crush quarry development were evaluated.

Once the field work was complete, a helicopter fly-over was done to view and photograph the investigated sites, existing borrow pits, potential quarry sites, and far-off deposits that were inaccessible from the current road network. This aerial view proved to be vital to the evaluation of areas of granular deposits and their extensions from existing pits and the access to new pits.

Once suitable aggregate sites had been identified and characterized in terms of material type, quality and quantity, a road development and route plan was devised to estimate the construction and maintenance costs for new access roads to these deposits.

Finally, the present Aggregate Resource Study Report was prepared to summarize the findings and present the results of our evaluation, along with recommendations for the development of multiple aggregate sources in the vicinity of Rankin Inlet to meet specified community needs over a 20 year period.

For simplicity, all existing borrow pits, future sources and existing physical features of interest have been referenced in kilometres from the Hamlet using the intersection of Eksusik Street and Tupirvik Ave immediately north of the Community Hall and Arena as km 0.0 (see Figure 6-1 on page 35 below).

2 SCOPE OF WORK

In response to the Call-Up Service Request Contract #MC1530291 from the Government of Nunavut (GN) issued November 17, 2015, JOURNEAUX ASSOC. submitted a proposal under Standing Offer SOA-2013-33, dated January 28, 2016, that outlined the scope of work and fee schedule for the project. Permission to proceed with the work was granted in a contract from the GN on March 21, 2016. The scope of work to conduct an Aggregate Resource Study was established in these documents, and includes:

- Review previous aggregate studies conducted by Trow Associates Inc. (2008) and WSP Inc. (2014) for the Hamlet, and develop a supplemental investigation program to locate and characterize additional deposits as necessary.

- Confirm locations and status of previously identified sites and identify at least two potential new aggregate sources through literature review and satellite imagery/air photo interpretation.

- Consider and identify natural granular deposits (borrow sites) and drill/blast/crush (DBC) quarry sites - as well as combinations thereof - in the evaluation.

- Confirm and refine estimates of aggregate types and volumes required to meet the Hamlet's immediate and long-term needs for the next 20 years.

- Consult with community stakeholders prior to evaluating deposits in the field to ensure the proposed deposits meet local requirements and expectations for land use and development.

- Visit Rankin Inlet to evaluate previously identified and newly identified sites in the field. Evaluation to be according to an established list of criteria that includes but is not limited to:
    - Volumes, type and quality of granular materials available at each site.
    - Proximity, accessibility and suitability to the Hamlet,
    - Methods, equipment and expertise needed to develop and operate the aggregate source,
    - The Hamlet's capacity to manage the aggregate resources,
    - Conformity with environmental and regulatory requirements,
    - Short and long-term suitability and sustainability
    - Sampling and laboratory testing to characterize granular deposits and bedrock outcrops, including general gradation and bedrock composition.
- Inspect the evaluated deposits by drone and/or helicopter to validate the observations made in the field.

- Evaluate the operational, environmental and economic feasibility of selected sites. Discuss the means to extract materials at each site and specific equipment and/or expertise needed to do so. Environmental feasibility includes a high-level environmental assessment to identify potential impacts on wildlife and sensitive environmental resources.

- Produce a road development plan that estimates the costs and aggregate quantities associated with road construction and maintenance required to access the identified sites.

- Compare life-cycle costs of road construction, maintenance and aggregate processing and hauling from distant sites versus the cost of blasting and crushing at closer sites to the Hamlet.

- Recommend which aggregate sites to develop based on the evaluations and lowest life-cycle costs.

- Present the findings, evaluation results and recommendations in the form of a report.

Additional information on each component and aspect of site evaluation, including a full list of criteria used to evaluate and rank each site, can be found in the following sections.

3 PROJECT LOCATION AND SETTING

3.1 Hamlet of Rankin Inlet, Nunavut

The Hamlet of Rankin Inlet is located on the western shores of Hudson's Bay within the Kivalliq region of Nunavut (Figure 3-1), and has geographic coordinates of 62^{o}48' north latitude and 92^{o}05' west longitude. There is no road access to Rankin Inlet from other communities, and the only commercial access is by air or sea.

The population of Rankin Inlet was originally reported as 2,266 persons in the 2011 Census Profile (Statistic Canada, 2012) but later revised to 2,577 after an amended count (Statistics Canada, 2014). The amended count represents a 9.3% increase since the 2006 census, following a reported 8.3% growth between 2001 and 2006 and 5.8% growth between 1996 and 2001.

The Rankin Inlet Integrated Community Infrastructure Sustainability Plan (ICISP) published by the Government of Nunavut Department of Community and Government Services (DCGS) in 2010 (Aarluk Consulting Inc., 2010) projected a population of 3,633 in year 2020, representing more than 40% growth in 9 years following the 2011 census. A more conservative growth rate of up to 10% every 5 years would result in a 2020 population of 3,100 people and a 2025 population of close to 3,500 people.

In any case, the ICISP report identifies community infrastructure needs to meet projected growth and replace aging infrastructure and is regularly updated online.

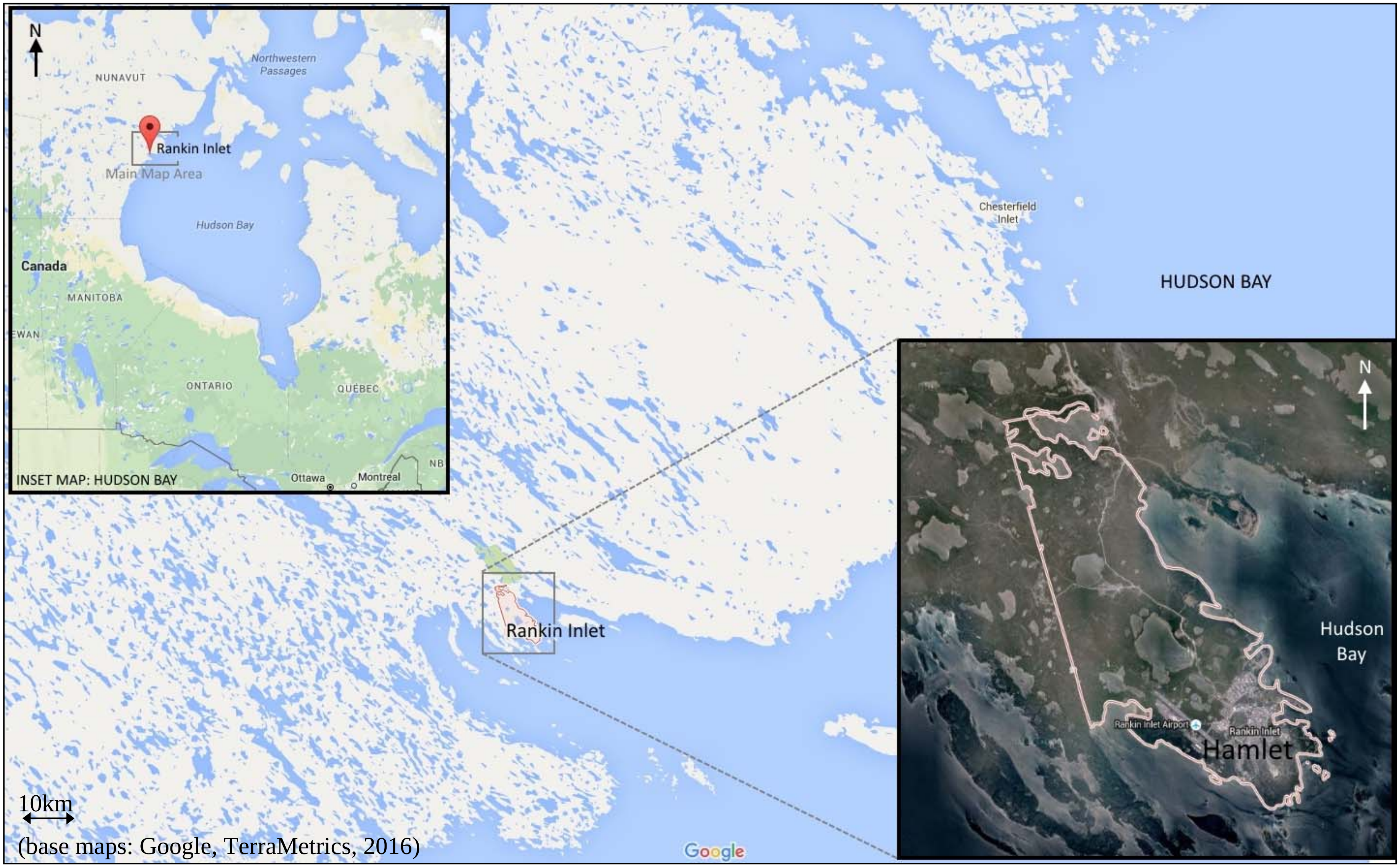


Figure 3-1: The Hamlet of Rankin Inlet, on the northwest coast of Hudson Bay.

The community is serviced by a local road network. North of the hamlet, three arterial gravel roads extend west, north and east, giving access to the Diane River, Iqalugaarjuup Nunanga Territorial Park, and the Agnico-Eagle Meliadine Mine, respectively. Numerous short branches from these three main roads provide access to existing gravel pits, the dump, multiple lakes, camps and other cultural and recreational sites. The majority of the roads are gravel surface, with some asphalt paved roads within the Hamlet.

3.2 Climate and Permafrost

Rankin Inlet has a subarctic/tundra climate and is situated above the tree line within the zone of continuous permafrost. Environment Canada 1981 – 2010 Climate Normals indicate a mean annual air temperature (MAAT) of -10.5^{o}C and mean January and July temperatures of -30.8^{o}C and +10.5^{o}C, respectively. Snow accumulation on the ground typically peaks at less than 40 cm by the end of March and the ground is usually snow-free by mid to late June.

The surficial active layer of seasonal thaw reportedly averages just over 1 m but may be as deep as 2.5 to 3.0 m in well-drained gravels or bedrock outcrops (Judge et al., 1991). However, due to average temperature and rainfall increases in Canada`s north since the publication date, it is expected that the active layer now typically exceeds 1 m in organic or silty soils and 3 m in dry gravels and bedrock. Permafrost features such as patterned ground, frost boils and ice wedges are common, as are seasonal freeze-thaw processes such as solifluction, contraction polygons and fractured bedrock.

3.3 Geology and Geomorphology

Rankin Inlet is situated on a peninsula between the mouths of the Meliadine River and Diana River which outlet into Hudson Bay. In addition to the coarse granular deposits associated with glacial outwash rivers, the surficial geology of the area is characterized by heavy glacial influence, marine submergence and re-emergence following deglaciation, and post-glacial drainage.

Surficial geology mapping by McMartin (2002) shows much of the area around Rankin Inlet to consist of glacially deposited silty tills, characterized by permafrost features such as mudboils and ice wedge polygons in fine-grained soil. Thick blankets of till are found beyond approximately 10 – 15 km northwest of the Hamlet, while thin veneers 1 to 2 m thick are commonly found closer to the coastline around the Hamlet. Large glaciofluvial deposits, including outwash deposits and eskers, can be found north of the Hamlet in northwest-southeast orientation parallel to ancient glacial ice sheet movement. However, the closest of these deposits are contained within the Iqalugaarjuup Nunanga Territorial Park and others are generally far from the Hamlet and inaccessible without long new roads. Metamorphosed volcanic and sedimentary bedrock is exposed in similar northwest-southeast ridges parallel to ice sheet movement, and is prevalent along the coastline southwest of the community and in areas north of the community. Marine deposits, including terraced gravel beaches and littoral sediments deposited during the post-glacial invasion of sea levels, are scattered throughout the area particularly to the north and northeast and are common sources of sand and gravel.

3.4 Topography and Drainage

The topography of the area around Rankin Inlet has moderate vertical relief consisting of undulating tundra, numerous high bedrock outcroppings and abundant shallow lakes. The prominent bedrock outcrops commonly rise above adjacent tundra or lakes by 10 to 20 m in height, sometimes fairly abruptly. The undulating tundra is generally well-drained and relatively smooth at higher elevations while the low areas are rougher due to patterned ground associated with the permafrost.

The numerous shallow lakes are rarely connected by distinct streams, and are more often connected by shallow braided wetlands and marshy areas where groundwater flows through the thawed glacial deposits atop permafrost that prevents ground water infiltration.

3.5 Infrastructure and Aggregate Acquisition

Northern communities such as Rankin Inlet present unique challenges for infrastructure development and aggregate acquisition. Short construction seasons, rugged terrain, a harsh environment, limited and costly modes of transportation, small labour forces and minimal contractor competition all contribute to high costs associated with any construction projects, including equipment and material acquisition.

Currently, meeting aggregate requirements in Rankin Inlet involves the Hamlet contracting with multiple contractors who have the equipment and capacity to extract, crush and screen these resources from approved borrow sources (Figure 3-2). In exchange, these contractors must apply for quarry permits and pay fees to the Hamlet under a Quarry Administration Agreement enacted according to the Commissioner's Land Regulations. This process would apply to any new aggregate sites developed within the Hamlet Municipal Boundary. Outside the boundary, however, new sites would require approval from the regional Kivalliq Inuit Association (KIA) and application for a quarry permit or lease from Aboriginal Affairs and Northern Development Canada (AANDC) under the Territorial Quarrying Regulations of the Territorial Lands Act. For this reason, sites within the Hamlet boundary are preferred if sufficient volumes are available.

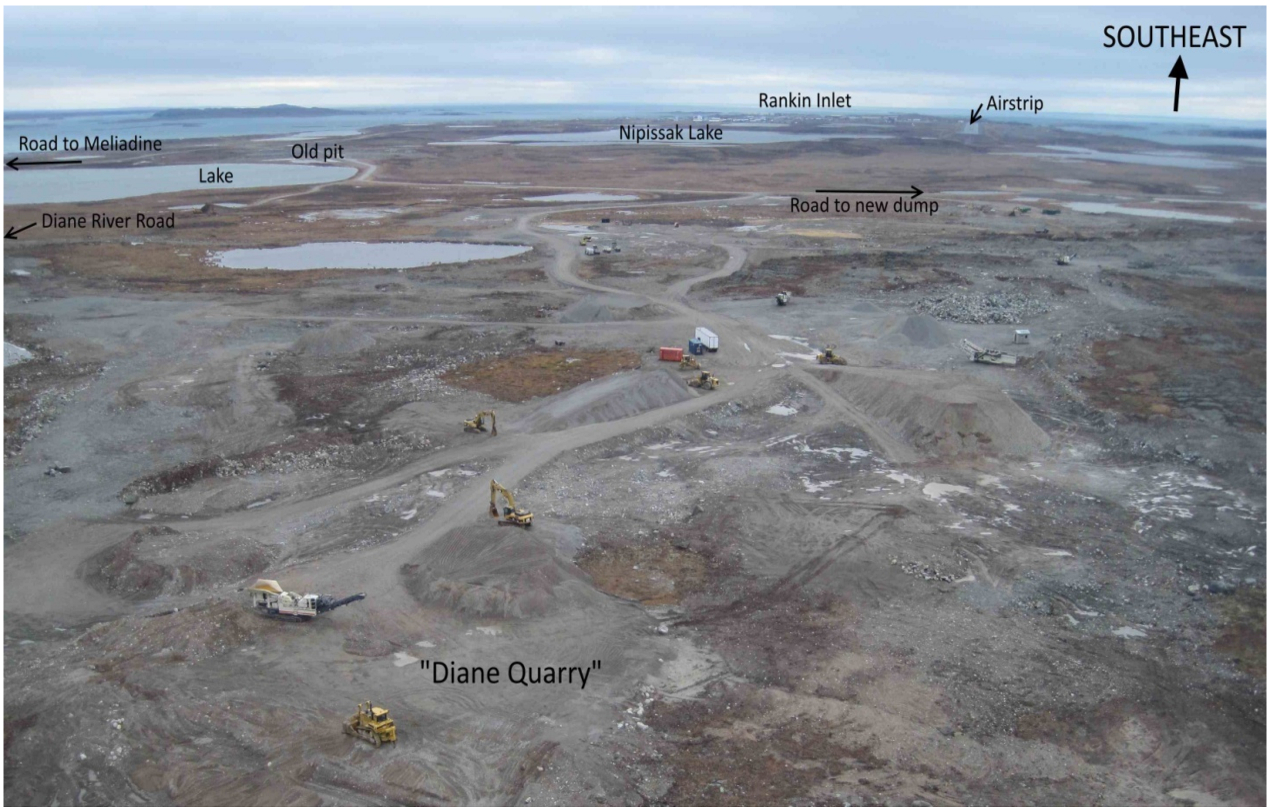


Figure 3-2: Contractor equipment working in the existing Diane Quarry (borrow pit) northwest of Rankin Inlet (Photo: Sept., 2014).

Large quantities of granular materials are required for road construction and level building pads on the rugged terrain in and around the community. However, the surficial geology of the region does not provide an abundance of readily accessible borrow sources, and extensive roads networks and increased haulage efforts are required to reach sources far from town.

Alternatively, expensive bedrock drilling, blasting, and crushing operations are used to meet aggregate needs, as was done in 2007 in a quarry south of the airstrip adjacent to the harbour. This quarry was developed by a contractor to produce maintenance aggregates, concrete and asphalt aggregates for the Hamlet (see Figure 3-3 below).

Figure 3-3: Existing bedrock quarry at the harbour south of the airport. It was initially used in 2007 to produce aggregates for the Hamlet. (Photo: July, 2016).

A thorough discussion and estimate of aggregate needs and potential sources for Rankin Inlet is found in the following sections.

4 DESKTOP BACKGROUND STUDY & DATA REVIEW

A desktop study of previous aggregate studies, available aerial photography, satellite imagery and surficial geology mapping was conducted to identify formerly exploited, currently active, and potential new aggregate sources prior to a field investigation, including both natural aggregate deposits and bedrock outcrops suitable for a drill/blast/crush operation. It was also used to eliminate deposits deemed unsuitable by the Hamlet and deposits where long roads would be necessary to reach small or uncertain volumes of aggregate. The desktop study provided the layout for the field investigation program by targeting promising deposits that were predicted to meet minimum reasonable costs per cubic meter to develop.

Other available documents, including the original published Integrated Community Infrastructure Sustainability Plan (ICISP) for Rankin Inlet (Aarluk Consulting Inc., 2010), and it's updated online version were also studied to develop an understanding of Hamlet infrastructure needs and available equipment. Initial discussions and a community consultation with Government of Nunavut (GN) officials and members of the Hamlet created a framework for the fieldwork and the project going forward.

4.1 Previous Aggregate Studies for Rankin Inlet

Previous aggregate studies conducted by Trow Associates Inc. (2008) and WSP Inc. (2014) were reviewed to determine previously identified and exploited aggregate sites and those that may still contain significant aggregate quantities for the future. The Trow report identified 14 potential sites within a 5 - 7 km radius of the Hamlet (Figure 4-1) and the WSP report investigated four of these sites in greater detail for meeting the Hamlet's short-term aggregate needs.

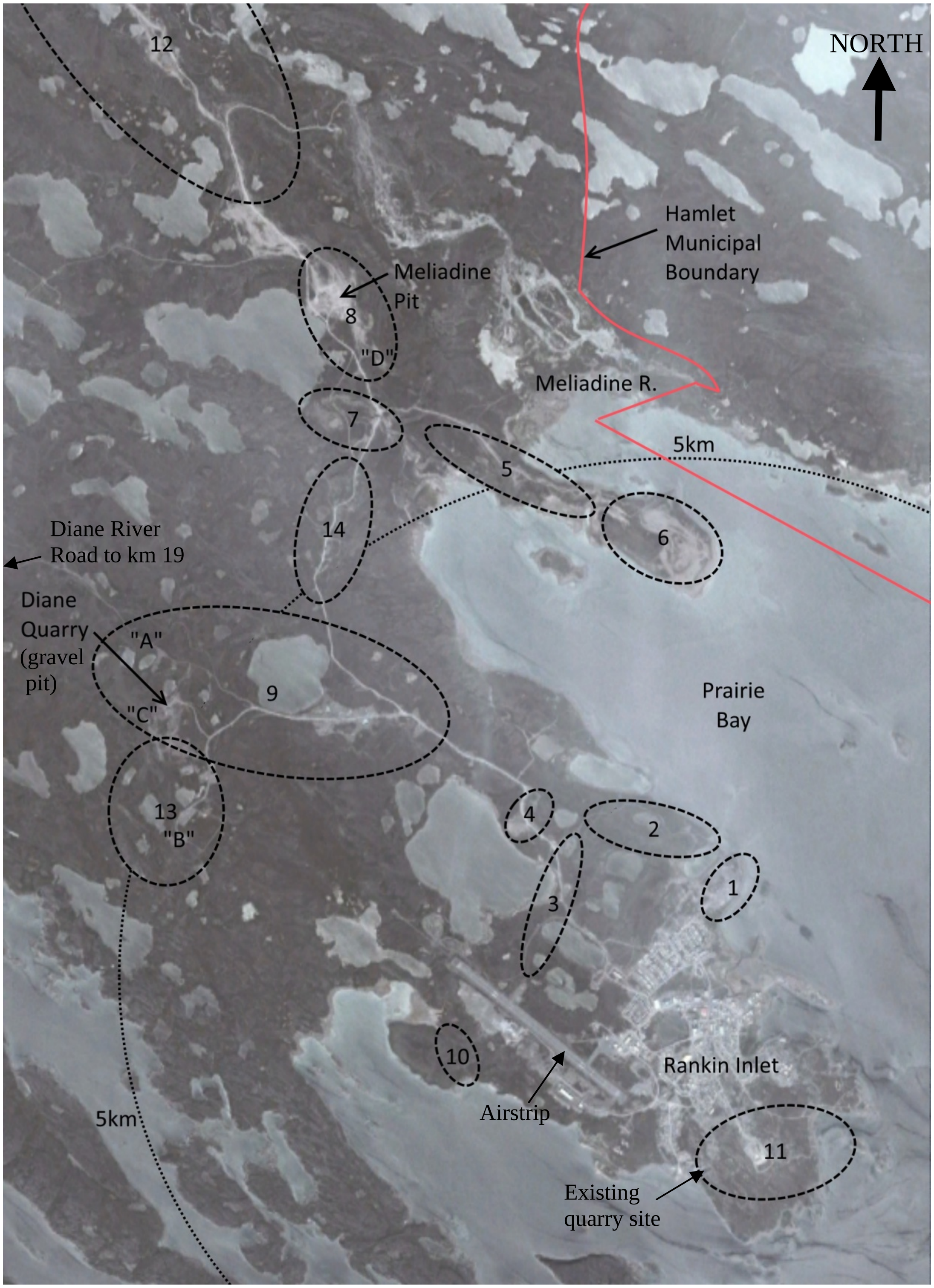


Figure 4-1: **Potential aggregate sources around Rankin Inlet investigated by Trow Associates Inc. in 2008 (#1 - 14) and WSP Inc. in 2014 (A – D).**

In addition, a report prepared for the development of the Agnico-Eagle Meliadine Mine road northeast of the Hamlet (Agnico-Eagle Mines Ltd., 2011) has also been reviewed. These reports are summarized in detail below.

- **March 2008, Trow Associates Inc.: Geotechnical Investigation – New Granular Sites Study. Project No. 07-3037, Rankin Inlet, Nunavut.**

The Trow report includes detailed descriptions of the 14 identified aggregate sources investigated within 5-7 km of the Hamlet. The material at each site is characterized based on samples and laboratory results taken from a series of 64 test pits conducted during the field study. These deposits are identified as area #1 through #14 in Figure 4-1 above. Table 4-1 below summarizes the current status of these previously investigated areas.

Many of the deposits identified by Trow close to the community have already been exploited as aggregate borrow sources, are slated for other community developments, or are protected within the Iqalugaarjuup Nunanga Territorial Park. Of note are areas #8 and #9 which are currently being at least partially exploited for aggregate borrow material and are known as the “Meliadine Pit” and “Diane Quarry” areas, respectively, although the latter is also a borrow pit rather than a quarry. Area #14, known as Apache Pass, was identified in the report as a potentially suitable location for a drill/blast/crush bedrock quarry operation. However, consultation with the community in April, 2016 deemed this site off-limits due to the historical and cultural significance of the area.

- **February, 2014, WSP Inc.: Aggregate Quantity and Quality Survey (Four Selected Sites at Rankin Inlet). Project No. 131-23088-00, Hamlet of Rankin Inlet, Nunavut.**

WSP Inc.'s 2014 investigation focused on four areas (labeled 'A' through 'D' in Figure 4-1 above) previously identified in the Trow report and selected by the CGS for further evaluation and characterization. These are also summarized in Table 4-1 below.

WSP sites A and C shown below in Figure 4-2 are within Trow's area #9 and may be considered expansions of the Diane Pit area, with site C directly overlapping the existing pit.

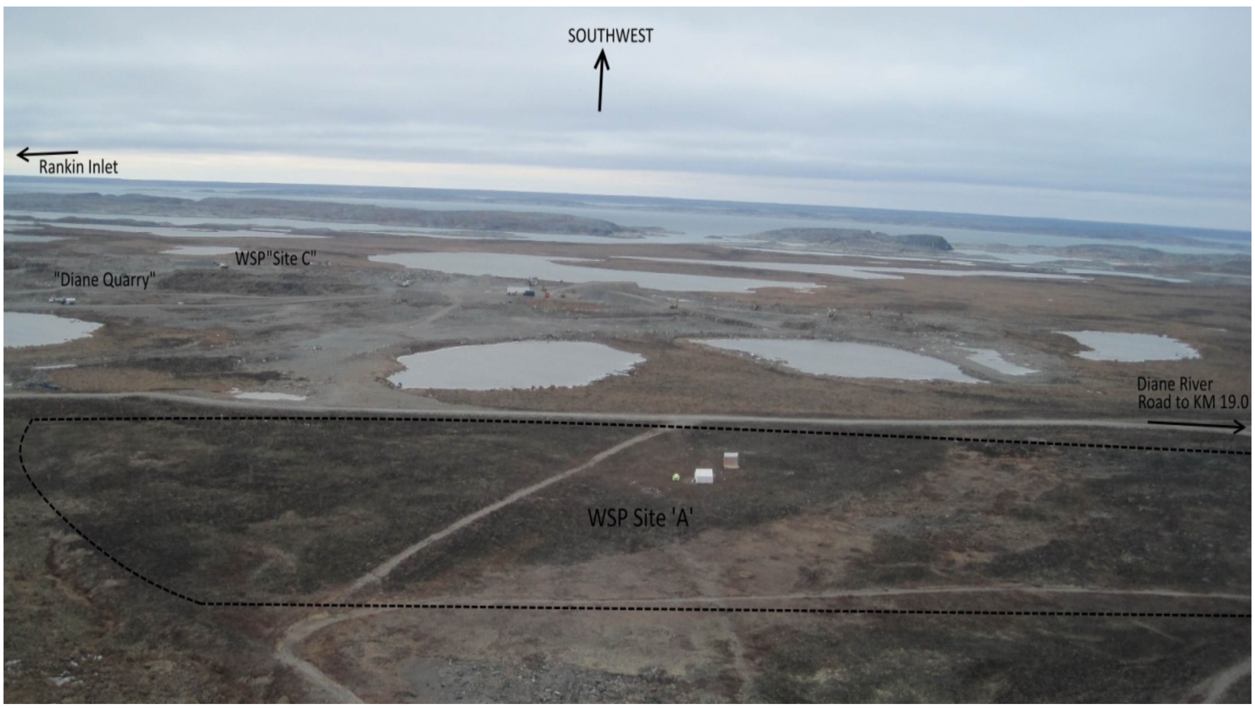


Figure 4-2: **Overlooking the existing Diane Pit area and WSP Sites A and C (Photo: September, 2014)**

Site A, shown above in Figure 4-2, is slightly northwest of the Diane Pit and has recently been approved for development by the Hamlet to meet short-term needs. It is expected to contain roughly 86,000 m^3 of suitable aggregate. Site B is south of the Diane Pit near the new dump site but has been reported to contain a very limited amount of suitable aggregate (less than 9,000 m^3).

Site D is south of the existing Meliadine Pit (Figure 4-3) and is part of the same long esker deposit that also extends north into the Territorial Park. It has been deemed too sand-rich and lacking in required coarse aggregate composition, although it would be still be suitable for building pad fills, road subbase material, landfill cover, and the anticipated new baseball diamond and graveyard expansion.

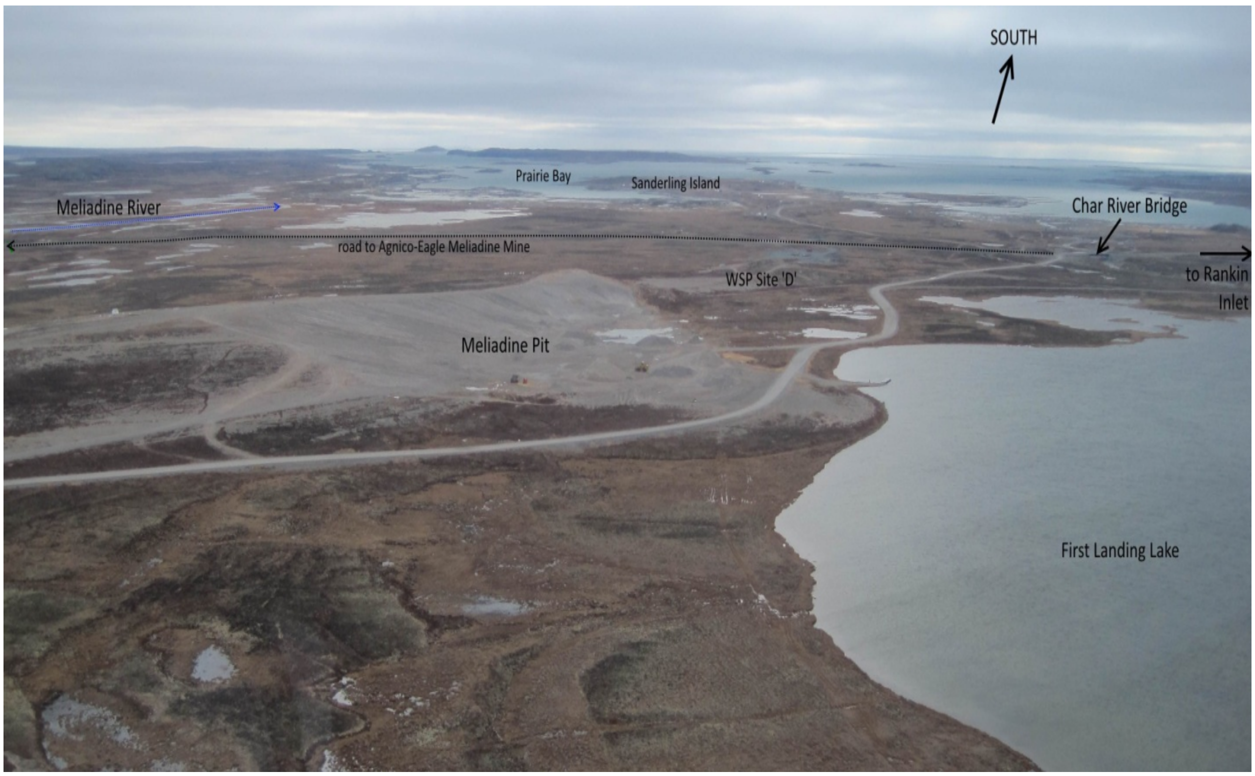


Figure 4-3: **Overlooking the existing Meliadine Pit area and WSP Site D (Photo: Sept., 2014)**

The WSP report indicated that the aggregate material tested at Sites A, B and C were generally well graded and suitable for common base material as well as concrete aggregate after some processing. Site A reportedly had a large portion of flat and elongated particles (30 - 60%). The material from Site D was sand-rich and most suitable for road sub-base or screened subgrade sand.

WSP reported that the gravel size fraction of the aggregate samples appeared to have a carbonate and felsic (granite) composition in an approximate 8:1 ratio by mass.

Table 4-1: Previously investigated sites, with current status as reported by Trow (2008), WSP (2014) or by Government of Nunavut officials.

TROW SITE	WSP SITE	REPORTED STATUS
1 – 6, 10	-	Depleted or unsuitable due to alternative proposed land uses, community significance or proximity to airstrip.
7	-	Char R. Bridge area, partially or completely depleted. Environmentally sensitive area.
8	'D'	Meliadine Pit area. Site D is south of existing pit and is sand-rich with lack of coarse aggregate material (suitable for sand fill applications).
9	'A' and 'C'	Diane Pit area. Site C overlaps existing pit and site A (~86,000 m^3) has been recently approved for development.
11	-	South tip of Hamlet. Depleted borrow source but bedrock outcrops previously used for drill/blast/crush quarry in 2007
12	-	Unsuitable. Contained within Nunanga Territorial Park
13	'B'	Contains a relatively low volume of suitable aggregate (<9,000 m^3)
14	-	Apache Pass. Limited or depleted borrow material, but reported as a potentially good source for a drill/blast/crush bedrock quarry. Consultation with community members in April, 2016 deemed this site off-limits due to the historical and cultural significance of the area

- **January, 2011, Agnico-Eagle Mines Limited: All Weather Road in Support of the Underground Program, Rankin Inlet to the Meliadine Site.**

This report was prepared for the development of the Agnico-Eagle Meliadine Mine road northeast of the Hamlet. The report identified the location of numerous aggregate borrow sources and potential bedrock quarry sites (Figure 4-4) directly along the proposed road right-of-way to the mine, all but one of which were outside the Hamlet municipal boundary. No detail was given as to volumes available and it is expected that many of the borrow sources were depleted during road construction. However, the newly constructed road gives access to potential deposits on either side of the road that were not considered or used during road construction.

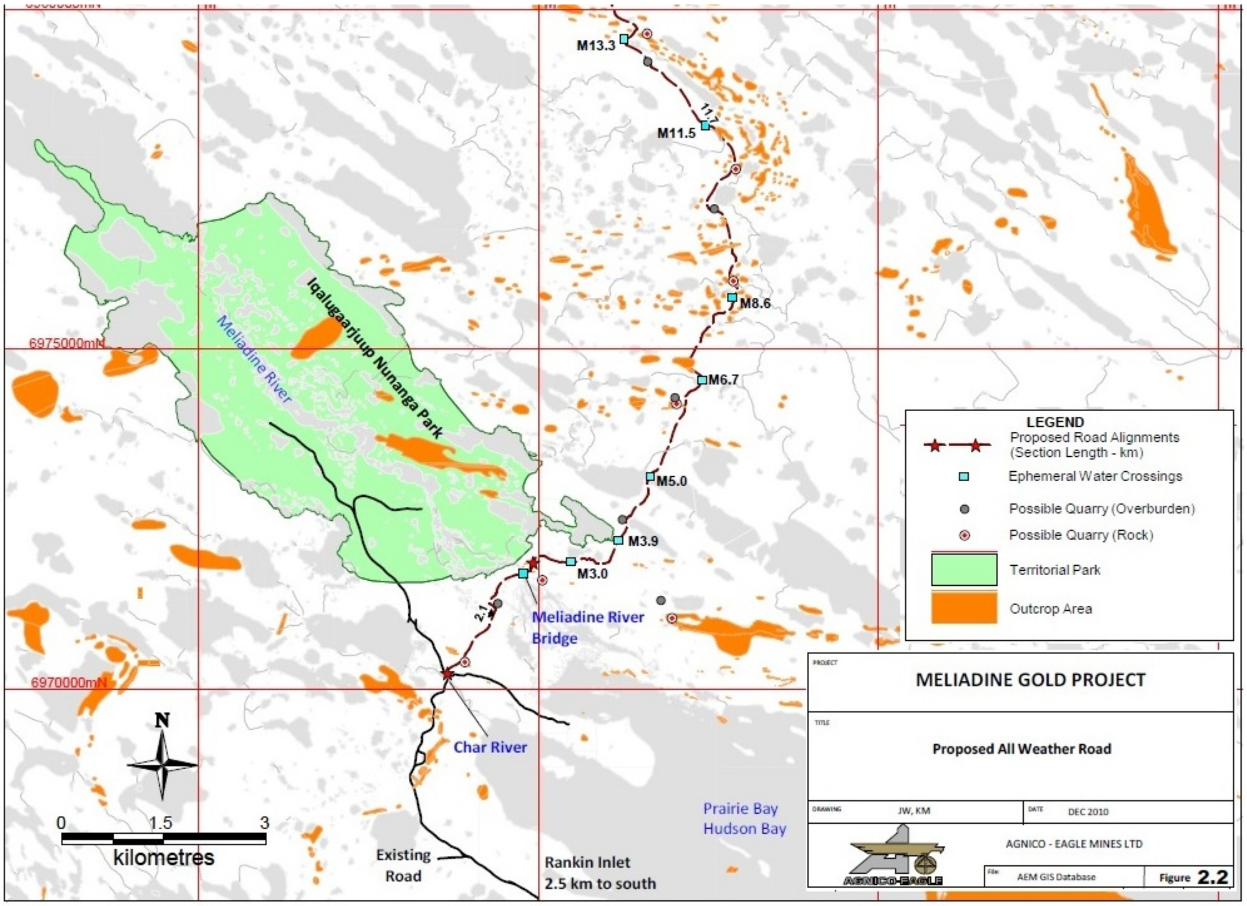


Figure 4-4: **Aggregate borrow sources and possible bedrock quarry sites proposed for the construction of the Meliadine Mine Road (Adapted from Agnico-Eagle Mines Ltd., 2011).**

4.2 Desktop Review of Aerial Photography and Satellite Imagery

An initial desktop assessment of existing and prospective aggregate sources was conducted using satellite imagery, aerial photography and surficial geology maps. Aerial photographs for the Rankin Inlet area dating from between 1949 and 1998 are available online from Natural Resources Canada. The most applicable set of air photos, dated August 9, 1995 (A28218), covers the entire subject area including east of the Meliadine River and west to the Diane River at a scale of 1:15,000. However, these photos are more than 20 years old and predate most of the modern road construction and aggregate acquisition around the hamlet. The same applies to some earlier air photo sets at larger scales (1:5,000 – 1:7,000) that do not extend beyond the developed area close to the hamlet. Because of the larger scales and/or out-of-date photos close to the Hamlet, these sets of air photos were not considered useful in the assessment of existing aggregate sources or the search for additional aggregate sources.

Instead, modern high-resolution, geo-referenced satellite imagery was used to identify the existing extent of the road network around Rankin Inlet and the location of currently active aggregate borrow sources, including the Meliadine Pit and Diane Pit. In addition, a serious of oblique aerial photographs taken by JOURNEAUX ASSOC. from a helicopter in September, 2014 were used to identify the current extents of these active borrow sources and to locate the previously investigated sites by WSP Inc (2014). Some of these photos were shown previously in Figures 3-3, 4-2 and 4-3.

The satellite imagery was combined with a geo-referenced overlay of the McMartin (2002) surficial geology map to identify potential *new* borrow source sites within proximity to the existing road networks both west towards the Diane River and east beyond the Meliadine River. Due to the concentration of known sites within 5 – 7 km of the Hamlet identified in the Trow and WSP reports, the desktop study concentrated on identifying new sites beyond 5 km from the Hamlet. Primarily, this included up to km 19 along the Diane River Road to the west, as well as potential sites east of the Meliadine River, accessible from the newly constructed Agnico-Eagle

Meliadine Mine Road. Naturally, preference was given to sites that were closest to the hamlet and on the existing road network.

The appended drawing L1860-01 shows the five potential new aggregate borrow sources labeled as JOURNEAUX-1 through JOURNEAUX-5, in black. Two of the new sites are very large natural deposits east of the Meliadine River (JOURNEAUX-1 and -2), which are accessible south of the Agnico-Eagle Mine Road (at KM 9.5 and KM 15) after crossing the Meliadine River Bridge (Figure 4-5).

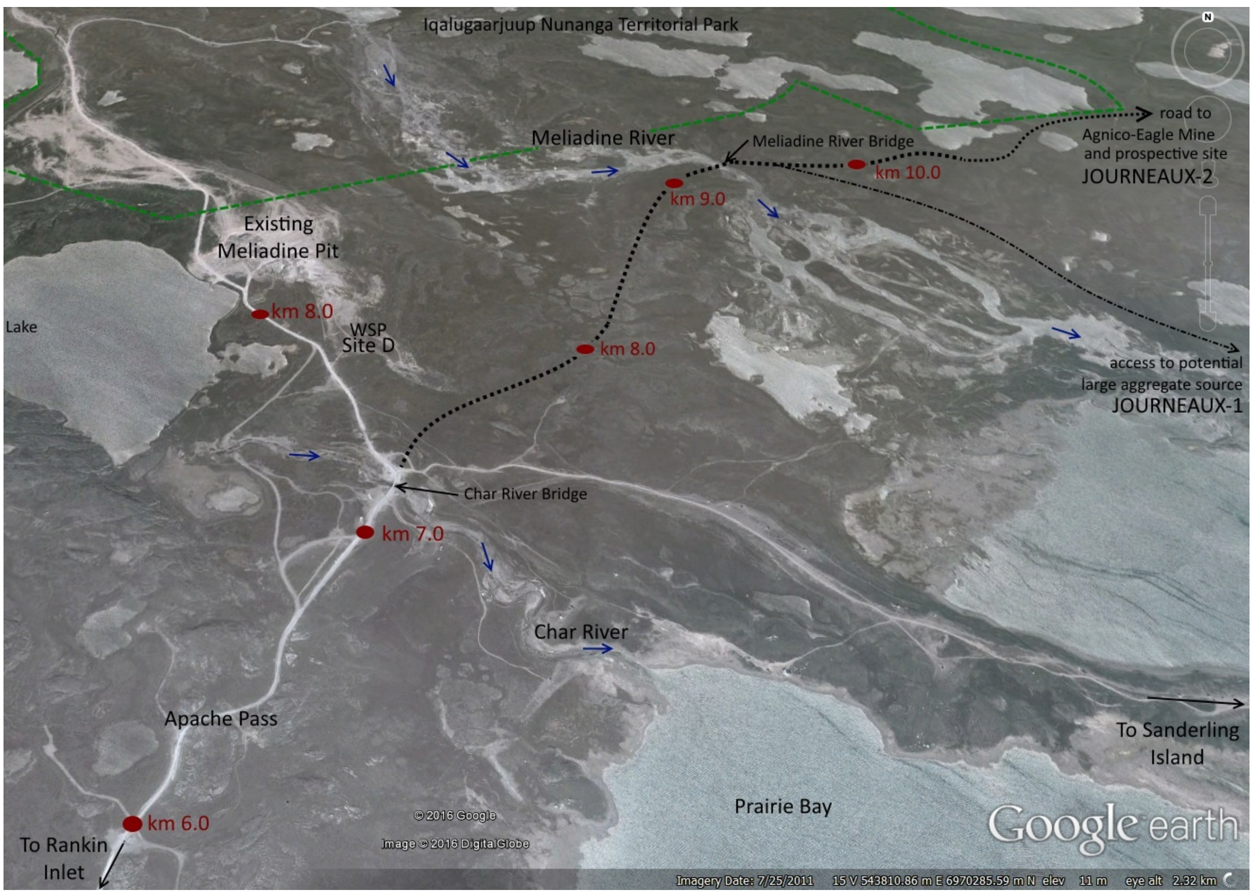


Figure 4-5: **Satellite image of the major intersection of roads near km 7 north of Rankin Inlet, showing the existing Meliadine Pit, access to the two large prospective borrow sites east of the Meliadine River from the Agnico-Eagle Mine Road, and the location of Apache Pass at km 6.0.**

The other three prospective new deposits identified in the desktop study are along the Diane River Road north of km 8, north of km 16 and at km 19. They are labeled JOURNEAUX-3 through JOURNEAUX-5 on drawing L1860-01, respectively. In addition, bedrock outcrop sites to be considered for a potential drill/blast/crush quarry operation were identified at the new dump site and further west at KM 13 on the Diane River Road.

Select existing sites and all the prospective new sites identified in the desktop study were investigated in the field, along with an additional borrow site at KM 18 and bedrock quarry sites by the harbour and in the existing Diane Pit. They are described in more detail in Section 6 of this report.

4.3 Community Consultation

In April, 2016, JOURNEAUX ASSOC visited the community of Rankin Inlet to meet with members of council, the CGS, and various other stakeholders to discuss the prospective new aggregate sources identified in the desktop study. A meeting was held on April 11th.

During the meeting, the present council members voiced a clear preference for the sites along the Diane River Road instead of the two large prospective sites east of the Meliadine River. This was largely due to the Meliadine deposits falling outside the Hamlet municipal boundary in Inuit Owned Lands, which would require approval from the Kivalliq Inuit Association (KIA) and could not be administered under the current Hamlet Quarry Administration Agreement.

Sites within the Hamlet municipal boundary, including those out to km 19 on the Diane River Road, would be administered under Rankin Inlet’s Quarry Administrative Agreement as per the

Commissioner's Land Act Regulations. These sites are preferred as initial sources to meet community needs based on the existing relationships that have been established between the Municipality and the various contractors under the existing Quarry Administrative Agreement.

Community consultation also revealed a prospective aggregate borrow source at KM 18 on the Diane River Road, and that the prospective drill/blast/quarry site at Apache Pass was unsuitable due to the historical and cultural significance of the area.

Finally, it was confirmed that the available aggregate material on the west side of the Meliadine River upstream of the Agnico-Eagle bridge and just south of Iqalugaarjuup Nunanga Territorial Park was off-limits due to caribou habitat.

Following the community consultation, it was decided that the field investigation program would initially focus on the prospective borrow deposits at KM 8, 15-16, 18 and 19 on the Diane River Road. Bedrock outcrops would be investigated around KM 13, the new dump and the existing quarry near the shore at the east end of the runway.

4.4 Identified Community Infrastructure Needs

In 2010, the Hamlet of Rankin Inlet published an Integrated Community Infrastructure Sustainability Plan (ICISP), coordinated by the Nunavut Community Infrastructure Advisory Committee (NCIAC) and Government of Nunavut Department of Community and Government Services (CGS). The report identifies community infrastructure needs listed as short-term, medium-term or long-term priorities. An updated list of priorities, dated 2016, was accessed from the BuildingNunavut.com website. Infrastructure identified in the report and updated list relevant to this study includes new roadways, facilities and buildings requiring granular material for construction, and equipment proposed for aggregate acquisition. These are listed below for reference:

- Short-Term Priorities (< 5 years)
  - Kivalliq Regional Visitor Centre
  - New Regional Multiplex with Arena with Swimming Pool
  - Hamlet Offices (likely to be added to new arena development)
  - Trade School and Heavy Equipment Training Ground
  - Elder Care Facility (approximately 10 beds)
  - Medical Boarding Home
  - New Daycare Facility
  - New GN Staff Housing
  - New Recycling Centre building
  - Graveyard Expansion (sandy fill)
  - Homeless Shelter and Soup Kitchen
  - New Baseball Diamond (sandy fill)
  - New Community Freezer
  - Johnson Cove Breakwater (large waste rock)
  - New subdivision roads (residential and industrial)
  - Annual road maintenance
  - Final landfill cover for existing landfill

- Medium-Term Priorities (5 - 10 years)
  - Airport Terminal building expansion
  - Arts and Crafts Centre (workshop, sales centre, tourist area)
  - Youth Centre expansion
  - Friendship Centre expansion
  - Addictions and Mental Health Regional Centre with storage facility

- New housing for single persons and large families
- Improve dump access road
- Municipal staff housing (2 units)
- Sewage Treatment Plant (new or renovate)
- Hamlet Maintenance Garage (new or renovate)
- Future Tank Farm capacity

- Long-Term Priorities (10 - 15 years)
    - Additional Hamlet parking garage
    - Additional public housing
    - Additional staff housing
    - Construct road from Rankin Inlet to Manitoba

Consultation with the GN during the 2016 site visit identified the location and approximate staging of new subdivisions and some of the short-term development sites. This includes the large regional multiplex (arena, pool, Hamlet offices) to be located just uphill to the west of the existing Health Centre in the middle of town, as well as a proposed trade school and heavy equipment training ground not listed in the ICISP. The GN indicated that the substantial expansions and upgrades to the Itivia staging area and barge landing site, including a hamlet bypass road listed in the ICISP would be conducted under a private contract that would include sourcing material from the adjacent harbour quarry specifically to meet project needs.

These identified infrastructure priorities have been used to develop projected quantities of aggregate needed over the coming 20 years. These quantities are discussed in Section 5 and tabulated in Appendix A.

4.5 Heavy Equipment Inventory

Heavy equipment in Rankin Inlet generally falls in to two categories: that which belongs to the hamlet, and that which belongs to independent contractors. The majority of equipment in the Hamlet belongs to independent contractors, particularly Inukshuk Construction, M&T Enterprises and Nunavut Excavating. Hamlet-owned equipment is tabulated below and was identified in the ICISP and confirmed by JOURNEAUX ASSOC. through discussions with hamlet personnel.

Table 4-2 : Hamlet Owned Heavy Equipment

EQUIPMENT	ACQUIRED	PROJECTED LIFE
Cat 950G Front-End Loader	1992	2012
Cat 950H Front-End Loader	2006	2025
Cat Bulldozer	1991	2009
Cat 140G Grader	1991	2010
Cat 814F Wheel Dozer	2003	2021
Ford L9000 Dump Truck	1994	2002
Gravel Screener	2009	2024

All the equipment is kept and maintained within the hamlet. The screener is currently located approximately 7.0 km west of the hamlet near the active Diane Pit.

The ICISP identifies equipment priorities expressed by the Hamlet Council, and recommends acquisition of a new dump truck and new grader in 1-2 years from publication. It was not confirmed whether these had been acquired as of the 2016 field investigation.

5 ASSESMENT OF GRANULAR MATERIAL NEEDS

The projected 20-year granular requirements for Rankin Inlet have been developed from identified infrastructure needs listed in Section 4.4 above. This list was compiled from the ICISP (2016) and consultation with local members of the GN, and comprises infrastructure projects that require granular material for construction and maintenance. These projects were evaluated in terms of their expected development footprint and location (where known) in order to estimate projected aggregate volume requirements by material type for the next 20 years.

5.1 Material Types

Granular material type needed by the Hamlet can be separated into two broad types:

- **'Common' pit-run** material sourced directly from borrow-pits with minimal or no subsequent processing. Common material is typically used as fill to establish rough site or road grades (sub base) or embankments, and occasionally includes oversize boulders or blasted rock that can be used to make up significant volume needs. Sometimes, depending on application, basic screening is conducted to remove oversize cobbles, typically above 75 mm (3 inches) in diameter.

  Furthermore, if the pit-run is predominantly gravel, sand may be mixed with the pit-run to improve workability and ultimate compacted strength.

- **'Select Grade'** material that has been processed (crushed/screened) to meet a specific gradation. Select grade material is typically described by its maximum particle size, for example '3/4" minus', 20mm minus', or '0–20 mm'. Select grades are used as a finishing or surface layer as they create even running surfaces for roads, airstrips and finished level surfaces for building lots, slab-on-grade support or pavement structures. They are also designed to minimise void space which improves compactablity and durability. In general, the cost of producing crushed aggregates increases as finer graded materials are specified, with the exception of crushed fines which are frost susceptible and usually discarded or used in deep fills which remain frozen or to fill voids in coarse fill.

Much of the readily available borrow source material in the area around Rankin Inlet is predominantly sand with a limited coarse gravel component, including the large source south of the Meliadine Pit identified by WSP as ‘Site D’. This sand material is still very useful for general subbase and building pad fill and for sand fill requirements such as the cemetery expansion and baseball diamonds.

Other materials readily available in the area, such as glacial tills (sands and silts) or oversize boulders and rock, may be used in various applications. Oversize material can be used for shoreline or embankment protection to reduce scour and erosion and preserve areas prone to flooding. In some situations, it can also be used as low-grade fill in low, marshy areas beneath roadways, although some migration of fines into large void spaces may lead to undesirable settlements. Tills comprised of sands, silts and clay may also be used for landfill cover material, impervious barriers (clay) for waste-water ponds, or general embankment fill, or as sub base fill during road construction where it can be sourced from the ditches along roadways.

5.2 Estimated Granular Volumes Required

Estimates of material volume requirements by type were developed based on known or estimated lot size or road dimensions, specific site or route conditions (where known), and a combination of aggregate construction standards and historical construction practices observed in Rankin Inlet. The estimated quantities are presented in Table A-1 in Appendix A. It must be noted that the infrastructure needs and associated granular requirements are estimated and subject to significant change as new or changing needs are identified. Although the substitution of one project for another will not likely impact the estimated quantities significantly, there may also be unexpected needs that arise due to unforeseen events such as flooding (washouts) or fire. Furthermore, population growth and infrastructure development will be closely tied to the continued operation and expansion of the Meliadine Mine project. It is also expected that, in general, realized budget restrictions will tend to reduce the annual quantities required.

- **Road Construction**

A number of new roads are proposed for subdivision development in Rankin Inlet, totalling roughly 4.9 km in length with a typical width of 7.5 m, plus an additional 500 m of improved access to the dump. Repair and maintenance of existing roads is estimated at 4,000 m of length per year based on consultation with the community and local contractors. Other road construction, such as widening the Diane River Road out to KM 20, is also included. The massive undertaking of constructing a road to Manitoba is not included in the assessment, since most of the aggregate for road construction would naturally be sourced along the road route.

Road construction generally requires the largest quantities of granular material, although careful attention to effective construction methods and route selection can greatly reduce the amount of granular material required. Figure 5-1 shows examples of the variable gravel quantities needed in road construction, which can greatly be reduced by careful route selection.

Figure 5-1a: The Diane River Rd. is an example of a narrow penetration road built with material from a drainage ditch with a thin sand and gravel running course where required.

Figure 5-1b: The wide Meliadine Mine Road is 2+ m thick and built entirely from hauled and placed material, with no ditches.

Common pit-run material should be used to create the sub base layer for strength and durability, and should vary in thickness as necessitated by the terrain (i.e. thicker through wet, hummocky areas and almost none across dry overburden areas or bedrock outcrops). A final surface layer of select 0-20 mm crushed gravel, no more than 75 mm (3 inches) thick, would provide a smooth running surface and allow easy grader maintenance. Select grade aggregate should not be used to construct embankments and fill in creeks and rivers during road construction. Instead, common pit-run including cobbles and small boulders should be used, and large oversize boulders can be placed to protect embankments from flowing water and erosion.

- **Residential Development**

Based on projected population growth and a subdivision plan provided by the GN, numerous single-family dwellings are expected to be developed over the next 20 years in new residential subdivisions on the north side of the Hamlet. Approximately 4.9 km of residential streets will be required to service the new lots. Some of the proposed new dwellings may be constructed as multi-family developments, reducing the lot sizes and aggregate needs. However, a conservative estimate has assumed development of 250 single-family lots and 10 new multi-family buildings.

The proposed new subdivision areas are situated on dry, but occasionally sloping terrain. Figure 5-2, below, shows some of the proposed future subdivision areas, as well as commercial sites for the proposed arena complex and trade school. Consideration must be given to the amount of aggregate material needed to create level building/parking pads, and sloping lots that require substantial fill should be avoided wherever possible. Furthermore, crushed 0-20 mm aggregates should be limited to necessary portions of the lot, such as the front yard/parking area and shared side yard between neighbouring houses. Aggregates are not necessary beneath buildings founded on piles nor in the back-of-lot or opposite side yard where it serves no purpose.

Figure 5-2: Looking southwest over the north end of Rankin Inlet. Numerous proposed development areas requiring aggregate fills are shown on the photo. (Photo: July, 2016).

- **Commercial Development**

A number of municipal and commercial developments are proposed, including a large arena/swimming pool multiplex with adjoining Hamlet offices just uphill to the west from the existing Health Centre, a new Kivalliq Regional Visitor Centre, and a trade school with a large, heavy equipment training area. Particularly large aggregate volumes are needed for the multiplex and trade school/training ground and the current subdivision under development (1 – 3 m fills).

These sites were evaluated to estimate the amount of aggregate required to create level building pads and parking areas. The amount of aggregate required for other commercial buildings proposed in unknown locations was conservatively estimated.

Similar methods of effective site selection and lot layout as described for residential developments can be used to reduce the amount of granular material required during lot grading of commercial sites.

- **Solid Waste Landfill Cover**

Best practice guidelines for Solid Waste Management in Nunavut stipulate that municipal solid waste must be covered with 0.3 m of dry, silty and sandy cover soil and compacted when required annually, and must be covered with 0.6 m of sloped and compacted granular material when the section of landfill is no longer to be used. In reality, these practices are rarely followed. However, new directives to improve solid waste management in the territory may begin to reverse this trend. A report prepared by Arktis Solutions Inc. in 2011 assessed the state of solid waste management and facilities in Nunavut and gave estimated volumes of waste produced and storage areas required. From the report, Rankin Inlet generated roughly 4.4 m^3 of municipal waste per capita annually. Assuming a 3x reduction in volume following compaction and a 2 m waste storage height as assumed in the Arktis Solutions report, the approximately 2,800-person Hamlet of Rankin Inlet (estimated for 2016) currently requires an area of approximately 2,000 m^2 of new municipal waste storage annually. Assuming 10 percent population growth every five years for the next 20 years, this could grow to an area of 3000 m^2 annually by 2035 or a total surface area of about 50,000 m^2. Google Earth satellite imagery from 2011 reveals the municipal landfill south of the Hamlet has an area of about 40,000 m^2. Recently, a new landfill site with properly constructed confinement was surveyed and prepared with a useable area of about 90,000 m^2 although it has not been put into operation as of 2016. During the 2016 site visit some cover material was being placed over a portion of the landfill, as shown in Figure 5.3 below.

Figure 5-3: Rankin Inlet's current landfill site. A bulldozer can be seen spreading a thin cover of soil over a portion of the landfill (Photo: July, 2016).

The granular volume needs assessment in Table A-1 in Appendix A assumes an average of 2,500 m^2 annually to be covered with 0.3 m of sandy reject overburden. The approximate 40,000 m^2 existing landfill area and projected 20-year additional area of 40,000 m^2 are expected to receive a final granular cover of 0.6 m in 5 years and in 20 years, respectively, or 50,000 m^3 for the final cover unless additional layers or lifts are considered to extend the life of the landfill. Bulk waste (vehicles, appliances, etc.) and hazardous waste are not buried in the landfill and are therefore not included.

6 EXISTING AND PROSPECTIVE AGGREGATE SOURCES

Prior to fieldwork, a desktop assessment of existing and prospective aggregate sources was conducted using satellite imagery, aerial photography and surficial geology maps combined with reports of previously identified deposits in the vicinity of Rankin Inlet (refer to Figures 4-1 and 4-5 on pages 13 and 20 in Section 4). Two general 'directions' of investigation were identified: one being west along the Diane River Road, and the second being northeast towards and beyond the Meliadine River on the recently constructed Agnico-Eagle Meliadine Mine Road. The majority of evaluated sites were west along the Diane River Road, as requested during community consultation.

In view of high estimated costs to construct roads, the primary targets were materials along existing roads and bedrock quarry sites where no access road was required. All sites were identified by their kilometre distance from a reference point (km 0.0) at the main street intersection just north of the existing community hall & arena as shown on Figure 6.1, below. Where new roads would be required to access sites, they were identified by both the distance traveled on the main road plus the distance of new road required and direction. For example, the identifier 'KM 15.0+1.0' would be used when 1.0 km of new road would be required from the main road at km 15.0.

This section describes the field investigation and the evaluated borrow sources and quarry sites capable of producing future aggregates needed to at least meet the 20-year requirements of Rankin Inlet.

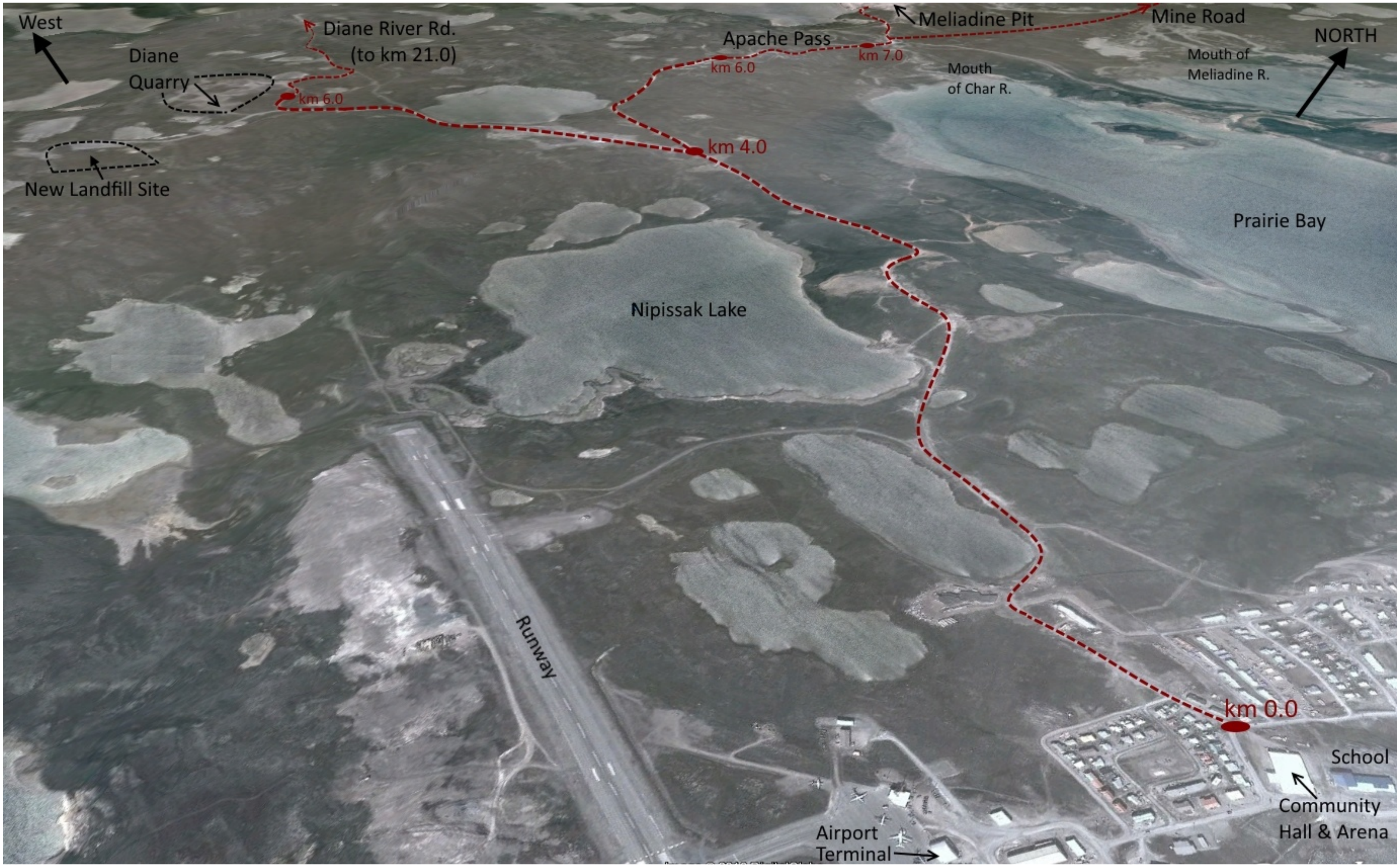


Figure 6-1: **Location of reference km 0.0 used to identify sites by distance from Rankin Inlet (base map: Google, DigitalGlobe, 2016)**

6.1 Field Investigation

Between July 18 and 24, 2016, JOURNEAUX ASSOC. conducted a field evaluation of prospective aggregate borrow sources in the vicinity of Rankin Inlet. Existing and potential quarry sites for a drill/blast/crush (DBC) operation near the hamlet were also identified and evaluated during this time. In total, 14 sites were investigated and evaluated:

- Seven (7) prospective new aggregate borrow sites,
- Three (3) active aggregate borrow sites,
- Three (3) prospective bedrock quarry locations, and
- One (1) previously active bedrock quarry location at the harbour.

This included all sites identified during the desktop study plus additional sites discovered during the field trip to Rankin Inlet. The potential quarry sites investigated included the existing quarry south of the airport by the harbour, and prominent bedrock outcrops at the current Diane Pit, the new dump site, and at KM 13 along the Diane River Road.

Based on the results of the earlier community consultation, the field investigation primarily focused on aggregate borrow-sources accessible by pick-up truck along the existing Diane River Road west from the hamlet. During the field trip, further consultation regarding existing and prospective sites was conducted with local contractors, community planners and local residents.

A handheld Garmin GPS unit was used to mark waypoints at each site and measure the approximate surface area of deposits (refer to Appendix B). In addition, a remote-operated drone was used to gain aerial perspectives of the investigated sites to better evaluate their size and potential based on costs of access roads required to develop the deposit.

Deposit volumes were estimated from a series of test pits (limited by permafrost) and/or general geological depositional history at the deposit. A rubber-tire backhoe was contracted from Inukshuk Construction and was used to excavate a series of thirty (30) test pits at four prospective borrow sources accessible out to 21 km west of the hamlet along the Diane River Road. Numerous samples were taken and returned to our laboratory in Montreal, QC, for testing. This included nineteen (19) grain size samples from selected borrow sources and representative bedrock samples from each of the investigated prospective quarry sites. Laboratory results are discussed for the relative sites below and are presented in Appendix D.

On July 23, a helicopter was contracted from Custom Helicopters Ltd., based out of Rankin Inlet, to fly reconnaissance over additional new sources further from the road network and east of the Meliadine River, and to obtain aerial photos and video of all investigated prospective sites for further evaluation in the office.

The investigated sites, the existing road network, optional new roads and other features of interest are shown on Figure 6-2 on page 38, below.

All evaluated sites are described in the sections below, categorized by borrow sources and quarry sites. The sites are also presented in Appendix B where demarcated site boundaries and GPS coordinates are provided in additional figures.

Figure 6-2: Map of natural aggregate borrow-sources and potential quarry sites investigated in July, 2016 and summarized in the following sections. Dotted outlined areas are prospective borrow sources, and red stars are potential bedrock quarry sites.

6.2 Active Borrow Sources with Remaining Material

Two major active borrow sources are in current use within the hamlet municipal boundary: The Diane Quarry (pit) and the Meliadine sand pit. These pits are identified on Figures 6-1 and 6-2 above and both contain substantial remaining material. A third active borrow pit was identified east of the Meliadine River on the north side of the Agnico-Eagle mine road. These sites are briefly described below:

- **Diane Sand & Gravel Pit**

This previously described borrow area is located between km 6.0 and 7.5 on the Diane River Road (Figure 6-3) and has been fully developed, with numerous stockpiles of various select crushed and screened materials remaining. The hamlet-owned screener currently sits in this pit, along with numerous pieces of equipment belonging to Inukshuk Construction. According to the contractor, the extracted sand and gravel material has varied across the pit area over the years.

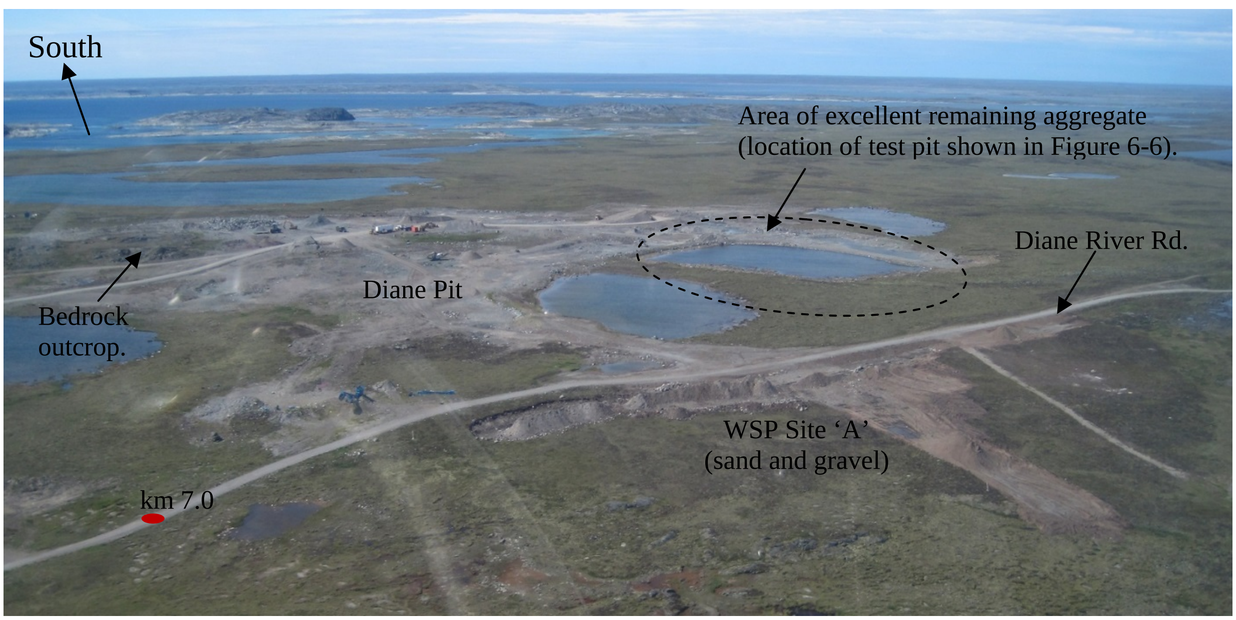


Figure 6-3: The Diane Pit and WSP sand and gravel source Site ‘A’, as of July, 2016.

Excavation throughout the Diane Pit has reached the underlying silty till and/or groundwater table in most areas, as can be seen in Figure 6-4 below.

Figure 6-4: Excavated, unprocessed material in the Diane Pit. The silty till pit floor is visible, coinciding with the local groundwater table (Photo: July, 2016)

Site ‘A’, investigated by WSP in 2014, is essentially an extension of the pit on the north side of the Diane River Road and reportedly contains 86,000 m^3 of aggregate. The local contractor has begun excavating and stockpiling the material, as can be seen in Figure 6-3 and in Figure 6-5, below. The material closest to the road contains significant coarse aggregate, but appears to become increasingly sandy farther from the road (to the north).

A significant quantity (~40,000 m^3) of high quality coarse aggregate also remains south of the road in the active pit, beneath and immediately west of the middle of three small lakes. Much of the gravel is below the water table. This area is circled in Figure 6-3 above and the quality of material is shown in Figure 6-6 below. A grain-size curve representing the minus 2” material is presented in Appendix D. The coarse fraction (minus 6”) is estimated at 40% of the deposit.

Figure 6-5: Recently excavated material from WSP Site 'A', which reportedly contains 86,000 m^3 of aggregate. View is north at KM 7.0 Diane River Road. (Photo: July, 2016).

Figure 6-6: Excellent course aggregate (~40,000 m^3) remaining alongside and beneath the small middle lake at the north end of the existing Diane Pit (Photo: July, 2016).

- **Meliadine Sand Pit and WSP Site 'D'**

The Meliadine Sand Pit (Figures 6-7 to 6-9) is located 7.5 km north from the hamlet near the entrance to Iqalugaarjuup Nunanga Territorial Park. The available material is predominantly sand, although stockpiles of clean gravel have been produced by screening the bulk excavated aggregate. The material is of glacial-fluvial origin, and thus the gravel is all hard, rounded fragments carried long distances and deposited in a glacial esker. South of the existing pit, the large ridgeline of the esker continues and was investigated by WSP in 2014 as Site 'D'. It is reported to be predominantly sand, but will continue to provide a long-term source of good clean sand for general building pad and road base fills, concrete mixes and sand applications. Site 'D' reportedly contains 170,000 m^3 of sandy aggregate material.

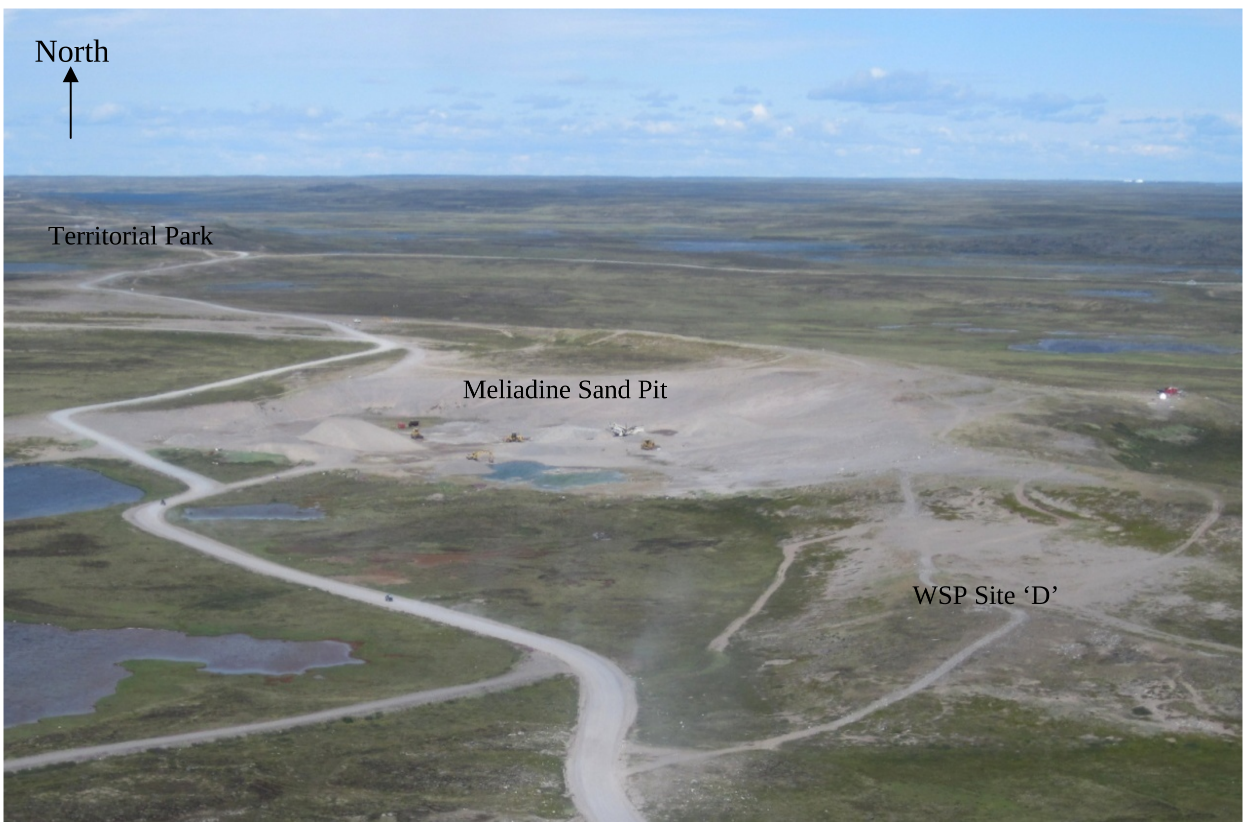


Figure 6-7: Aerial photo of the Meliadine Sand Pit and WSP Site 'D' (Photo: July, 2016).

Figure 6-8: Drone photo of Meliadine Pit stockpiles and equipment (Photo: July, 2016).

Figure 6-9: Screened stockpiles of fine gravel (left) and clean sand (right) in the Meliadine Pit (Photo: July, 2016).

- **Agnico-Eagle Mine Road Pit**

This pit was located by helicopter during reconnaissance east of the Meliadine River and is located on the north side of the Agnico-Eagle Meliadine Mine Road about 17 km northeast from the hamlet and outside the municipal boundary (Figure 6-10). It can be located between Mile 8.6 and 11.5 on Figure 4-4 on page 18 and is considered to have been developed during construction of the mine road. It is presently used for road-surface maintenance. The source appears fully developed between two lakes and a prominent bedrock outcrop. It is estimated that roughly 20,000 m^3 of material has been stockpiled, with an additional 20,000 to 30,000 m^3 remaining to be excavated.

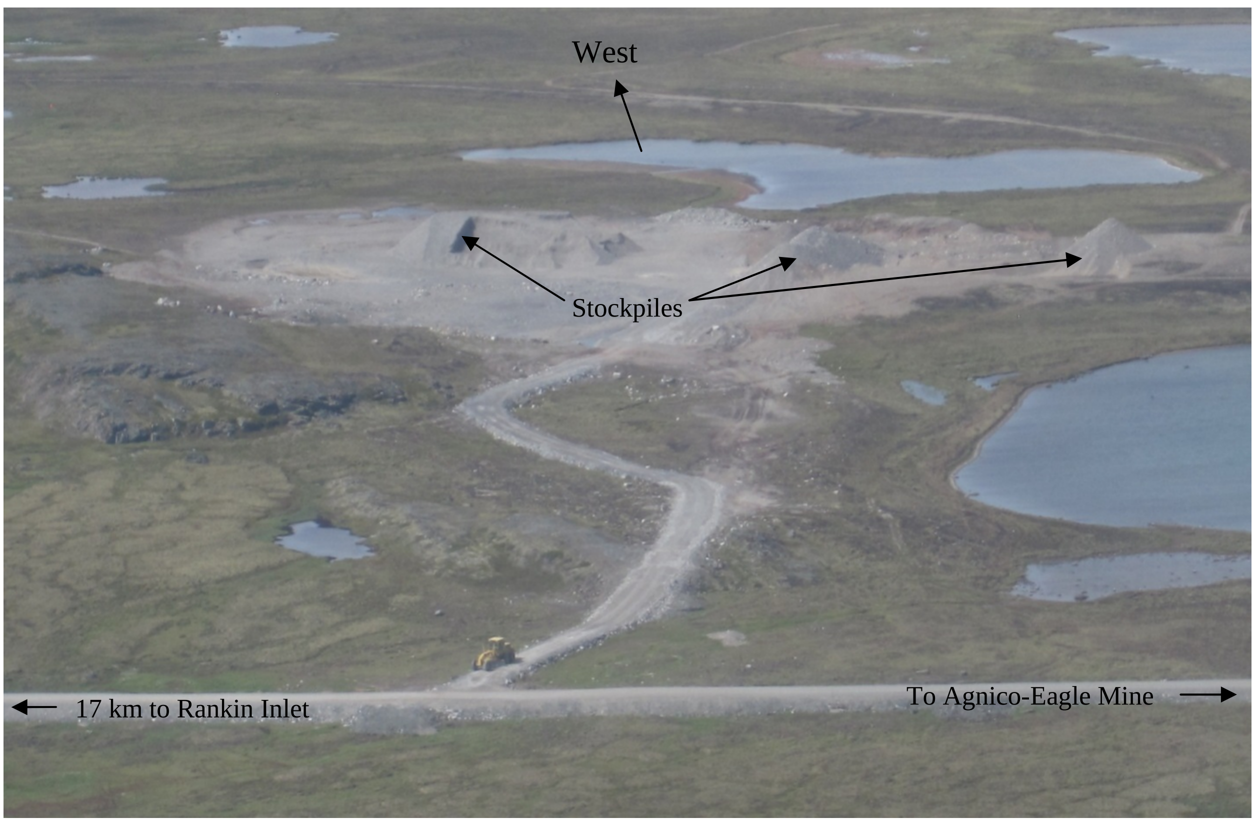


Figure 6-10: Existing active borrow pit north of the Agnico-Eagle Meliadine Mine Road 17 km northeast of the hamlet, and used for mine road maintenance (Photo: July, 2016).

6.3 Potential New Borrow Sources

Potential new borrow source locations were initially identified on satellite imagery and surficial geology maps, and then confirmed in the field. Ground investigations focused west along the Diane River Road within municipal boundaries as requested during community consultation. These sites were identified by their kilometre distance along the Diane River Road. Two additional sites, identified as Journeaux-1 and Journeaux-2 in the desktop study, were evaluated from the air by helicopter. The estimated quantities of granular material at each of the potential new borrow sites evaluated in the field are summarized in Table 10-1 on page 90. Appendix B also presents GPS coordinates demarcating the boundaries of the investigated expansion areas evaluated above. All investigated prospective borrow sources are described below.

- **KM 8.0 on Diane River Road (Journeaux-3)**

This raised beach deposit is located north of the Diane River Road at KM 8.0 and can easily be identified by a prominent, north-south ridge perpendicular to the road with highly-visible cobble beaches on either side of the ridge. Two cabin sites occupy the ridge, and the south cabin closer to the road also contains a grave site. An aerial photo of the deposit is shown in Figure 6-11 and additional photos of the deposit are shown in Figures 6-12 and 6-13. Three test pits were excavated throughout the deposit on the west side of the ridge and revealed hard, rounded to sub-angular coarse gravel and cobble transitioning to clean sand downslope to the west typical of the raised beaches in the region. Photos of the test pits are shown on Figure 6-11 and additional photos are provided in Appendix C. Grain size results from the obtained samples are presented in Appendix D. Up to 70,000 m^3 of aggregate may be obtained from the site (see Appendix B).

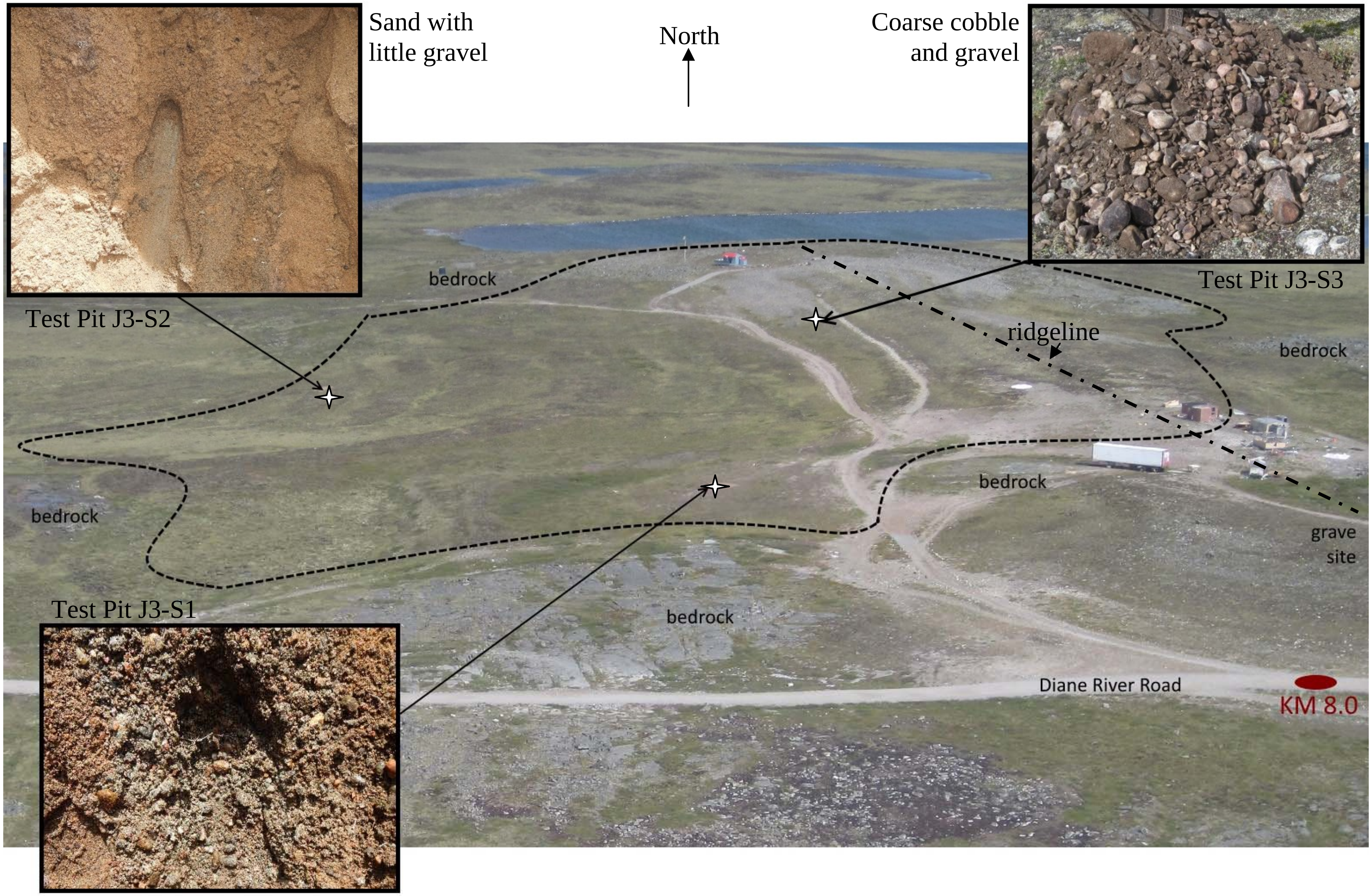


Figure 6-11: Raised sand and gravel beach deposit against a bedrock ridge at KM 8.0 on the Diane River Road (Journeaux-3), with up to 70,000 m^3 of aggregate. The deposit transitions from gravel to sand downslope to the west (Photo: July, 2016).

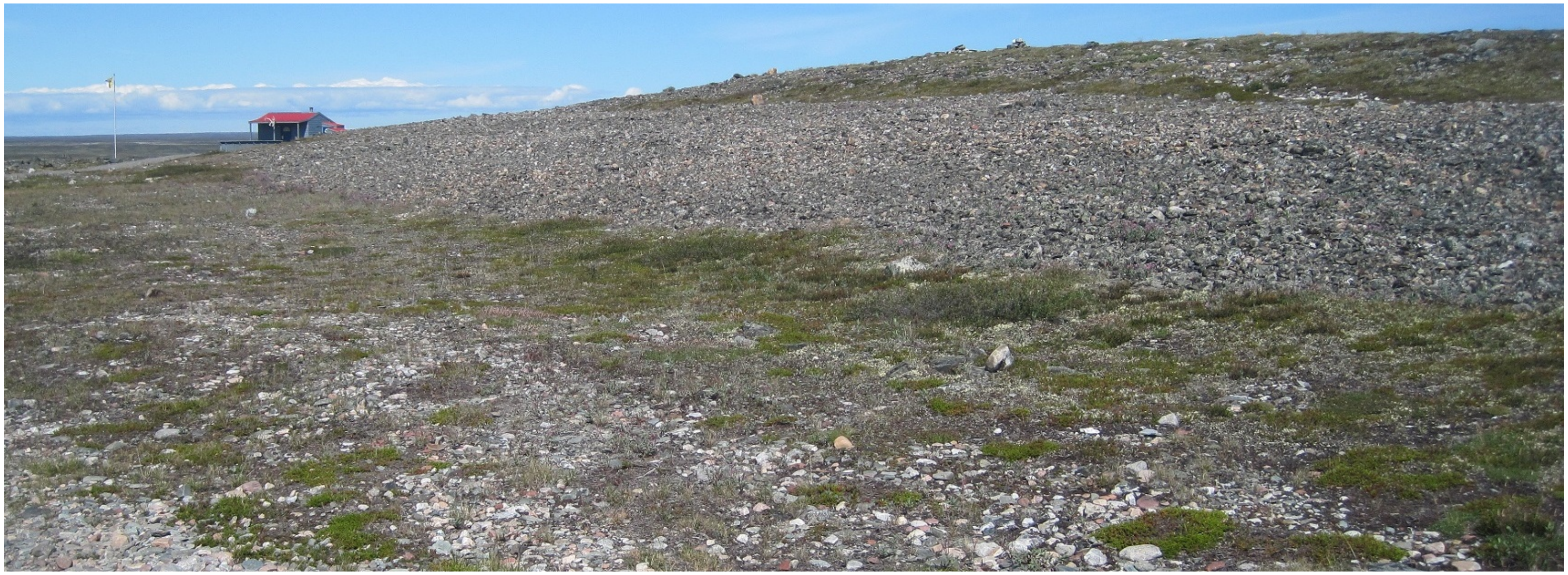


Figure 6-12: view towards the north and a new cabin along the upper cobble beach ridge at KM 8.0 (Photo: July, 2016).

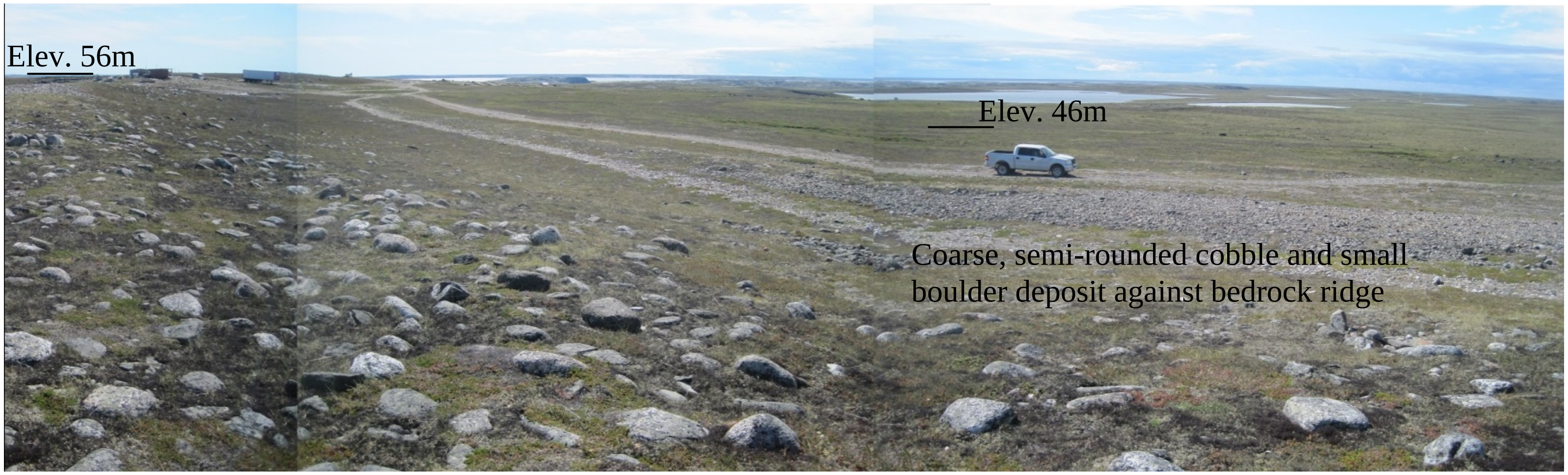


Figure 6-13: view downslope from ridgetop towards the southwest across the deposit (Photo: July, 2016).

Development of this deposit as a borrow source would require some level of mixing of the sand and gravel/cobble deposits. The tested samples contained less than 1% fine-grained soils.

The deposit is well drained and no groundwater was encountered in the test pit excavations. Permafrost was encountered at 0.9 to 1.2 m below grade in each test pit. Ice lenses are not expected in the permafrost soils and there is little potential for thermokarst formation. Should the deposit be developed, drainage should be continually maintained downslope to the west, and sedimentation barriers may be required at the west end of the active pit area. No creeks, streams or water bodies would be impacted by development. Due to the gentle slope angles, significant erosion and/or slumping would not be expected as the granular soils are not thaw-sensitive. An obvious impediment to the development of this deposit is the two cabin sites and grave site along the ridge. No signs of wildlife were observed during evaluation of the deposit.

- **KM 16.0 and KM 15.0+1.0 on Diane River Road (Journeaux-4)**

Two large elevated beach deposits were identified at KM 16.0 on the Diane River Road and immediately to the north, accessible by up to 1.0 km of new road from KM 15.0 on the main road. These deposits are shown viewed to the south and north, respectively, on Figure 6-14 and 6-15 below. Both deposits are oblong in shape with coarse cobble and gravel appearing at the crest and transitioning to finer gravels and sand downslope on all sides. The two deposits are separated by a low-lying wetland/stream and small ponds are situated in the flat crests of each deposit. A series of nine (9) test pits were excavated throughout the southern deposit, accessible from the main road and are also shown on Figure 6-15. Additional photos and grain size curves are presented in Appendix C and D, respectively.

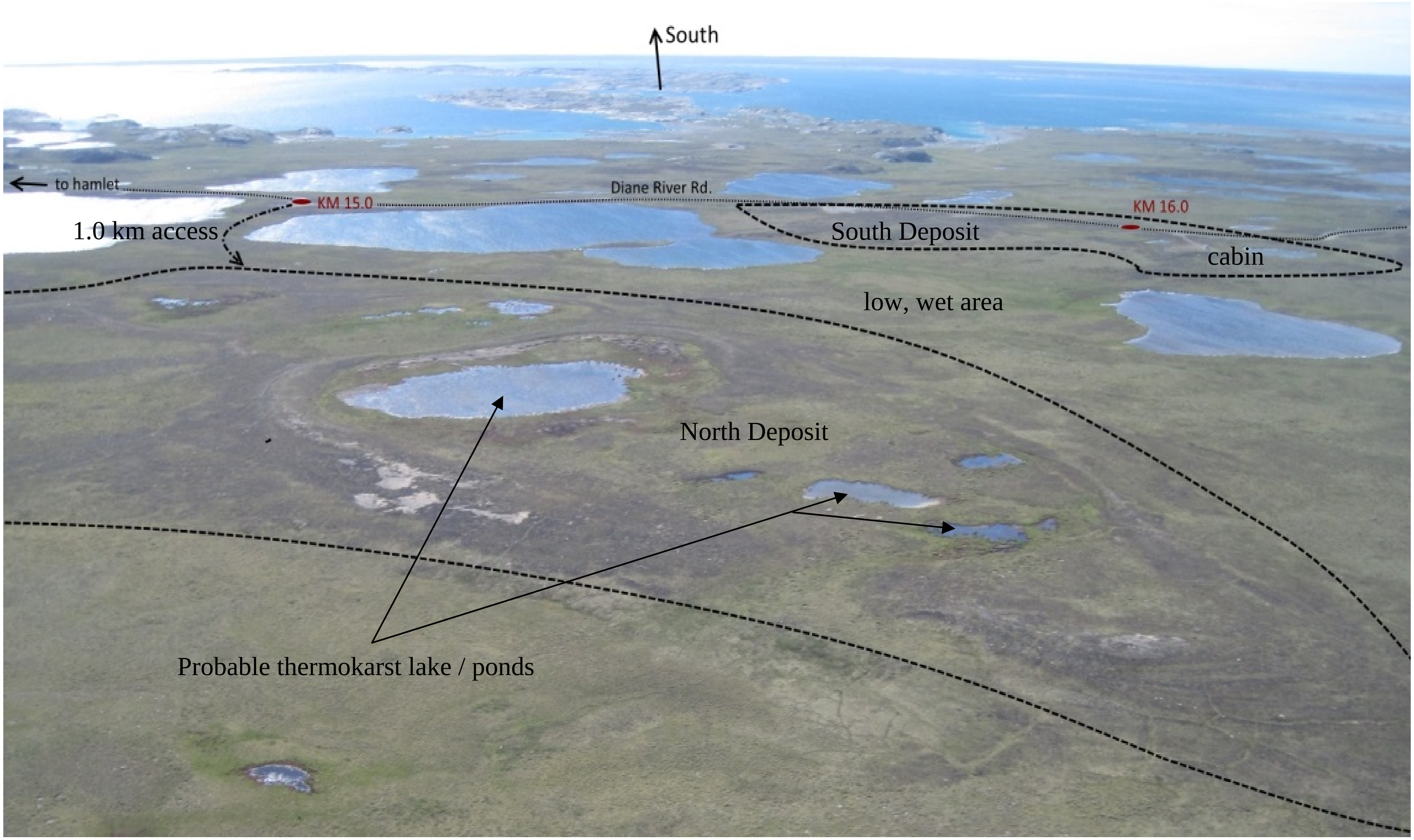


Figure 6-14: The twin deposits at KM 15+1.0 and KM 16 viewed towards the south with the north deposit in the foreground. Development of the north deposit would require up to 1.0 km of new access road crossing a small, shallow creek between two lakes. It would require carefully avoiding or draining a few shallow thermokarst ponds to prevent erosion (Photo: July, 2016).

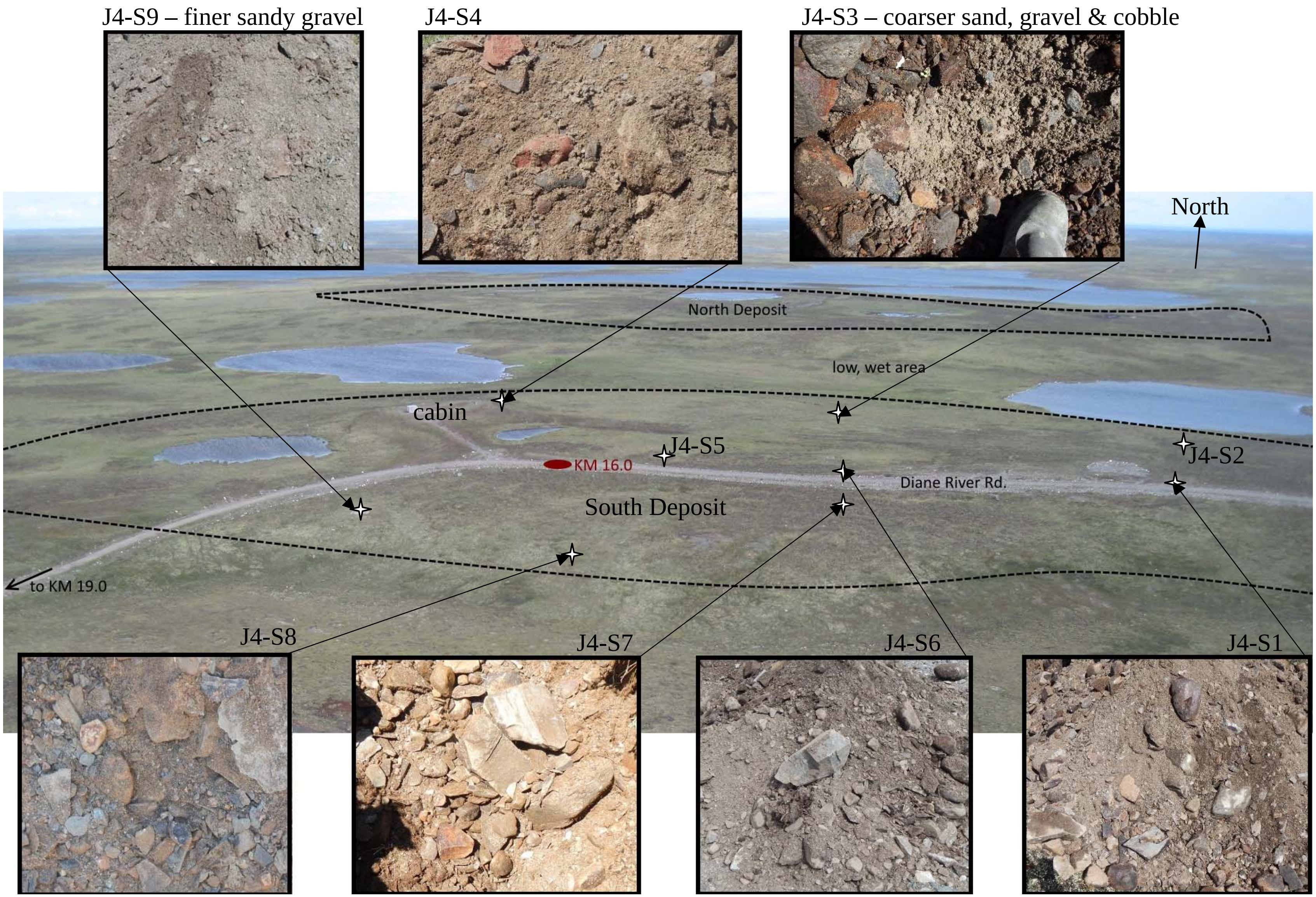


Figure 6-15: The twin deposits at KM 16 and KM 15+1.0 viewed towards the north. Nine test pits were excavated to depths of up to 1.5 m throughout the southern deposit, for which typical photos of the material are also shown (Photos: July, 2016)

Figure 6-16 shows another perspective looking east over the southern deposit at KM 16. The test pits excavated in the southern deposit revealed the coarsest gravel to be located south of the road and beneath the road along the crest of the ridge, with material in the minus 2" range consisting of roughly 60-75% gravel, 20-40% sand and 2-7% fine-grained silts and clay (see Appendix D). Material lower on the slopes was sandier, with 48-64% sand and 9-16% fine-grained silt and clay. Moisture content of the tested samples ranged from 2 – 14% but was generally less than 8%. The coarse gravel fraction was mostly angular to sub-angular and contained a significant amount of flat, elongated shale and slate (~20-40%), which is a softer, easily crushable rock.

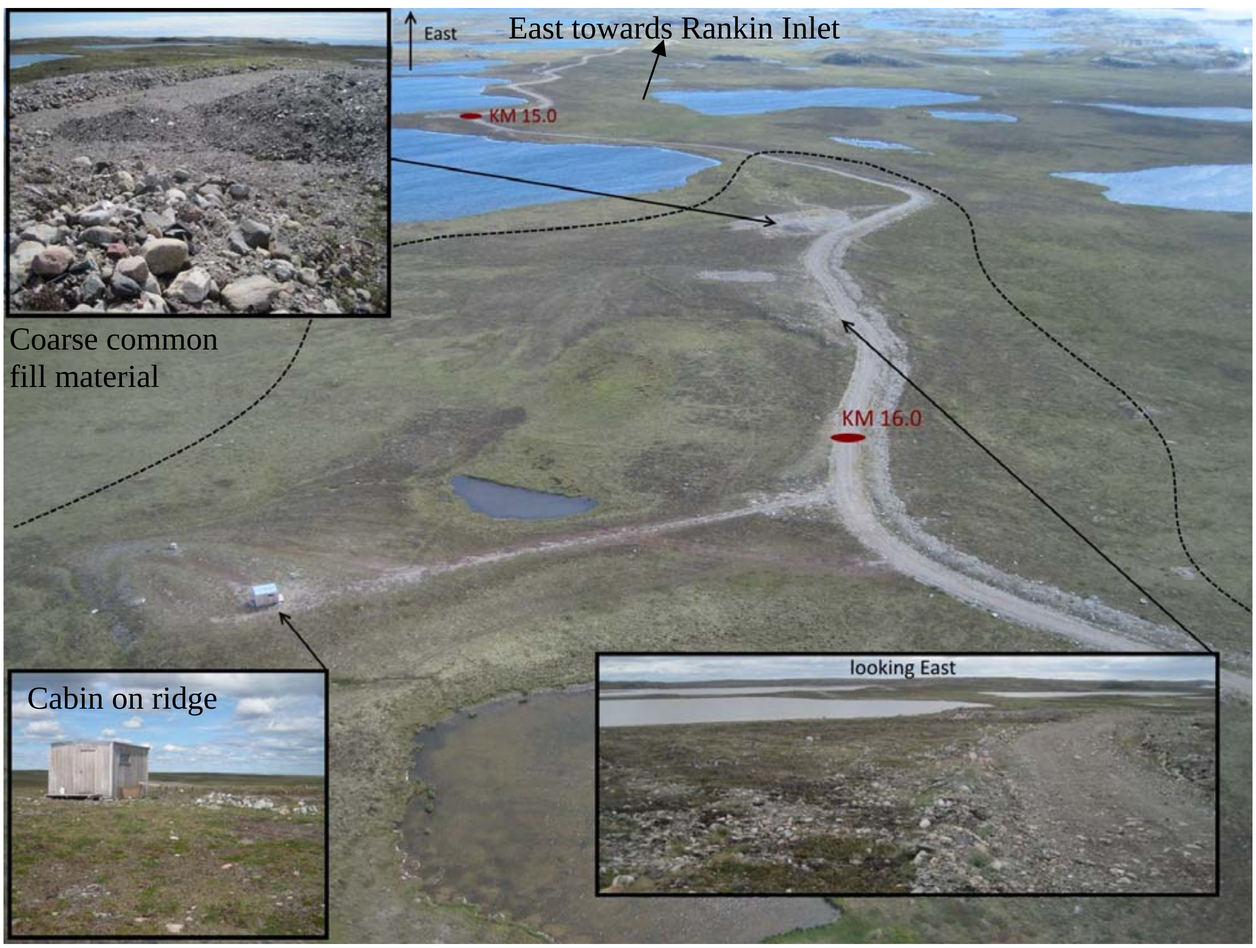


Figure 6-16: Looking east across the south deposit at KM 16 (Photo: July, 2016).

Silty till was encountered underlying the gravels at depths between 0.5 – 1.0 m in the test pits at lower elevation, but was not encountered within the 1.5 m excavations near ridge-top. Thus, an average depth of 1.0 m may be considered for the sand and gravel deposits overlying the till. The underlying silty soil may also be blended with the clean sands and gravels to meet various specifications. No bedrock was encountered within excavations at the site.

Permafrost was encountered between 0.8 m below grade in the lower elevation test pits (commonly corresponding with the silt till) and up to 1.5 m in the dry coarse sand and gravel at ridge-top. The deposit is well drained and no groundwater was encountered in the test pit excavations. Ice lenses are not expected within the sand and gravel soils.

Approximately 150,000 m^3 of high quality aggregate material may be recoverable from each of the south and north deposits, assuming an average deposit depth of 1.0 m (see Appendix B). The material in these deposits would be suitable for bulk pit-run fill and for crushing/screening to produce select aggregates. As is typical of such beach deposits, development of the deposits as borrow sources would likely require some level of mixing of the sand and gravel/cobble as the material gradation changes with elevation.

No creeks, streams or major water bodies would be impacted by development. The southern deposit would require setbacks from the two medium-sized lakes at either end of it. A few small, shallow thermokarst ponds at the crest of each deposit would need to be avoided or drained to prevent erosion. Due to the gentle slope angles and dry granular soils, erosion and/or slumping would not be expected.

Access to the northern deposit is recommended from KM 15 on the Diane River Road, instead of across the low wetland area directly between the two deposits. This route would require 700 to 1,000 m of new road and construction would be relatively straightforward, with predominantly dry, smooth terrain connecting the two deposits. A small creek roughly 100 m north of the existing Diane River Road would require a small-diameter culvert at its crossing to maintain flow during spring runoff and rain events.

It should be noted that there is an existing cabin site situated on the southern deposit, although satellite imagery from 2011 shows the cabin wasn't there at the time and must be recent. Numerous siksiks inhabit the dry sandy soils on the slopes of the investigated southern deposit. Large numbers of sand cranes and other waterfowl were observed in the lakes and low, wet areas east of the deposits between KM 14.0 and 15.0 on the Diane River Road.

- **KM 18.0 on Diane River Road**

This deposit, 18 km west of town on the Diane River Road, was identified during community consultation and subsequently investigated during the July fieldwork. It begins from the east with a high, narrow ridge (on which the road is built) that then spreads out into a wider deposit at the west end (Figure 6-17). The slope on the north side of the ridge drops steeply by about 5–7 m to the low-lying terrain, while more gentle slopes exist south of the ridge. A portion of the deposit at the west end has been stripped and partially used for construction of the road (Figure 6-18).

Two test pits were excavated – one on each side of the road – towards the wider west end of the deposit. Photos of the test pits are shown on Figure 6-17 below and in Appendix C, and grain size results from tested samples are presented in Appendix D.

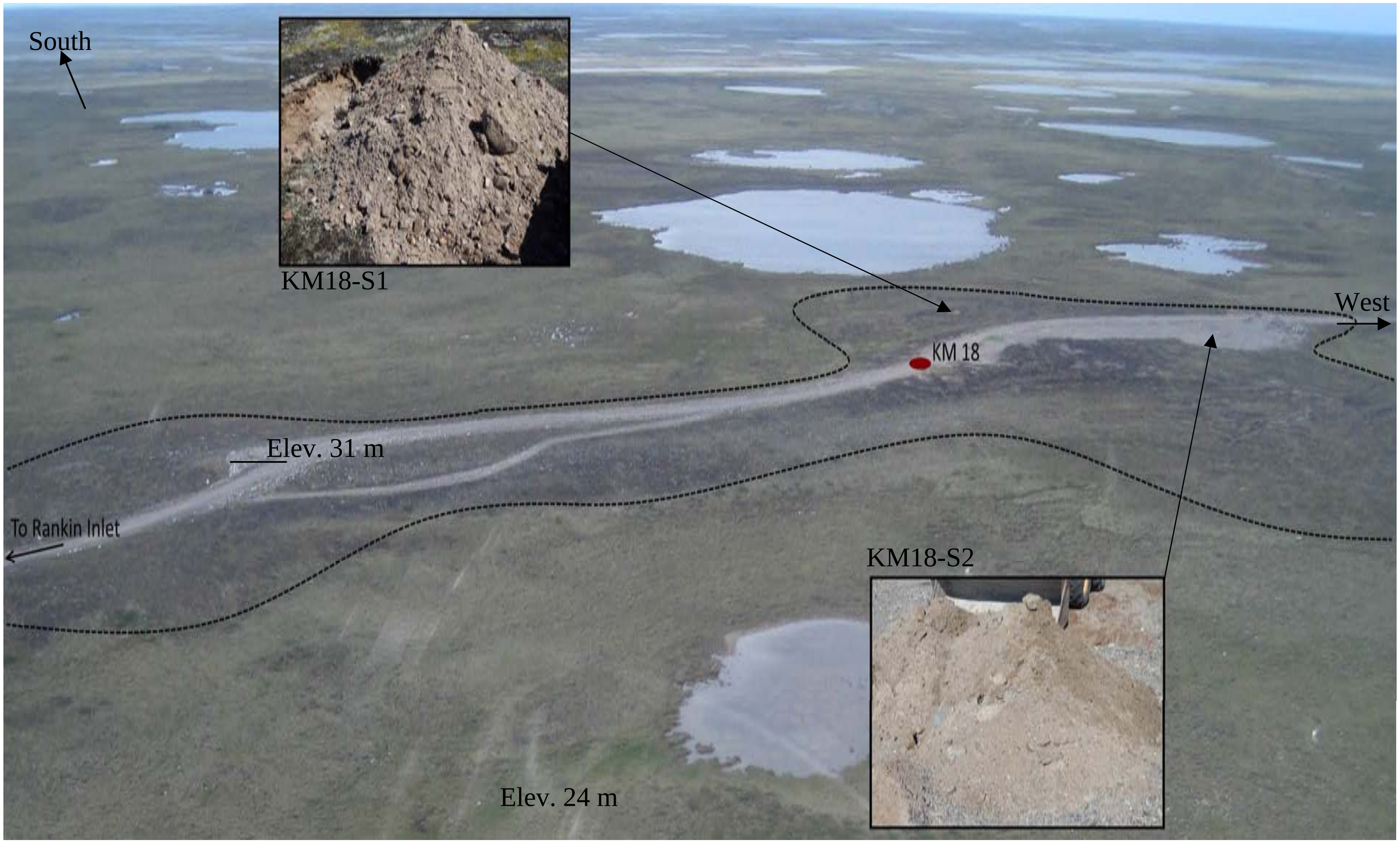


Figure 6-17: The deposit at KM 18.0 on the Diane River Road, which begins at the east end as a high, narrow ridge before flattening and widening out to the west. The deposit is expected to be at least 2 m deep, capable of producing upwards of 140,000 m^3 of granular material (Photo: July, 2016).

Figure 6-18: A test pit being excavated in the stripped area at the west end of the deposit at KM 18.0. The long narrow ridge can be seen extending eastward in the background, with the steep slope down to the north (left). (Photo: July, 2016).

Both test pits encountered gravel with sand and occasional cobbles that extended to at least the depth of the permafrost table, which was encountered between 1.2 m and 1.4 m below grade. Based on the grain size curve (Appendix D), the material in the minus 2" range is generally poorly-graded with roughly 52% gravel, 40% sand and 8% fine-grained silts and clay. Moisture content of the tested sample was 3%. The coarse gravel component contained a substantial amount of flat, elongated shale and slate rock (roughly 10 - 20%). This material could be screened to meet select-grade gravel although a crusher would be needed to process the 30-40% in the gravel range that is greater than 20 mm in size depending on application.

The surface area of the deposit is roughly 70,000 m^2 and is anticipated to be quite deep along the elevated ridge. An average deposit depth of 2 m has been estimated. GPS coordinates demarcating the site boundaries are shown in Appendix B. It is estimated that upwards of

140,000 m^3 of good granular material is available from this source. Development of the source would require diverting the main road to one side or the other of the borrow pit as it expands.

The deposit is well drained and no groundwater was encountered in the test pit excavations. Ice lenses are not expected and there is no potential for thermokarst development. No creeks, streams or water bodies would be impacted by development. Erosion and slumping of the steeper slopes could be easily prevented by leaving the lower slopes vegetated as the deposit is excavated down in even layers year by year.

No signs of wildlife were noted at the deposit. A single caribou was observed approximately 1 km south of the deposit during the field work.

- **KM 18.5 – 21.0 on Diane River Road (Journeaux-5)**

This area was identified on surficial geology maps as an extensive deposit between KM 18.5 and 21.0 on the Diane River Road and is shown viewed to the east and northeast, respectively, on Figure 6-19 and 6-20 below. The deposit is roughly 2.5 km long in the east-west direction along the length of the road and varies in width between 100 m and 500 m. The wide, sinuous ridge that the road follows is generally about 300 m wide and relatively flat, and is dotted with small, shallow ponds. Numerous ATV trails and the main road cross the deposit, and a small area near KM 20 has been stripped and partially used for road construction.

A series of fifteen (15) test pits were excavated throughout the deposit and their locations are shown on Figure 6-19, below. Photos of the test pits are shown in Appendix C, and grain size results from select tested samples in the minus 2" material range are presented in Appendix D.

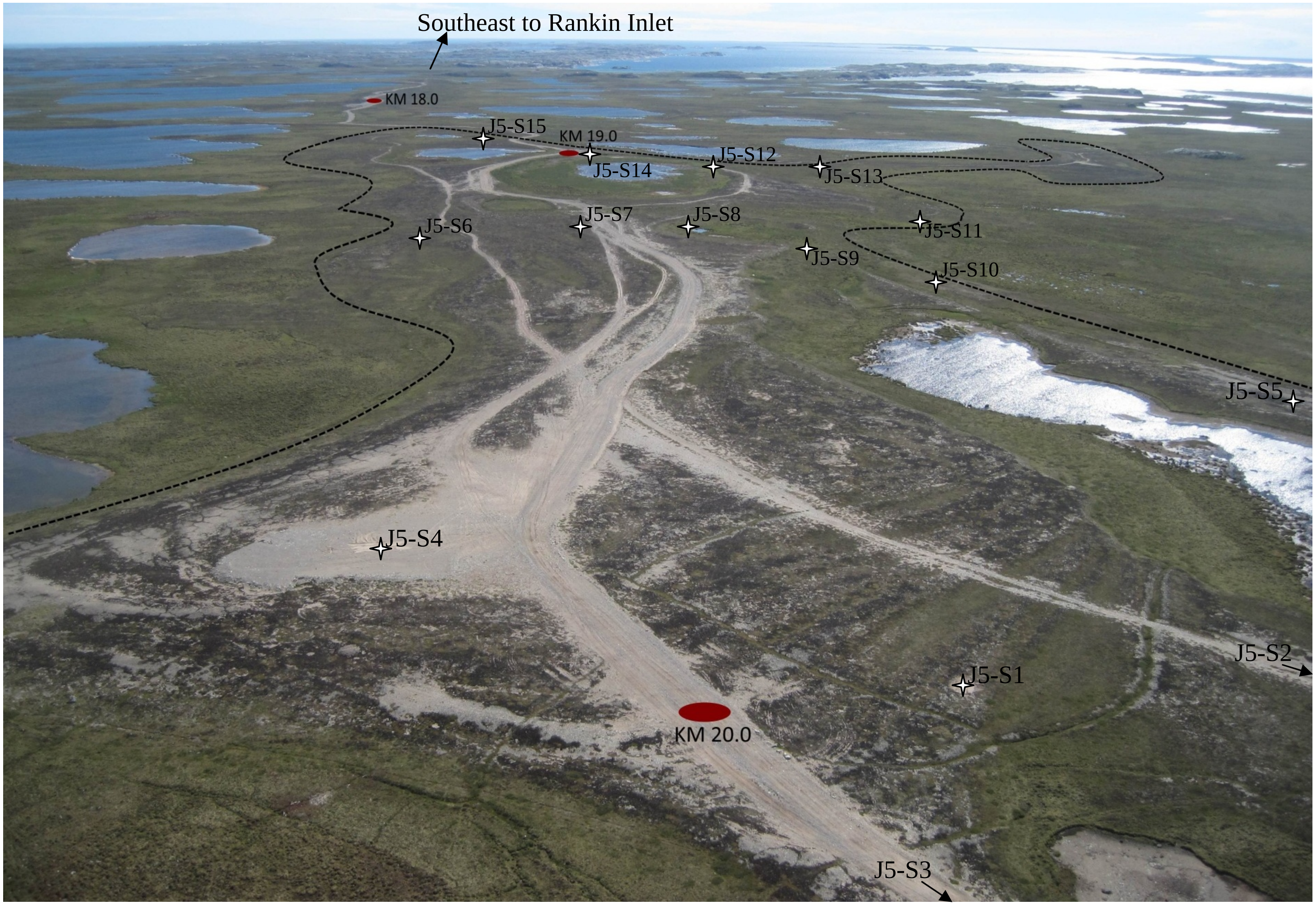


Figure 6-19: The extensive deposit (with test pit locations) between KM 18.5 and 21 on the Diane River Rd. (Photo: July, 2016)

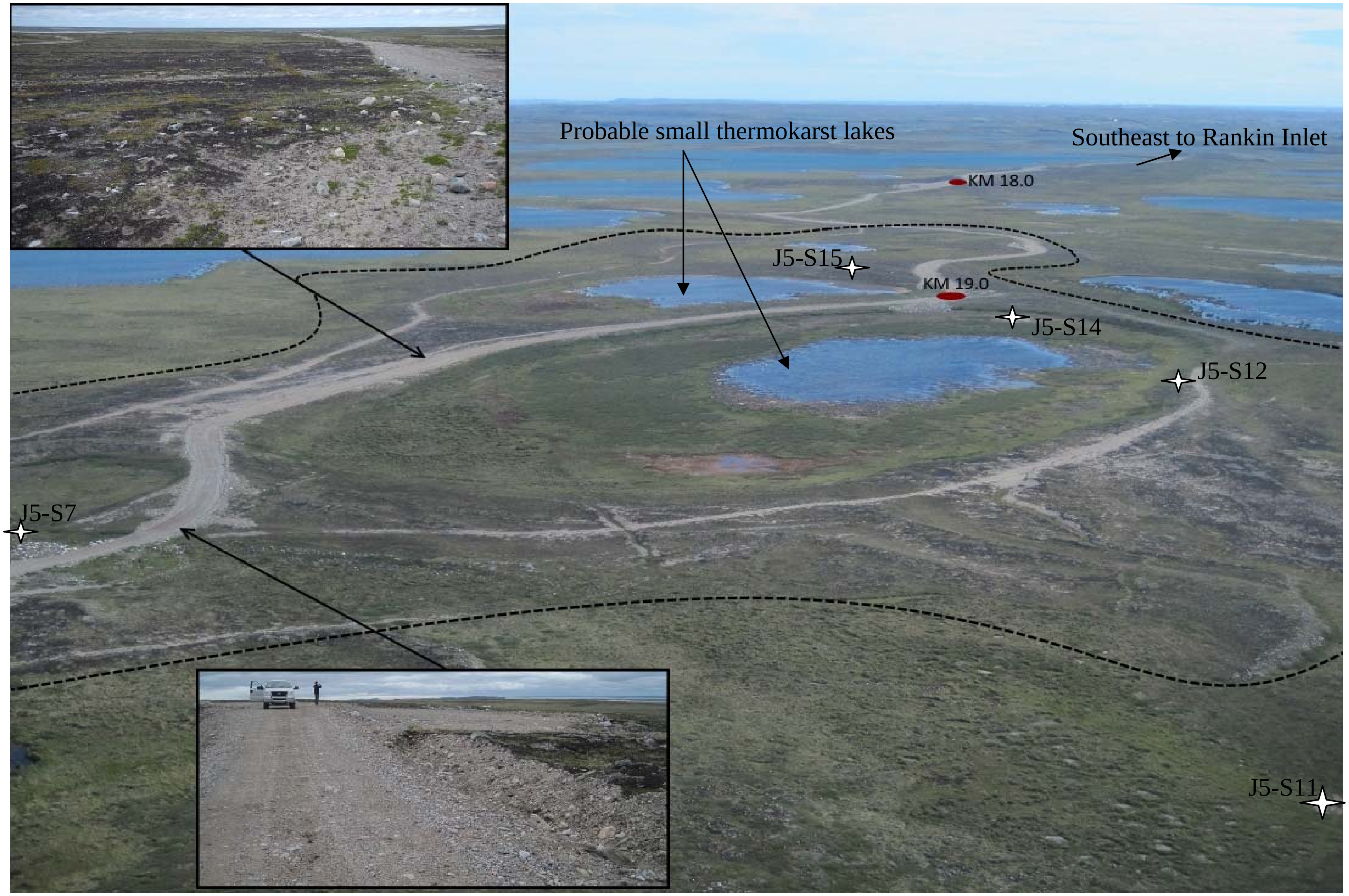


Figure 6-20: The east end of the deposit, around KM 19.0 surrounding two small thermokarst lakes that have mostly drained.

Test pits encountered variable composition of aggregate throughout the deposit (Table 6-1, below), although in general coarse cobble and gravel appear at the crest of the ridge throughout the centre of the deposit with a sandier gravel at the east and west end (Figure 5-21 on the following page), all transitioning to finer gravels, sand and eventually silt downslope towards the low, wet till plains on either side. The coarse fraction varied throughout the deposit but was generally sub-angular hard igneous rock with a shale/slate component of 10-20%, similar to the KM 18 deposit and somewhere in between that of the KM 8.0 deposit and the KM 16 deposit.

Table 6-1: Aggregate type and moisture content sampled between KM 18.5 - 21.0

J5 TEST PIT #	SOIL DESCRIPTION	MOISTURE CONENT (%)
S1 – S4, S14, S15	Gravelly Sand (~60% sand, 37% gravel, < 3% silt)	2 – 7 %
S6, S8 and S12	Sandy Gravel (~60% gravel, 40% sand, < 1% silt)	2 – 4 %
S7 and S13	Gravel with Sand (70% gravel, <30% sand, 1% fines)	1 – 2 %
S5, S10	Sand with trace to some gravel, trace fines	~ 7.5 %
S9, S11	Grey silt with sand or sandy silt with trace gravel	-

Excavated test pits in the gravels and gravelly sands of the prominent ridge did not reach underlying silt or bedrock but instead encountered the permafrost table in the present aggregate materials at depths that ranged from 1.2 to 1.9 m below grade. Thus, an average depth of 2.0 m may be considered for the sand and gravel deposits forming the elevated ridge. Permafrost was encountered in the lower test pits in sandy and silty soils at depths between 0.7 and 1.1 m below grade. These silty soils will be useful for blending with the clean sands and gravels to meet various specifications. No bedrock was encountered within excavations at the site.

The deposit is generally well drained although some former and current small thermokarst lakes or ponds exist within the deposit and are underlain by sands and gravels. Groundwater was only encountered above the permafrost table in test pit #S1. As with the other deposits, excavations were terminated at the permafrost table and the presence of ice lenses within the permafrost could not be discerned.

The surface area of the total deposit is approximately 400,000 m^2 and the expected average depth of gravels and gravelly sand is considered to be 2.0 m. The deposit is thus expected to produce upwards of 800,000 m^3 of suitable aggregate, ranging from coarse gravel requiring crushing and screening, to finer gravelly sand suitable for screening to meet surface-coarse road gravel or concrete aggregate. Roughly 200,000 m^3 of coarse gravel with cobble can be expected along ridgetop. The entire deposit is delineated with GPS coordinates in Appendix B.

Figure 6-21: Drone photo of the gravelly sand soils exposed at the surface at the west end of the deposit, near test pit J5-S4 (Photo: July, 2016).

No creeks, streams or major water bodies would be impacted by development. A few small, shallow ponds at the crest of the deposit would need to be drained. Due to the gentle slope angles and dry granular soils, erosion and/or slumping would not be expected. Excavations in the lower sandy and silty soils would require careful management to avoid flooding from the higher terraces and to prevent erosion and sedimentation of the lower till plain.

Numerous siksiks inhabit the sandy hillsides lower down on the deposit slopes, and some caribou tracks were observed in the exposed gravelly sands at ridge-top. A small bear track was also noted on the ridge. No fish or waterfowl were observed in the small, shallow ponds along the ridge.

- **Journeaux-1 at KM 10.5+2.5 on Meliadine Mine Road**

This large deposit area east of the Meliadine River was identified during the desktop study and evaluated by helicopter fly-over during the field work. The area consists of numerous gravel beach deposits surrounding prominent bedrock outcrops (Figure 6-22) and is accessible by ATV trail from the east side of the Meliadine River.

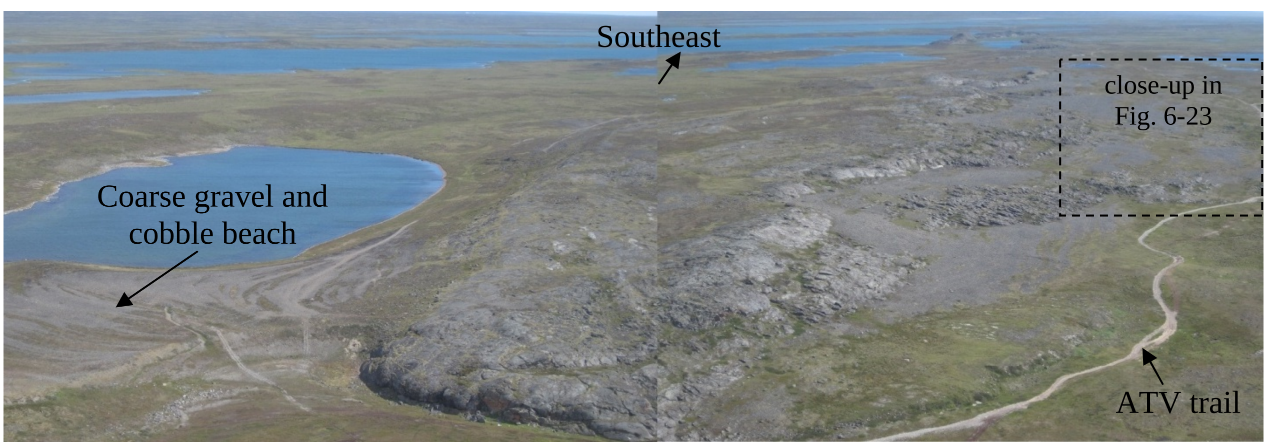


Figure 6-22: Extensive beaches and bedrock outcrops of deposit 'Journeaux-1'

The deposit is outside the municipal boundary and would require 2.5 km of new access road south from KM 10.5 on the Agnico-Eagle Meliadine Mine Road. Although significant material is available at this source, it is expected that bedrock is generally shallow under the visible gravel, and development would be challenging amongst the undulating bedrock. Further south, the deposit appears to transition into sandier gravel surrounding a small lake, as shown on Figure 6-23 below. It is difficult to estimate a volume of obtainable aggregate in the area due to the patchy distribution of gravel amongst the bedrock outcrops, but it is expected that at least 800,000 m^3 of aggregate could be obtained throughout the area.

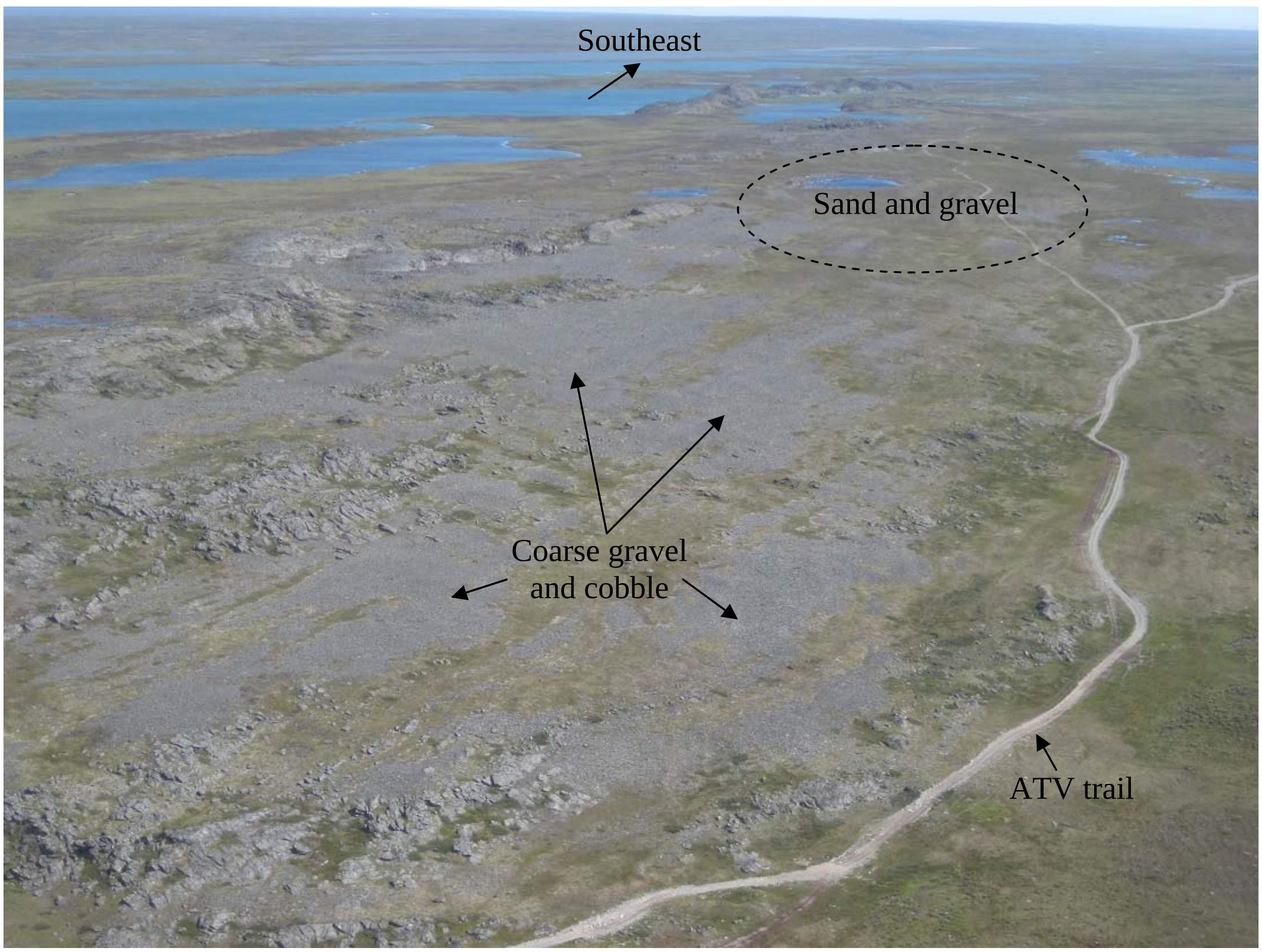


Figure 6-23: coarse gravel beaches amongst the bedrock outcrops roughly 3 km southeast from KM 10.5 on the Agnico-Eagle Meliadine Mine Road (Photo: July, 2016).

At present, consultation with the community indicated that this site was not desirable for development due to being outside municipal boundaries and visible across Prairie Bay from the hamlet. Further ground investigation of the site should be undertaken in the future if it is to be considered as a potential aggregate source.

- **Journeaux-2 at KM 15.0 on Meliadine Mine Road**

This is a second, massive deposit area northeast of the Meliadine River that was identified from surficial geology maps and evaluated by helicopter fly-over during the field work (Figure 6-24). It is outside the Hamlet municipal boundary and is accessible directly east from KM 15.0 on the Agnico-Eagle Meliadine Mine road by about 300 to 500 m across an exposed bedrock outcrop.

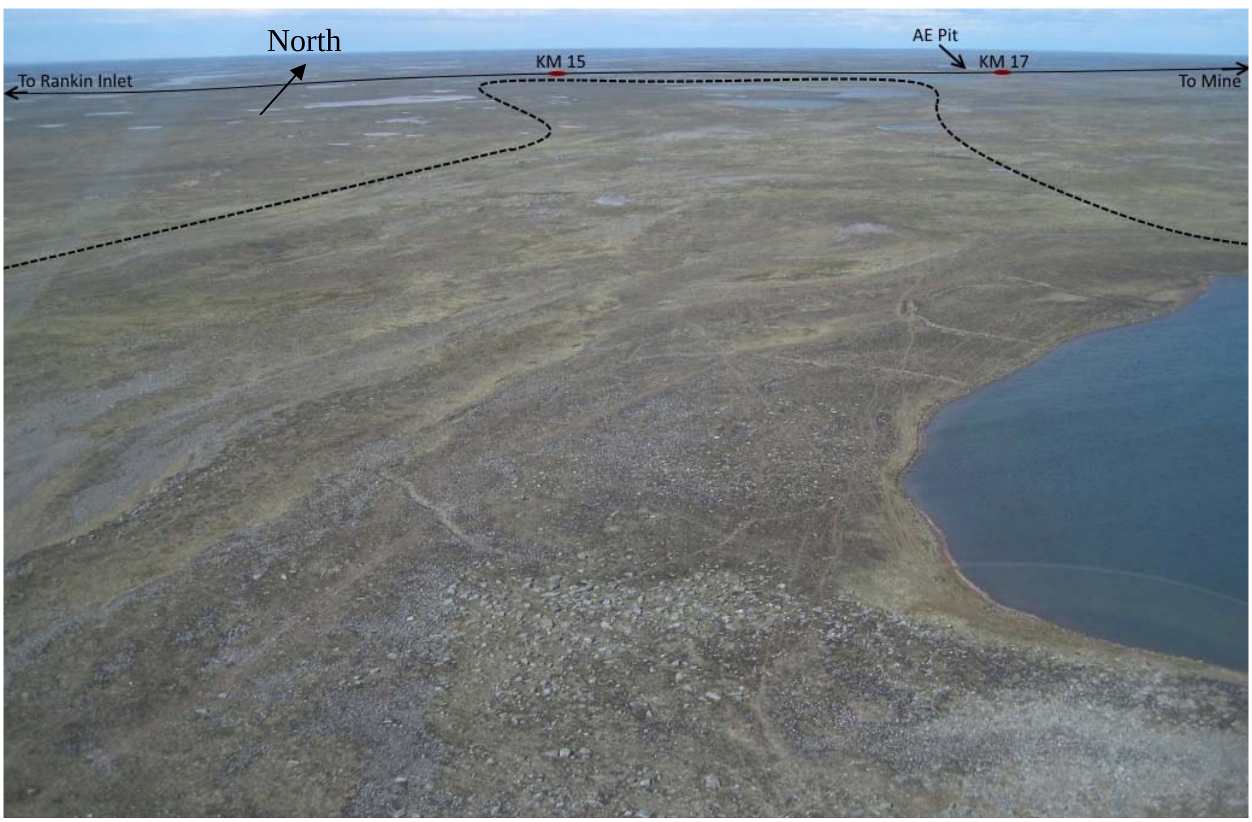


Figure 6-24: Extensive marine washed beaches of deposit 'Journeaux-2' (Photo: July, 2016)

This extensive area – roughly 3 square kilometers in size – consists of seemingly endless shallow marine beaches of sand and gravel deposited against gently rising terrain to the northeast. Much of the area is poorly drained however, and deposits of granular material may be thin over underlying silt tills. A preliminary estimate of 1.2 million cubic meters of sand and gravel may be available throughout the area. Further ground investigations would be required to determine the deposit depth and to better identify large, concentrated potential borrow source areas within the overall deposit area. Community consultation indicated that this site was not desirable for development due to being outside municipal boundaries and far from the hamlet.

7 POTENTIAL DRILL/BLAST/CRUSH QUARRY SITES

In lieu of developing natural granular deposits further from the hamlet, an evaluation of an existing quarry site at the Rankin Inlet harbour was carried out to determine the feasibility of reopening this quarry with a drill/blast/crush (DBC) operation. In addition, three (3) potential new quarry sites that would have less visible and audible impact on the community were considered and evaluated during the field investigation. All four potential drill/blast/crush quarry sites are situated within Hamlet municipal boundaries.

7.1 Investigated Quarry Sites and Prominent Outcrops

Numerous prominent bedrock outcrops exist near Rankin Inlet, particularly close to town and along the coastline. In order to reduce the potential environmental impact and cost to develop, prospective quarry sites were sought near already developed industrial areas on the existing road network, including existing borrow sources and the future dump site. Both existing quarries and both new quarry sites are described in detail below:

- **Existing Harbour Quarry**

Figure 7-1 below shows the entrance to the harbour quarry and the steep face of the bedrock outcrop. Figure 7-2 on the following page is a satellite image of the Rankin Inlet harbour, showing the location of the harbour quarry and its proximity to other infrastructure. Historic operation of this quarry has created a deep uneven face approximately 16 m in height over a width of approximately 30 m and a depth into the outcrop of approximately 80 m (see Figure 7-2). The base of the quarry is at an elevation of approximately 10 m AMSL and the outcrop reaches an ultimate height of over 30 m AMSL. A stockpile of crushed gravel (minus 1”) produced a number of years ago exists at the foot of the outcrop.

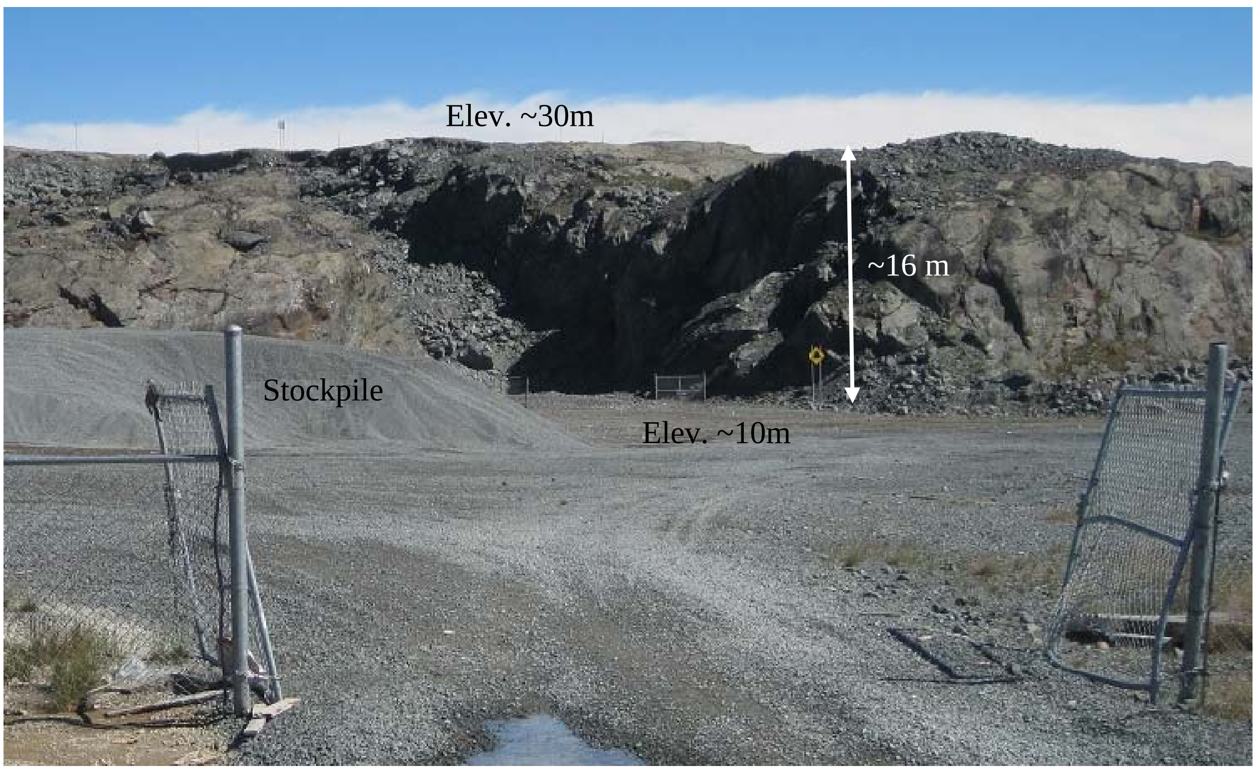


Figure 7-1: The existing quarry in a massive, resistant igneous outcrop at the harbour south of the hamlet (Photo: July, 2016)

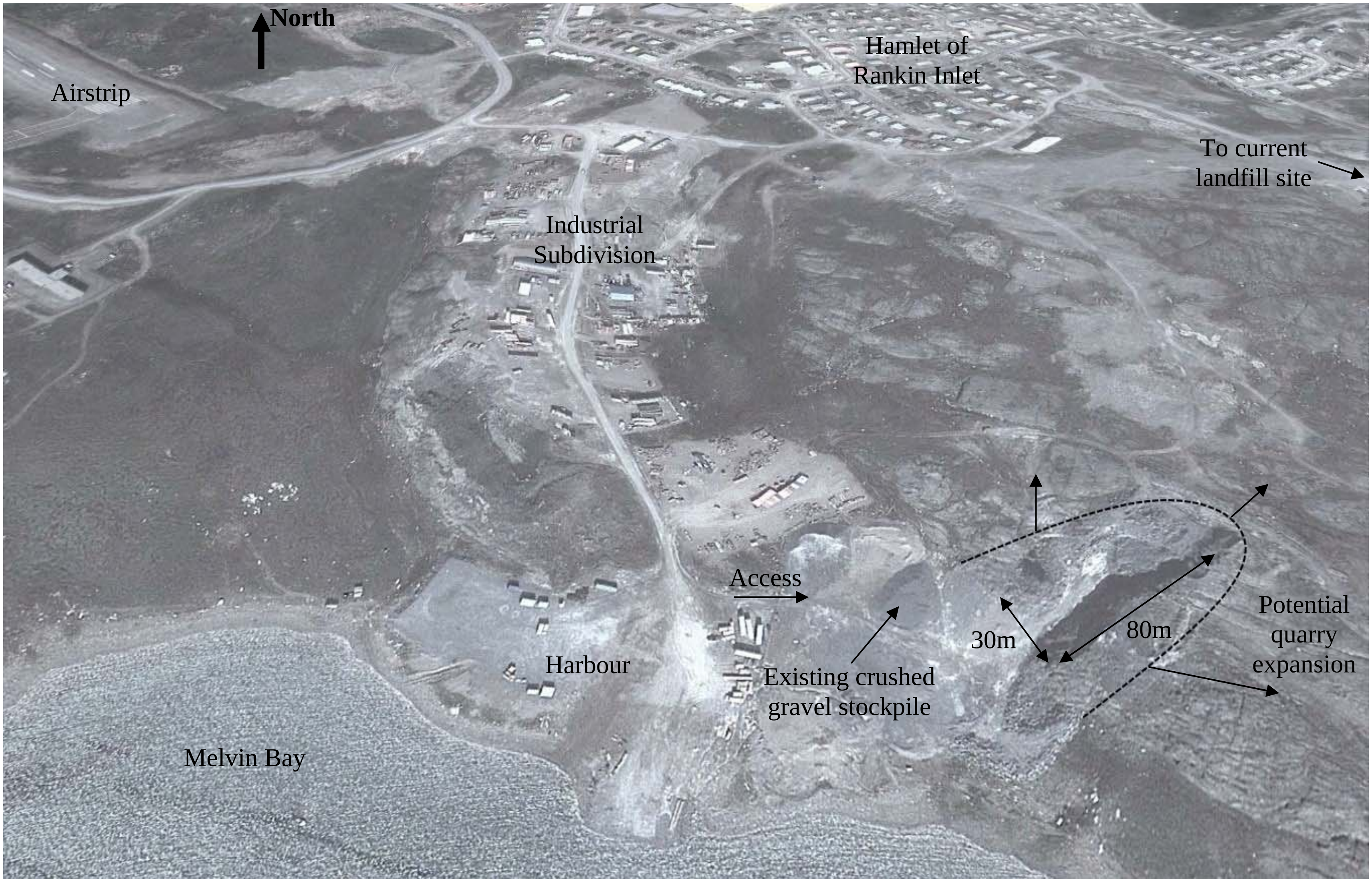


Figure 7-2: Satellite view of the existing harbour quarry and surrounding infrastructure (GoogleEarth/DigitalGlobe, 2016).

Figure 7-3 below shows a photograph of the bedrock lithology, looking across the top of the quarry towards the south. Additional photos of the quarry are provided in Appendix C.

Figure 7-3: The bedrock lithology as viewed to the south across the top of the quarry.

The bedrock at the harbour quarry is a very hard and resistant, fine-grained, metamorphosed igneous rock. It is generally massive with widely spaced joints with the exception of a thinly bedded cap rock formation at the crest of the outcrop on the north side of the quarry.

The bedrock outcrop in which the quarry is situated extends primarily to the south along the shoreline and east towards the current landfill site. Expansion of the quarry site would need to be directed southeast to maintain a high face and a water free work area and to work away from the community. This would also allow use of the long, steep face exposed on the south side of the quarry while at the same time widening the currently narrow quarry. If expansion is directed south, an area at least 100 m east-west by 200 m south by 15 m high could be quarried. This would produce roughly 450,000 m^3 worth of high-strength crushable aggregate (bulking factor is roughly 50-60%). Approximate expansion dimensions with coordinates are given in Appendix B.

Prior to reactivating the harbour quarry, the quarry walls should be carefully assessed and scaled to remove the numerous large rock slabs and boulders that are precariously perched on the slopes and top of the quarry walls. Currently, it is considered highly dangerous for machines and operators to work within the bottom of the constrained quarry.

Benefits of this quarry site are its proximity to the hamlet and harbour, suitable rock characteristics, and existing blasting face. Drawbacks are the increased noise and dust from construction traffic through the hamlet which should be avoided. It is understood that the quarry is proposed to be used again on a contract basis to produce aggregate for upgrades to the Itivia staging area, barge landing site and hamlet bypass road from the quarry. If this bypass road is constructed, this site becomes a much more desirable quarry location.

- **Diane Quarry Bedrock Outcrop (KM 6.5 on Diane River Road)**

A prominent bedrock outcrop was located in the centre of the current 'Diane Quarry' borrow pit at KM 6.5 on the Diane River Road (Figure 7-4, below). Although not as high or extensive as the harbour quarry, it is a broad low outcrop in the already active pit, which is beneficial for many reasons. The outcrop is comprised of two benches, with the lower northern bench being roughly 5 – 6 m high and the upper bench being set back about 30 m and adding 2 to 3 m in height. The toe of the outcrop is easily accessible on the northeast side by an existing pit road and is dry and well drained. The outcrop is demarcated with GPS points in Appendix B and additional photos of the outcrop are presented in Appendix C.

The bedrock here consists of a lower bench of weaker, more thinly bedded, finer-grained volcanic rock possibly deposited in a water environment. The bedrock of the larger, elevated outcrop behind it to the west is much more massive, comprising the very hard and resistant, medium-grained, crystalline igneous rock. A portion of the lower, thinly bedded formation at the foot of the outcrop is easily excavatable with the large Cat 325C excavator owned by Inukshuk Construction.

The total outcrop area is roughly 100 m wide by 100 m long, of which roughly 30% is at the lower elevation of 5 – 6 m above the pit floor. This outcrop could produce roughly 110,000 m^3 of crushable aggregate (based on a bulking factor of roughly 50-60%).

The advantages of this prospective quarry site include its relative proximity to the hamlet and excellent access, and its location in an already developed, environmentally compromised area. The drawbacks may include the limited extent of the outcrop for long-term sustainability. The outcrop is also 3.5 km directly northwest in line with the airstrip approach.

Figure 7-4: The 6 – 10 m tall bedrock outcrop near the centre of the active Diane Pit (Photo: July, 2016).

- **New Dump Bedrock Outcrop (South of KM 6.0 on Diane River Road)**

A prominent bedrock outcrop can be accessed adjacent to the newly constructed landfill site south of the Diane Quarry pit, as shown in Figure 7-5. The prominent outcrop is approximately 150 m in length and 8 m in height as shown in Figure 7-6. Dimensions and geographic coordinates for the outcrop are given in Appendix B and additional photos are presented in Appendix C.

The outcrop could be quarried for approximately 75 m to the west before dropping off down to the lower terrain to the west. This outcrop could produce roughly 140,000 m^3 of crushable aggregate (based on a bulking factor of roughly 50-60%).

Figure 7-5: looking north from the top of the new dump outcrop towards Diane Pit.

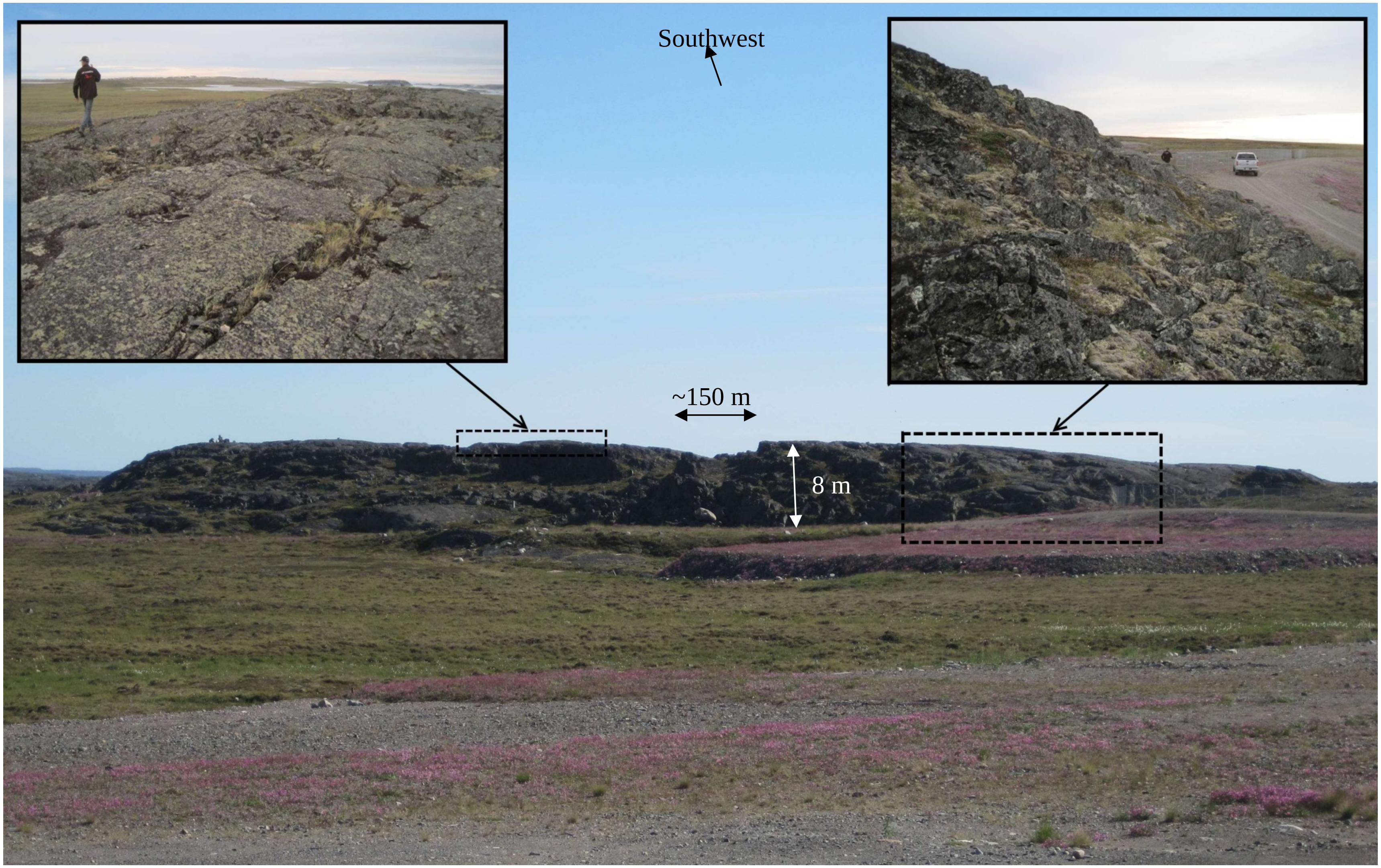


Figure 7-6: the prominent bedrock outcrop adjacent to the new dump site is ~150 m long by 8 m high (Photo: July, 2016)

The bedrock here is similar to the upper Diane Pit bedrock outcrop, and consists of the same dense igneous rock that has been weathered and fractured at the surface but would be massive and intact below the annual freeze-thaw layer.

The advantages of this site include its proximity to the hamlet and already established road access, and its location in an already developed, environmentally compromised area. It also presents an excellent long and high vertical face for initiating the quarry. The downside is that it may conflict with future landfill operations.

- **Bedrock Outcrop at KM 13.0 on Diane River Road**

This outcrop is immediately adjacent to the Diane River Road as the road bends sharply around the outcrop at KM 13.0. Numerous pockets of gravel have been excavated from the base of the outcrop for road construction. The outcrop rises gently above the surrounding terrain and does not present a high vertical face from the road. The most abrupt face is shown in Figure 7-7 and would be the most suitable location to initiate the quarry. The outcrop also extends below the road and towards the lake just west of the site. If the main road is re-routed close to the lake, this portion of the outcrop could also be quarried after the higher portion of the outcrop had been removed although a sufficient setback from the lake should be established. Adequate drainage and sedimentation barriers and a sedimentation pond will be required to prevent sedimentation and contamination of the lake downhill to the west.

The bedrock here is the same composition as that at the Diane Pit and new dump outcrosp and consists of massive, resistant igneous rock with thick quartz seams.

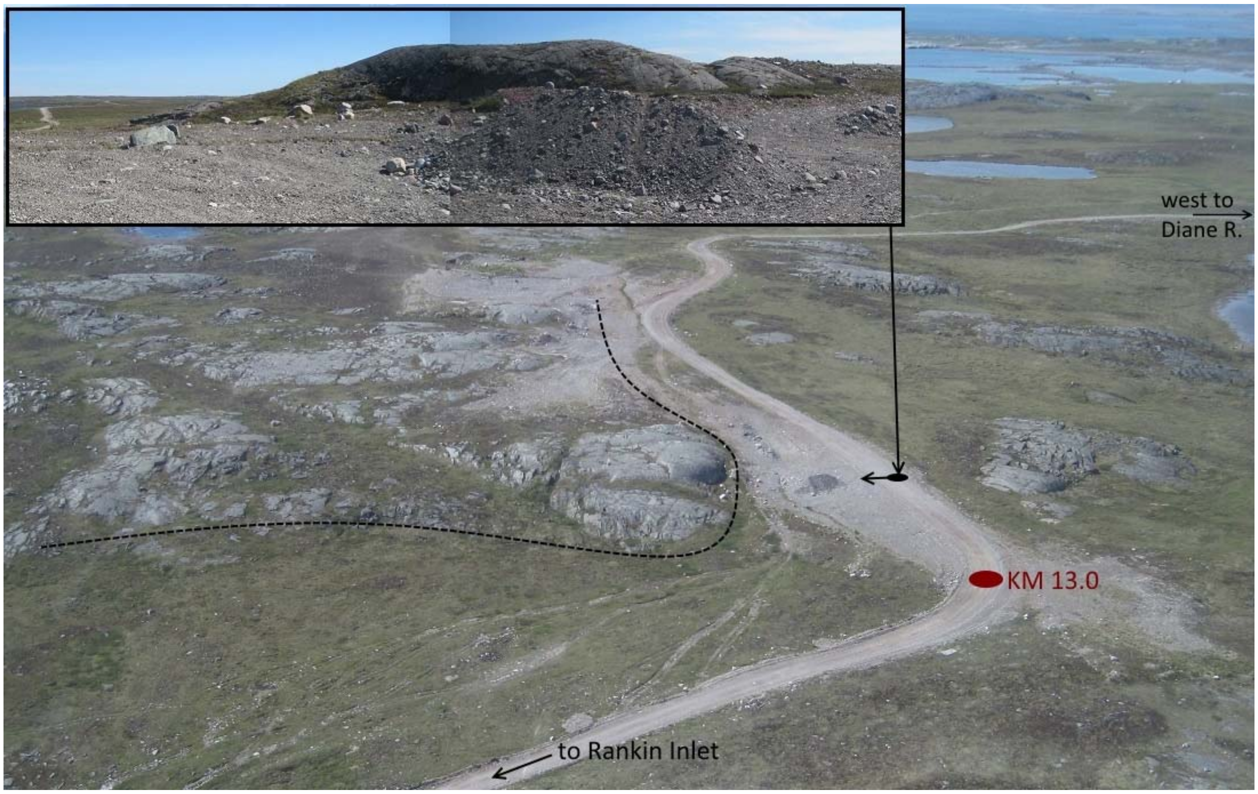


Figure 7-7: Bedrock outcrop at KM 13 on the Diane River Road (Photos: July, 2016).

The total outcrop area above the road is roughly 150 m long by 100 m wide, and is roughly 4 m high above the road. This outcrop could produce roughly 90,000 m^3 of crushable aggregate initially (based on a bulking factor of roughly 50-60%) with much great volumes available if the quarry floor is stepped down into the massive outcrop.

Positive aspects of this site include its orientation away from the Hamlet at a distance that would make operation inaudible to Hamlet residents. It is also a very well-drained, elevated site. The downsides include a relatively low, small face to initiate the quarry, and the fact that the main road would need to be diverted away from the quarry face to provide sufficient space and safety for the quarry operation and passing vehicles.

8 ROCK CHARACTERISTICS

8.1 Bedrock Characteristics

In general, the exposed bedrock at the investigated outcrops in Rankin Inlet is dark, fine to medium-grained igneous rock. Figure 8-1 shows a close-up photo of typical rock fragments obtained from the evaluated outcrops in Rankin Inlet. No sedimentary bedrock outcrops were evaluated in the field.

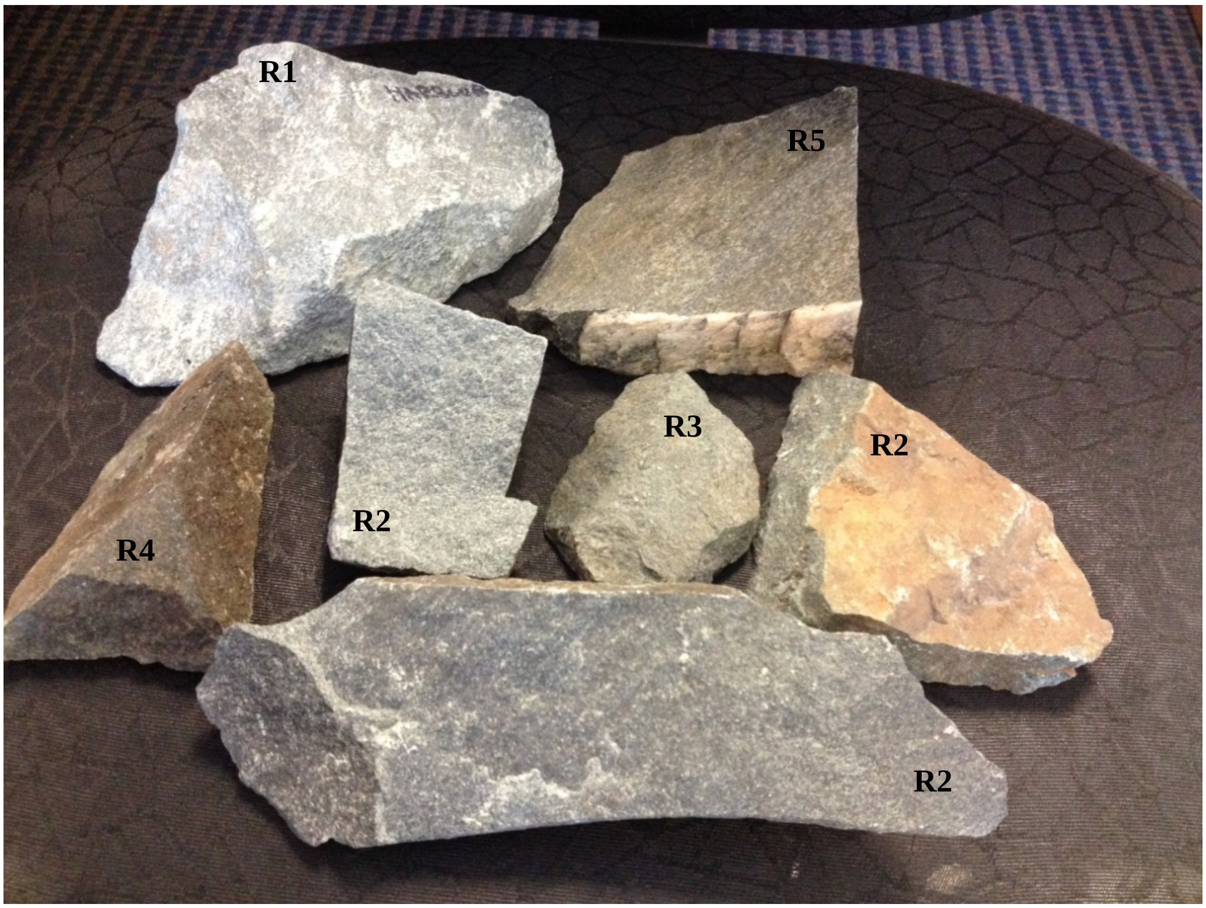


Figure 8-1: Bedrock samples from Rankin Inlet showing fine to medium grained, hard igneous rocks with sharp edges and conchoidal fracture faces.

The rock is composed mostly of mafic minerals such as pyroxene and plagioclase, forming a hard dense rock, with high specific gravity. The rock at the tall harbour quarry (R1) appears to have undergone high-grade metamorphism which differentiates it from the other tested outcrops and has an even higher specific gravity. Samples R2 and R4 show oxidization caused by weathering over repetitive freeze-thaw cycles that slowly fracture the surface rock.

Specific Gravity and Absorption Tests carried out on rock samples retrieved from each of the evaluated outcrops are shown in Table 8-1.

Table 8-1: Results of Laboratory Testing on a Bedrock Sample from Harbour Quarry

BEDROCK TEST NO.	OUTCROP SOURCE	SPECIFIC GRAVITY	ABSORPTION (%)
R1	Harbour Quarry	2.99	0.19
R2	Diane Quarry Top of Outcrop	3.04	0.31
R3	Diane Quarry Foot of Outcrop	2.92	0.65
R4	New Dump Outcrop	2.98	0.26
R5	KM 13 Outcrop	3.00	0.21

Absorption results below 1.0% by weight are considered to be low and usually denote a rock formation resistant to degradation under freeze-thaw conditions. Typical absorption limits for various applications, including road surfacing or concrete aggregate, range from about 1 to 3%.

The hard, resistant characteristics of the bedrock will make crushed aggregate from these sources durable on roadways and airstrips although a substantial amount of fine-grained blending material will be required to mix with the crushed gravel to produce suitable select-grade gravel that will meet compaction and durability requirements. Fine grained blending material is readily available from the floor and surrounding areas of the current Diane Pit.

8.2 Gravel Coarse Fraction Characteristics

The coarse gravel fraction at the KM 8.0 beach deposit consisted entirely of hard, rounded to sub-angular igneous rock as shown in Figure 8-2 below, and the tested samples from the deposit all had less than 1% fine-grained silts, indicating that this material was transported long distances by rivers and/or worked continually by the waves that formed the beach.

Figure 8-2: Coarse gravel fraction (retained on 10 mm sieve) from test pit S2 at KM 8.0 deposit, demonstrating sub-angular to rounded particles of hard, resistant rock that have been transported long distances and/or continually exposed to years of wave action.

Comparatively, the coarse fraction in the deposits further west on the Diane River Road at KM 16.0, 18.0 and 18.5 – 21.0 is more sub-angular to angular and also contains roughly 10 to 40% lightly to moderately metamorphosed sedimentary shale rock or slate (Figure 8-3). The tested pit-run gravel samples from these deposits also contained a higher fraction of fine-grained silts and clay (~2 – 9%). Both characteristics indicate that this material spent less time being transported or impacted by water and were likely deposited as glacial outwash features that were then only moderately shaped by wave action of the post-glacial seas.

Figure 8-3: Coarse gravel fraction (retained on 10 mm sieve) from test pit S1 at KM 18.0 deposit, demonstrating angular to sub-angular particles of hard, resistant rock mixed with roughly 20% flat, elongated shale and/or slate.

Micro-Deval testing of a sample from the Journeaux-5 deposit between KM 18.5 – 21.0 indicated 13.7% loss. The test simulates particle abrasion and impact and provides a measure of how much mass is lost in the process. A threshold of 18% loss is commonly used to separate durable, abrasion-resistant aggregate (< 18% loss) from weaker, unsuitable aggregate (>18% loss) for general construction use. The low value suggests that these glaciated materials are of suitable quality for roadway and other construction use.

9 ENVIRONMENTAL AND REGULATORY REQUIREMENTS

The environmental impacts of developing granular borrow sources and/or quarry sites to produce aggregates must be considered prior to selecting sites for development. Development and operation of such sites would consist of the following activities that could potentially impact the local environment:

- Construction of access roads
- Transportation, storage and use of diesel fuel
- Stripping and stockpiling overburden soils
- Excavation and removal of in-situ granular material
- Drilling and blasting of bedrock outcrops
- Crushing and sieving to produce specific gradations
- Stockpiling pit-run and select-grade gravels, and oversize boulders
- Washing out of fines from the crushing operation
- Hauling materials between sources, stockpile sites and project sites in the hamlet.

The above activities have the potential to detrimentally impact:

- sensitive tundra vegetation and permafrost
- wetlands, streams and water bodies (fish habitat and drinking sources)
- wildlife habitat, including migratory bird nesting areas
- human health and safety
- natural aesthetics.

A number of regulatory authorities and legislative acts ensure quarry and borrow source development adhere to environmental regulations as well as other administrative regulations.

The environmental impacts, other sensitive land-use issues and regulatory requirements are discussed in the sections below.

9.1 Environmental Impacts

The following sections discuss some of the primary environmental impacts and general mitigative measures associated with development and operation of access roads, borrow sources and quarries. Active or abandoned borrow sources that can be expanded will generally have less impact than development of new borrow source areas which will need new access roads and disrupt previously undisturbed tundra. Single large deposits are favoured over numerous shallow deposits which lead to widespread scarring of the landscape when exploited. Access roads should be routed to avoid sensitive areas, particularly wetlands, and to minimize watercourse crossings. In general, quarry sites reduce the environmental impact by concentrating operation in a smaller area and well away from significant water bodies. These and other factors are discussed below.

- **Habitat Disturbance**

Fish and wildlife habitat are of primary concern when considering developmental impacts on the environment. The existing borrow pits and evaluated quarry sites are all within close proximity to the hamlet and near developed areas, and expanded development would not likely constitute a further risk to wildlife habitat. Quarry blasting could be considered a significant disturbance to migratory bird nesting sites. With the exception of the outcrop at KM 13 on the Diane River Road, the site selections are already in developed and congested areas and significant disturbance is not expected. Numerous sand cranes and other water fowl were observed in the low-lying lakes and wetland area downhill to the west of the KM 13 outcrop, and may require further assessment for nesting and migratory patterns prior to development.

New borrow sources identified beyond km 9 on the Diane River Road and the two large deposits east of the Meliadine River will have the most impact on the environment and will disturb areas of tundra habitat because of increased traffic and construction noise. The deposits on the Diane River Road do have human-traffic precedence as the road already passes through each one and the deposits at KM 8.0 and KM 16.0 have established cabins on site. However, numerous siksik dens were noted at several of the deposits, and some caribou and bear tracks were noted at the large deposit around KM 20. A species-at-risk review may be required prior to development of new deposits, particularly at KM 18 and KM 18.5 – 21.0.

- **Sensitive Vegetation and Permafrost Degradation**

Stripping of new borrow source areas should be limited to the approved development areas and the stripped organics should be stockpiled for use in future site reclamation. Vehicles should adhere to established routes to avoid unnecessary vegetation disturbance. Excavation and extraction of the thawed aggregate during summer will proceed to degrade the underlying permafrost. This will have a further impact on sites apart from providing additional volumes of useful materials after thawing of the frozen overburden. Precautions should be taken to ensure the excavated areas remain positively graded and well drained to prevent ponding of warm rain-water. Although significant ground ice is not expected at the investigated sites, it should be avoided if encountered. The exception may be the northern of the two deposits at KM 15+1.0 and the deposit area at KM 19 where possible small thermokarst lakes may have massive ground ice beneath them. Test pits in the dried out portion of the lake beds around KM 19 revealed sand and gravel beneath the lake bed, so any presence of massive ground ice would need to be confirmed with exploratory boreholes before pit development encroached on the small lakes.

If borrow pits are developed at the deposits to the west on the Diane River Road, increased construction and regular vehicular traffic on the upgraded, widened road could potentially increase the active layer depth, although the road upgraded road would have an increased subbase fill thickness (~1 metre) which will more than compensate for the increased thaw penetration.

- **Wetlands and Water Bodies**

None of the evaluated borrow-pits or quarry sites lie within large wetlands or in close proximity to significant watercourses or lakes. As described previously, the only exception are small, shallow ponds and/or thermokarst lakes around KM 19, and at the crests of the deposits at KM 15+1.0 and to a lesser extent at KM 16. The demarcated boundaries of the deposit at KM 16 have been set to maintain a 100 m setback from the two medium-size lakes nearby.

The existing Diane River Road follows elevated, dry terrain for the majority of the route with the exception of three locations where the road traverses low wet areas with small creeks for which three individual culverts have been installed. These are located at approximately km 9.2, km 11.6 and km 16.7 along the Diane River Road. Should the deposit at KM 15.0+1.0 be developed, a single culvert would be required on the access road to the deposit.

- **Erosion and Sedimentation**

Sediment laden run-off from quarries or borrow pits entering local water bodies is the most likely source of (fish) habitat disruption. This can be mitigated by providing sedimentation and surface run-off control measures such as gently sloped drainage, sedimentation barriers and sedimentation ponds or by pushing up stripped surface soils into small ridges to direct drainage and prevent sedimentation of the surrounding undisturbed tundra.

- **Noise and Vibration**

One of the investigated quarry sites – the existing harbour quarry – is within 500 m of a residential area where blasting and the breaking of large boulders using heavy machinery would be significant noise and vibration generators noticeable in the hamlet. The other investigated quarry sites are at least 4 km from the hamlet and are all within or adjacent to existing developed areas and would not likely cause further impact to wildlife habitat. Operation of the harbour quarry would be most audible to members of the hamlet, while the quarry sites at the new dump or the Diane Quarry pit would be situated at a suitable distance to limit noise pollution. Blasting at these sites would most likely not be audible in the higher summer temperatures and vibrations would not be noted in the hamlet, particularly if delay blasting with small explosive charges is used and the direction of the blast oriented to minimize vibrations being directed towards the hamlet. Blasting would be an infrequent occurrence during the summer period. Appropriate warnings would be posted to warn local residents of scheduled blasting times and traffic control would also be installed on all roads.

- **Dust Pollution**

Dust generation from borrow pits and quarries can have negative impacts on the surrounding environment. Gravel roads can be very dusty in the dry summer periods, and can be a source of significant dust pollution when traveled frequently and at high speed. Dust suppression such as watering or spreading other dust suppressant liquid or solid agents may be effective in preventing dust generation during periods of high use (haulage). Freezing temperature reduce dust pollution during winter months.

- **Fuel and Explosive Handling**

Fuel handling must follow strict regulations. Fuel left on site must only be stored in secure reservoirs placed in designated areas that meet regulatory requirements. Fuel trucks bringing fuel to the sites should have automatic shut-off valves to avoid overfilling vehicles, machinery and construction equipment. All blasting material must be stored in appropriate tamperproof shelters situated well away from the blasting sites and must only be used by licenses explosive and blasting personnel.

9.2 Archeological, Historical and Traditional Land Use Areas

Consultation with members of hamlet and the GN indicated that none of the proposed borrow-pits or quarry sites conflict with known archaeological or historically significant sites. The hamlet would be further consulted prior to selecting specific sites for development in order to identify and avoid any sensitive areas. Sites need to ultimately be approved by the Hamlet Council to ensure they do not adversely impact traditional land use areas or archaeological sites. The GN Department of Culture and Heritage may be required to review land use proposals to identify potential impacts to cultural and heritage sites, although no concerns are expected. No carving stone deposits were identified during the field study.

9.3 Regulatory Authorities

A number of regulatory authorities govern borrow pit and quarry development in Nunavut in order to ensure compliance with applicable acts, regulations and guidelines, including:

- Territorial Lands Act and Territorial Quarrying Regulations
- Commissioner's Land Act and Hamlet Act
- Nunavut Land Claims Agreement Act
- Nunavut Planning and Project Assessment Act
- Canadian Environmental Protection Act and Environmental Assessment Act
- Nunavut Waters and Nunavut Surface Rights Tribunal Act
    - Nunavut Water Regulations (SOR/2013-69) is a regulation under the above act.

The primary regulatory authorities are:

- the Department of Community and Government Services (DCGS), which manages and administers Commissioner's Lands on behalf of the Government of Nunavut;
- Aboriginal Affairs and Northern Development Canada (AANDC), which manages and administers Crown Land on behalf of the Federal Government.
- The Nunavut Planning Commission (NPC), which works with these government bodies to establish sustainable land use plans for the Territory.

Quarry or borrow source development near Rankin Inlet will require Quarry Permits and Land Use Permits from one or more of the above agencies. It should be noted that the term 'Quarry' refers to both drilled/blasted/crushed bedrock sources and natural occurring deposits of either granular or till-like materials developed as borrow-pits in the regulations listed and in the context of obtaining permits.

All public, un-surveyed lands within the Rankin Inlet Municipal Boundary that are not federal lands, water bodies, Inuit owned lands or privately owned lands are known as Commissioner's Lands and are administrated by the Government of Nunavut DCGS for the use and benefit of the municipality. Quarry development within hamlet municipal boundaries must be conducted in accordance with the Commissioner's Land Act and requires a quarry permit or lease from the DCGS, and may require approval from the NPC.

In Rankin Inlet, the Hamlet has established a Quarry Administration Agreement with the DCGS which allows them to assume administration control over quarries within the municipal boundaries and collect fees for quarried material as per the Commissioner's Land Act Regulations. Contractors who wish to extract material from quarries within municipal boundaries must apply to the hamlet for a quarry permit.

All the evaluated drill/blast/crush quarry sites and the borrow source deposits west of the hamlet on the Diane River Road are situated within the Hamlet Municipal Boundary (Refer to Figure 6-2 on page 38). The investigated sites *outside* the municipal boundary are the two large deposits east of the Meliadine River accessible from the Agnico-Eagle mine road (see Figure 6-2 on page 38). Development of these sites would require application for a quarry permit or lease from Aboriginal Affairs and Northern Development Canada (AANDC) under the Territorial Quarrying Regulations of the Territorial Lands Act

Other regulatory authorities that have jurisdiction over proposed quarry or borrow source sites include the:

- Nunavut Impact Review Board (NIRB), which reviews potential developmental impacts to the residents and communities of Nunavut and the environment.
- Nunavut Water Board (NWB), which regulates water usage and waste deposition in terms of water quantity and quality.
- GN Department of Environment which has legislative authority under the Canadian Environmental Protection Act and Canadian Environmental Assessment Act (CEAA)

Any proposed borrow source or quarry is subject to environmental approval and must be screened and approved by the Nunavut Impact Review Board (NIRB). An application to the NIRB requires site specific details, expected environmental impacts, and proposed mitigation measures. A simple screening or thorough impact assessment may be required depending on the scope and scale of the project. Additional environmental assessments may be required under the Nunavut Planning and Project Assessment Act and/or Canadian Environmental Assessment Act (CEAA), although not expected for the evaluated sites.

A water use application to the Nunavut Water Board (NWB) is required where road construction crosses watercourses (Nunavut Water Regulations, SOR/2013-69). Depending on the size and intermittency of the watercourse, use may be granted without a license or may require a Type B license. The use of water for producing washed gravel or dust suppression on roadways, if necessary, would also require application to the NWB and may require licensing depending on daily volume of water required. Deposit of wastewater associated with quarrying and gravel washing may be approved by the NWB without a license if waste is not deposited directly to surface water or within 31 m (100 ft.) of the ordinary high water mark of any water body. Application to the NWB requires specific details about the proposed water use or waste deposition, and may require a technical and public review as part of the licensing process. It is recommended that the NWB be consulted prior to developing or constructing road access to any borrow source or quarry site.

Consideration was given to known environmentally or historically sensitive areas during the desktop study and field evaluation of potential borrow sources and quarry sites and no significant concerns were noted regarding any of the evaluated sites. Discussion with hamlet personnel did not raise any environmental or land use concerns specific to the sites. At this time, all sites are considered able to meet compliance feasibility as described in the RFP. However, strictly from an environmental and regulatory compliance standpoint, continued or expanded development of existing, already environmentally compromised areas in proximity to the hamlet along the existing road, are favoured over new borrow sources requiring new access roads through undisturbed land.

10 AGGREGATE RESOURCE DEVELOPMENT ANALYSIS

At present, the majority of common pit-run material and select-grade aggregate used in Rankin Inlet construction projects is being acquired from the Diane Pit, with sandy materials sourced from the Meliadine Pit. Local contractors are well equipped and experienced in extracting and processing these materials using their own crushers, screeners, excavators, loaders and dump trucks. The Hamlet itself has a screener, loader and multiple dump trucks to excavate and haul limited aggregate quantities as necessary for specific small projects. As discussed previously, the Hamlet has an established Quarry Administrative Agreement that enables them to manage the borrow sources and charge nominal fees to the contractors for gravel extraction. This arrangement seems to be working effectively in Rankin Inlet, which is a rapidly growing community with continuous large-quantity aggregate needs.

Based on Table A-1 in Appendix A, the total approximate volumes of select-grade crushed gravel and pit-run material needed for the next 20 years are about 75,000 m^3 of 0-20 mm crushed material and 565,000 m^3 of common pit-run, totalling 640,000 m^3 of total aggregate.

In order to meet these aggregate needs to year 20 and beyond, new sources of additional aggregate – particularly coarse gravel – will be needed. Ideally, these sources would be on existing road networks (requiring upgrading), within municipal boundaries and operational with existing expertise and equipment in the hamlet. Table 10-1 on the following page summarizes all the existing and prospective sources identified and evaluated by JOURNEAUX ASSOC. in this study.

Table 10-1: Summary of Evaluated Borrow Sources and Quarry Sites near Rankin Inlet

SOURCE	HAMLET DISTANCE	ESTIMATED VOLUME	MATERIAL TYPE & DETAILS
Diane Pit	6.5 km	126,000 m^3	Active pit with remaining material in recently opened area of gravel and sand north of road (WSP Site 'A') and excellent gravel around and beneath small lake
Meliadine Pit	7.5 km	170,000 m^3	Active sand pit with significant remaining sandy material in ridge to the south (WSP Site 'D') suitable for sand fill and general subbase fill applications.
Agnico-Eagle Pit	17.0 km	50,000 m^3	Active existing pit on Meliadine Mine Road used for road maintenance. Estimated volume in stockpiles and ground.
Journeaux-3 (Diane RR)	8.0 km	70,000 m^3	Raised beach with coarse gravel/cobble at ridgetop transitioning to clean sand at lower elevation. No shale. Mixing/crushing req'd. Cabins and grave site nearby.
Journeaux-4 (Diane RR)	16.0 km & 15.0+1.0 km	150,000 m^3 + 150,000m^3	Two deposits, one on the road and one accessible with 1.0km new road. Excellent source of coarse cobble & gravel (20-40% shale/slate), sand and binder material, with potential small thermokarst lakes on northern deposit.
KM 18 (Diane RR)	18.0 km	140,000 m^3	High, dry ridge with excellent gravel and sand suitable for crushing and/or screening. 10-20% shale/slate component
Journeaux-5 (Diane RR)	18.5 – 21.0 km	800,000 m^3	Complex deposit with some thermokarst lakes and variable material of which ~200,000 m^3 is expected to be coarse cobble and gravel (10-20% shale/slate) near ridgetop.
Journeaux-1 (Meliadine Mine Road)	10.5+2.5 km	800,000 m^3	Extensive area east of the Meliadine River (outside municipal boundary) accessible by 2.5km new road. Coarse beaches against bedrock outcrops and large gravel/sand area surrounding small lake.
Journeaux-2 (Meliadine Mine Road)	15.0 km	1,200,000 m^3	Massive area east of the Meliadine River (outside municipal boundary) roughly 3 square km in size. Investigated by helicopter only. Poorly drained. Volume roughly estimated.
Harbour Quarry	-	450,000 m^3	Existing quarry at harbour.
Diane Quarry Outcrop	6.5 km	110,000 m^3	Moderate-sized outcrop in existing pit
New Dump Outcrop	7.5 km	140,000 m^3	Long, high outcrop next to new landfill site
KM 13.0 Outcrop	13.0 km	90,000 m^3+	Broad outcrop traversed by Diane River Rd at KM 13

The existing stockpiles and remaining aggregate material in both the Diane Pit and Meliadine Pit, including their adjacent sites identified as WSP Sites ‘A’ and ‘D’, respectively, hold sufficient sand and gravel to meet roughly 30 to 40% of the total 20-year requirement. Much of this available material, including the estimated 170,000 m^3 remaining south the Meliadine Pit in WSP Site D, is predominantly sandy and will be particularly useful for projects such as baseball fields, cemetery expansion, landfill cover and general fill. However, large volumes of coarser aggregate will be required for building fills and road subbase material, and to be crushed or screened to produce select-grade gravel for road surfacing, airstrip resurfacing, parking-lot surfacing, concrete and asphalt mixes and other specialized needs. A new source of coarse aggregate will likely need to be developed in the short to medium term as the Diane Pit and WSP Site A near depletion.

As described throughout the previous report sections, numerous other factors, beyond aggregate quantity and quality, influence the ultimate decision on which source(s) should be developed.

A feasibility analysis was conducted considering select new borrow source sites and potential quarry sites in order to recommend the most sustainable method for acquiring aggregate to meet short to long-term needs to 20 years. This was done using a set of ranking criteria in addition to sheer volume of material available to determine the most suitable, economical and environmentally and socially compliant sites. The ranking criteria are grouped in three primary categories: Operational Feasibility, Compliance Feasibility and Economic Feasibility. All the criteria were applied in the evaluation of each prospective new aggregate source.

OPERATIONAL FEASIBILITY

- Site provides aggregate suitable for all types of projects
- Site offers a long-term sustainable method to meet 20-year needs
- Site can be operated under existing Quarry Administration Agreement
- Site operation does not exceed community capacity (skilled labour, fuel supply)
- Site maximizes use of construction season
- Site allows on-demand production (to meet changing or unexpected needs)

COMPLIANCE FEASIBILITY

- Site minimizes environmental impact
- Site accommodates community concerns
- Site minimizes visual and audible impact on community
- Site avoids impact on archaeological or historical sites

ECONOMIC FEASIBILITY

- Site minimizes cost of addressing aggregate requirements
- Site minimizes mobilization/haul distance (proximity to Hamlet)
- Site minimized road construction costs

In the two sections below, prospective new borrow source sites and quarry sites are discussed and qualitatively ranked in each category according to the applicable ranking criteria listed.

Class D (unit rate) cost estimates are used to evaluate site development and operation, and any necessary road construction and maintenance to provide access to the site. Per-cubic-meter costs presented for equipment include operator and fuel costs and account for capital costs and maintenance costs over an approximate 20-year life cycle. A Road Development Plan for upgrading the Diane River Road to KM 20 is presented in Section 10.3.

Basic costs to load and haul common pit-run gravel from existing pits within ~8 km of the hamlet (Diane Pit/WSP Site A and Meliadine Pit/WSP Site D) is estimated at $45/m^3$. This accounts for equipment costs (excavator/loader and truck), labour costs, fuel costs and quarry fees. Basic screening to supplement 0-20 mm aggregate needs would add an approximate $20/m^3$ and crushing is estimated to add $20/m^3$. According to the local contractor, the crushing and basic screening of material for road maintenance and building pad surfacing, etc., is not designed to meet particular specifications and would not meet rigorous quality control testing. Contracts that require rigorous quality and gradation control to meet certain specifications are at a premium of approximately $100/m^3$. Table 10-2 summarizes these costs.

Table 10-2: Estimated costs associated with supplying aggregate from present borrow pits.

AGGREGATE TYPE	UNIT COST
Basic Excavate, Load & Haul (within 8 km)	$45/m^3$
Excavate + Load & Haul + Screen	$65/m^3$
Excavate + Load & Haul + Crush/Screen	$85/m3
Crushed, blended, screened & tested to meet specifications for asphalt/concrete/MG20	$100/m^3$

10.1 Future Aggregate Acquisition: Develop New Aggregate Borrow Sources

Development of a new source of coarse aggregate consisting of sufficient cobble, gravel and sand for a crushing operation will be required in the short to medium-term to produce select-grade crushed gravel in addition to bulk coarse pit-run for strong, compact building and road fills. The Hamlet has voiced a clear preference for new sources within municipal boundaries, which generally restricts development to the identified deposits west of the community as previously described in Section 6.3. These sites include the deposits at KM 8 (Journeaux-3), KM 16

(Journeaux-4), KM 18, and KM 18.5 – 21 (Journeaux-5) on the Diane River Road. To evaluate which site(s) would be most suitable for development, these four sites were ranked according to available aggregate volume, and the criteria list above, as shown in Table 10-3. The northern site at KM 15.0+1.0 should be further evaluated prior to constructing a road to access it.

Table 10-3: Ranking of prospective aggregate borrow sources on the Diane River Road.

CATEGORY	KM 8.0	KM 16.0	KM 18.0	KM 18.5-21.0
Available Aggregate	70,000	150,000	140,000	800,000
Aggregate Type/Quality	Beach deposit of durable, rounded gravel and cobble transitioning to sand downhill. No shale and <1% fines	Glacial deposit of relatively well-graded coarse gravel. Largest shale fraction but also 2-16% fines	Glacial outwash deposit of gravel and sand. Some shale in coarse fraction. 8% fines.	Glacial outwash reworked by waves. Complex & variable with some shale in coarse fraction
Operational Feasibility	Not sustainable to 20yrs. Materials are segregated. Sloping terrain. Occupied with cabin and grave site.	Meets all aggregate type requirements. Large volumes. Well-drained. On existing road.	Coarse gravel and sand. Sustainable in short-medium term. Well-drained. Requires relocating road.	Huge volumes sustainable through 20yrs. Complex layout, requires careful planning
Compliance Feasibility	Occupied, including grave site. Requires erosion control. No wildlife noted.	Occupied by small cabin, possible small thermokarst pond, siksik habitat.	No environmental or community concerns. No wildlife noted.	Complex site, potential thermokarst lakes, caribou and bear tracks
Economic Feasibility	Closest to hamlet, no road required. Need to relocate occupants and maybe grave site	Requires upgrading Diane River Rd. to KM 16.0	Requires upgrading Diane River Rd. to KM 18.0	Requires upgrading Diane River Rd. to KM 21.0
Rank:	**#3**	**#1**	**#2**	**#2**

Operationally, the deposits at KM 16 and KM 18.0 – 21.0 offer the most accessible sources with large volumes to be sustainable through the long-term to beyond year 20. They also contain all required aggregate types; particularly coarse gravel and small cobble, as well as adjacent binder material for mixing. The sites are all generally well drained, although the large deposit beyond KM 18.5 will require working around some small lakes at ridgetop.

In terms of compliance feasibility, the deposits at KM 8 and KM 18 have the least environmental impact while those at KM 18 and 18.5-21 are unoccupied and far from the hamlet, thus having the least impact on community members. The deposit at KM 8 would generate the most resistance from community members who use the site, particularly considering a grave is present at the site.

The economic feasibility of each site is ranked in order of closest proximity to the hamlet, as each subsequent deposit would require upgrades of additional length of the Diane River Road to develop them. All sites are equally developable by the hamlet and local contractors and therefore will all benefit the local economy.

Ultimately, it is recommended that if future borrow sources are selected for development instead of bedrock quarry sites, than the deposits at KM 16, 18, and up to 21 should be developed in that order, with road upgrades conducted as necessary to facilitate more efficient hauling between the source and the hamlet. The deposit at KM 15.0+1.0 should be further investigated prior to development, preferably with boreholes, to determine the presence of ground ice that may be contributing to the formation of thermokarst lakes at the crest of the deposit.

10.2 Future Aggregate Acquisition: Local Quarry Operation

Depending on costs and other feasibility ranking, resorting to an operation involving drilling/blasting/crushing of bedrock to meet aggregate needs is an alternative to developing distant new natural borrow sources. Quarry evaluations have been based on producing primarily 0-20 mm crushed aggregate and 0-100 crushed aggregate (comparable to pit-run).

The massive, resistant igneous bedrock at each site is suitable for quarrying and it is considered that all blasted bedrock volumes would return about 50-60% more volume due to the swelling factor. As an example, producing 15,000 m^3 of blast rock for crushing and screening would require approximately 10,000 m^3 of solid bedrock.

To evaluate which quarry site would be most suitable for development, the outcrops described in detail in Section 7.0 were ranked according to minimum quarriable volumes and the operational, compliance and economic feasibility criteria listed earlier, as shown in Table 10-4.

Table 10-4: Ranking of potential quarry sites near the Hamlet

RANK CATEGORY	HARBOUR QUARRY	DIANE PIT OUTCROP	NEW DUMP OUTCROP	KM 13.0 OUTCROP
Available Rock Volume	450,000 m^3	110,000 m^3	140,000 m^3	90,000 m^3 +
Operational Feasibility	In town – noise, dust, traffic etc.	Limited volume	May conflict with landfill operation	Too distant at km 13.0
Compliance Feasibility	Existing quarry near harbour. Currently unsafe	Already active borrow pit	New activities in environmentally impacted zone	On existing road, far from hamlet
Economic Feasibility	Close to hamlet Dust and noise control measures	Best – already established pit/quarry site	Needs new access road next to dump	Increased haul costs
Overall Rank:	**#2**	**#1**	**#2**	**#4**

The bedrock outcrop in the existing Diane Pit ranks highest for developing a quarry because of its strategic location within an already active borrow pit where crushing and screening and other equipment is already staged, but also because it is an already environmentally impacted area. It is also in close proximity to the hamlet which reduces transport costs and winter/spring snow removal costs compared to more distant sites. The only downside is the limited size of the relatively low outcrop, although it could easily produce all the select-grade crushed aggregated needs if other borrow sources were developed for pit run and screening only.

The tall, well-established face of the New Dump outcrop also presents a favourable quarry location with large volumes of blast rock to be produced. Depending on when the new dump is activated, road access would need to be added or improved to accommodate the operation of both the quarry and the landfill.

The Harbour Quarry presents the largest attainable volume, but would require scaling and other safety improvements prior to reuse. It also has the lowest compliance ranking due to its location within the hamlet. It is understood that this quarry may be used for future production of aggregate on a contract basis for upgrades to the Itivia staging area at the harbour and a hamlet bypass road to provide direct access towards the Meliadine Mine Road.

10.3 Diane River Road Upgrade Plan

The existing Diane River Road from the Diane Pit turnoff out to KM 20 is a typical penetration road built from a combination of material excavated from drainage ditches alongside the road and some imported fill, topped with a thin sand and gravel running course where required. It is roughly 3-4 m wide with a low profile that follows the natural ground (Figure 10-1). The route follows dry, elevated terrain for the majority, with only four noted sections of lower wetland crossings. These occur between KM 9 – 10 and KM 11.0 – 12.5, at KM 16.5 and at KM 18.3. Small-diameter culverts (24-36”) were noted within these wetland sections at KM 9.2, KM 11.5 and 12.5 and KM 16.7 (see Figure 10-1).

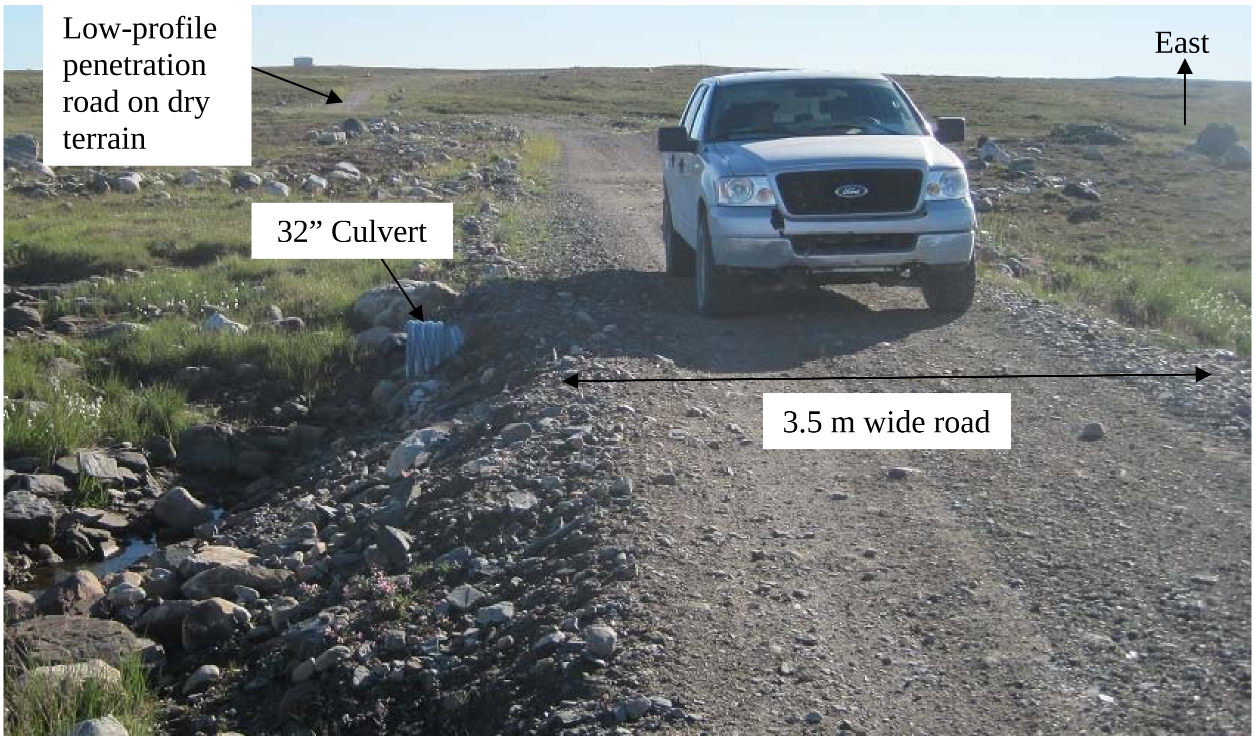


Figure 10-1: The 3-4 m wide, low profile Diane River Road, looking east from the culvert crossing at KM 16.7 towards the cabin on the deposit at KM 16.0 (Photo: July, 2016).

In order to develop the borrow sources between KM 16 and KM 21 on the Diane River Road, upgrades to the road will be required to facilitate two-way traffic and dump trucks to travel at moderate speed. Upgrades will require widening the road to approximately 8 m with excavated ditch material and imported pit-run fill followed by placing a 75 mm thick running course of select-grade sandy gravel (minus 3/4”) at the surface. Enlarging the radii of curves in the roadway would also allow higher haul speeds, particularly at KM 13.0 (Figure 10-2).

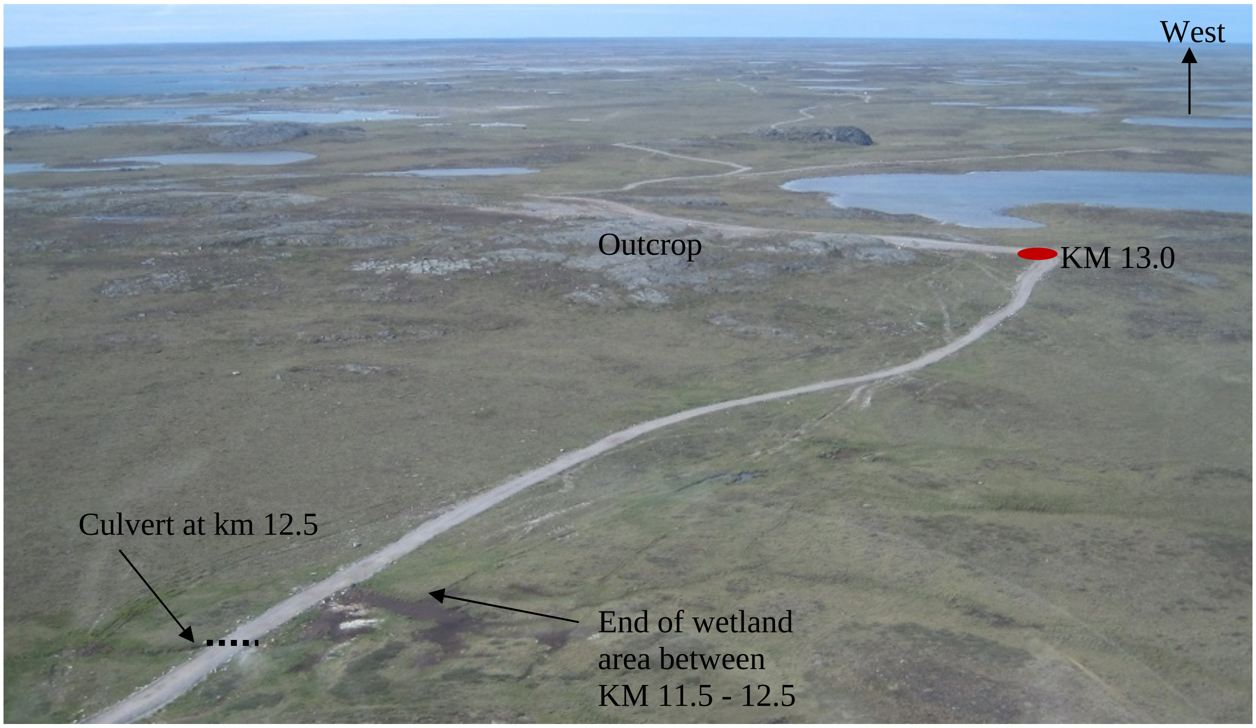


Figure 10-2: The present 3-4 m wide Diane River Road, looking west near KM 13.0. The sharp turns around the prominent outcrop slow traffic speeds (Photo: July, 2016).

Roads engineered to accommodate low volumes of higher-speed, two-way traffic can be upwards of \$80 per m^3 (\$600,000 per km) based on previous estimates in the north. Estimated costs for upgrading 15 km of the Diane River Road between KM 5 and KM 20 are presented in Table 10.5 below assuming common pit-run materials will be a combination of side ditch material recovered by the excavator and other material hauled from nearby sources. Roughly 11.5 km of the route is on smooth, dry terrain and would require only 0.3 to 0.5 m of pit-run subbase fill, while the remaining 3.5 km through hummocky, wet terrain would require up to 2.0 m of fill. Accounting for shoulder slopes, an average fill thickness of 1.0 m over a 5 m expanded road width was used to estimate pit-run fill volumes needed to upgrade the road. An 8 m wide, 75 mm thick running surface of screened minus 20 mm gravel was used in road upgrade calculations. Crushed gravel for a running surface, if used, will need to be hauled from a crushed stockpile at the present Diane Pit.

Table 10-5: Economic feasibility of upgrading Diane River Road to KM 20.0

DIANE RIVER ROAD UPGRADES	QUANTITY	UNIT COST
Common Pit-Run for Road Foundation:	75,000 m^3	$\$45/m^3$
0-20 mm Screened Gravel Surface:	9,000 m^3	$\$65/m^3$
Place and Compact (Dozer, Packer):	84,000 m^3	$\$20/m^3$
ECONOMIC FEASIBILITY OF ACQUIRING AGGREGATE BETWEEN KM 16.0 – 21.0	**QUANTITY**	**UNIT COST**
Associated Access Road Costs to Acquire:		$\$5/m^3$
Associated Road Maintenance Costs to Acquire:		$\$1/m^3$
Excavate/Haul (Average 18 km) Costs to Acquire:		$\$60/m^3$
Crush and/or Screen as Required:		$\$30/m^3$
Total Costs to Acquire:	**1.1 million m^3**	**$\$66 – 96/m^3$**

Based on the first part of the table, the cost of 15 km of road upgrades would cost roughly $5.6 million (~$375,000/km), which equates to an associated cost of $\$5/m^3$ to acquire the estimated 1.1 million cubic metres of aggregate available at the deposits directly on the road between KM 16.0 and 21.0. Maintaining the road with the addition and grading of a 40 mm thick resurfacing layer up to 3 times between completion and year 20 would cost roughly $400,000 each time (~$27,000/km) or $1.2 million up to year 20. This adds an associated cost of $\$1/m^3$ to the cost of acquiring the 1.1 million cubic metres of aggregate at the end of the road.

Once operating, gravel excavation and hauling to the hamlet is estimated to cost about $\$60/m^3$ to excavate, load and haul ($\$45/m^3$ within 10 km plus about $2 extra per km per m^3 for the additional ~8 km required). Combining these brings the total unit rate to $66/m^3, without any screening or crushing. This is shown in the second part of Table 10-5 above. Crushing and/or screening of aggregate would add about $30/m^3 on average to the cost per cubic metre for a total cost of $96/m^3.

10.4 Class D Cost Comparison and Rankings

The Class D unit costs to develop and operate new borrow sources between KM 16 and 21 on the Diane River Road were presented in the sections above and are summarized for comparison with a drill/blast/crush quarry operation in Table 10-6, below.

Table 10-6: Comparative Class-D cost estimates to supply aggregate to Rankin Inlet

	EXISTING PITS	PITS BETWEEN KM 16.0 – 21.0	BEDROCK QUARRY
Load/Haul Only	\$45/m^3	\$60/m^3	\$20 - \$30/m^3
+ Crush/Screen	\$30/m^3	\$30/m^3	\$30 - \$40/m^3
+ Drill/Blast	-	-	\$50/m^3
+ Access Road	-	\$5/m^3	-
Total Unit Cost:	**\$45 - \$75/m^3**	**\$66 - \$96/m^3**	**\$100 - \$120/m^3**

The quarrying haul costs and crush/screen costs depend on the proximity to the hamlet and the gradation of crushed select-grade gravel produced, respectively. Drilling and blasting costs have been estimated at $50/m^3. Based on these cost estimates, upgrading the Diane River Road and developing the borrow sources between KM 16 and 21 is a more economical means of obtaining aggregate than a bedrock quarry, particular for pit-run and general fill needs. A quarry may prove to be competitive for producing the crushed select-grade aggregate needs. It must be noted that all material produced from a quarry will be crushed to a select-grade gravel, which naturally has a much higher cost. Natural borrow sources are preferred for pit-run, general fill, sand and silty fill requirements. However, other criteria must be considered in the aggregate development plan selection as previously discussed.

11 RECOMMENDATIONS AND CONCLUSIONS

Based on short, medium and long-term infrastructure needs identified by the Hamlet, an estimated total of close to 640,000 m^3 of aggregate may be required over the 20 year period, of which approximately ten percent needs to meet select-grade crushed gravel specifications. Currently active borrow pits have substantial remaining material, much of which is sand or gravelly sand, and are capable of meeting short-term needs for the next 3-5 years. Beyond that, additional new borrow sources or a bedrock quarry is required to meet medium to long-term aggregate needs to year 20.

In the field, seven (7) prospective new natural borrow sources and three (3) potential new quarry sites were investigated. This supplemented the three (3) existing borrow pits and one (1) former quarry site that were also evaluated. The three main gravel and sand deposits evaluated along the Diane River Road at KMs 16, 18 and 18.5 - 21.0 west of the hamlet contain large volumes of quality aggregate to supply sufficient aggregate to meet hamlet needs to 20 years and beyond. These sites are all within hamlet municipal boundaries and satisfy community concerns while enabling operation under the current Quarry Administration Agreement.

Additional, massive sand and gravel deposits were evaluated by helicopter northeast of the Meliadine River and accessible from the Agnico-Eagle Meliadine Mine Road. These sites are outside municipal boundaries and are thus undesirable at this time, but would be capable of meeting hamlet needs for a long time into the future.

The investigated bedrock outcrops at the present Diane Pit and new dump site would be capable of producing high-quality, durable crushed gravel to meet select-grade aggregate needs without requiring new roads. Furthermore, they are located in already environmentally-compromised areas. The existing quarry at the harbour is also capable of producing large quanitites of high-quality, durable crushed gravel, but requires safety measures prior to reopening the quarry, and would benefit from a bypass road around the hamlet so that hauling could avoid residential streets.

Based on the operational, compliance and economic ranking schemes and Class D cost estimates used to evaluate alternative sites, upgrading the Diane River Road between KM 5 and 20 and developing the natural borrow sources at KM 16, 18 and 18.5 – 21.0 are recommended to supply common pit-run and screened or crushed select-grade materials over the next 20 years. A quarry operation may be competitive for producing select-grade crushed gravel on specific contracts when large quantities are required.

12 REFERENCES

Aarluk Consulting Inc. 2010. *Infrastructure for a Sustainable Rankin Inlet – Integrated Community Infrastructure Sustainability Plan Volumes 1 and 2*. Iqaluit, Nunavut.

Agnico-Eagle Mines Limited. 2011. *Project Description: All Weather Road In Support Of The Underground Program, Rankin Inlet To The Meliadine Site.*

Arktis Solutions Inc. (2011). *Report on Current State of Solid Waste Management and Facilities in Nunavut and Cost-Benefit Analysis of Selected Solid Waste Management Approaches.* GN-CGS Project #2010-27. Yellowknife, NT.

Dyke, A.S., Moore, A and Robertson, L. (2003). *Deglaciation of North America; Geological Survey of Canada Open File 1574*.

Judge, A.S., Tucker, C.M., Pilon, J.A., and Moorman, B.J. 1991. *Remote Sensing of Permafrost by Ground-Penetrating Radar at Two Airports in Arctic Canada.* Arctic, Vol. 44, Supp. 1 (1991), pp. 40-48

McMartin, I. 2002. *Surficial Geology, Rankin Inlet, Nunavut*; Geological Survey of Canada, Open File 4116, scale 1:50,000.

Statistics Canada. 2012. *Rankin Inlet, Nunavut (Code 1320) and Canada (Code 01)* (table). *Census Profile*. 2011 Census. Statistics Canada Catalogue no. 98-316-XWE. Ottawa. Released October 24, 2012. http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E (accessed March 21, 2016).

Statistics Canada. 2014. *Corrections and updates: Population and dwelling amendments, 2011 Census.* Released March 4, 2014. http://www12.statcan.gc.ca/census-recensement/news-nouvelles/corr/cgen004-eng.cfm (accessed March 21, 2016)

Trow Associates Inc. 2008. *Geotechnical Investigation: New Granular Sites Study, Rankin Inlet, Nunavut.* Project No. 07-3037. Ottawa, Ontario.

WSP Inc. 2014. *Aggregate Quantity and Quality Survey (Four Selected Sites at Rankin Inlet), Hamlet of Rankin Inlet, Nunavut.* Project No. 131-23088-00. Peterborough, Ontario.

13 LIMITATIONS

The estimates of aggregate needs within this report are based on reviews of published reports and supporting documentation available at the time the report was prepared, and are subject to change with changing community needs and availability of project funding. Furthermore, estimated aggregate quantities are based on limited subsurface data and samples obtained during the field investigation. Although the conditions encountered during the fieldwork are deemed to be reasonably representative of the investigated sites, additional mechanical drilling would be required to determine the available quantities with greater accuracy and to identify any ice lenses or massive ground ice in the deposits.

This report has been prepared for the exclusive use of the Government of Nunavut (Department of Community and Government Services), the Hamlet of Rankin Inlet and its agents for specific application to the scope of work described in this report. It has been prepared in accordance with generally accepted geoscientific and engineering practices. No warranty is expressed or implied.

AGGREGATE RESOURCE STUDY

RANKIN INLET, NUNAVUT

Prepared by:

Cameron Ross, M.Sc., P.Eng (AB, NU, NT)

Noel L. Journeaux, Eng., M.S.C.E., F ASCE

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.
801 Bancroft Pointe-Claire, QC H9R 4L6
T (514)630-4997 F (514)630-8937

APPENDIX A

Table of Estimated Aggregate Needs for 20 Years

TABLE A-1: ESTIMATED VOLUMES OF AGGREGATE MATERIAL REQUIRED FOR NEXT 20 YEARS

PROJECT	SIZE (L x W) (m)	AREA (m^2)	MATERIAL	THICKNESS (mm)	PIT-RUN VOLUME (m^3)	CRUSHED GRAVEL VOLUME (m^3)
ROADS						
Maintenance of existing roads (1600 m^3/yr)	~4,000 m/yr length		0-20 mm Crushed Gravel	40	---	32,000
New residential streets (7.5 m wide)	4,900 x 7.5	36,750	Pit-run	1,000	36,750	---
			0-20 mm Crushed Gravel	75	---	2,750
Improved dump access road:	500 x 3.0	1,500	Pit-run	1,000	1,500	
	500 x 10.0	5,000	0-20 mm Crushed Gravel	75	---	375
Improve Diane River Road from KM 5 to 20	15,000 x 5.0	75,000	Pit-run	1,000	75,000	---
	15,000 x 8.0	120,000	0-20 mm Crushed Gravel	75	---	9,000
Road to Manitoba *not included in total volume calculation	-	-	-	-	-	-
HOUSING UNITS						
250 new public and staff single-family units: Lot	30 x 30 (x250)	225,000	Pit-run	1,000	225,000	---
Parking	30 x 15 (x250)	112,500	0-20 mm Crushed Gravel	50	---	5,600
10 new public and staff multi-family bldgs: Lot	100 x 30 (x10)	30,000	Pit-run	1,000	30,000	---
Parking	100 x 15 (x10)	15,000	0-20 mm Crushed Gravel	50	---	750
COMMERCIAL FACILITIES						
Kivalliq Regional Visitor Centre	60 x 40	2,400	Pit-run	1,000	2,400	---
		1,200	0-20 mm Crushed Gravel	50	---	60
New Arena, Swimming Pool & Hamlet Offices on large site west of Health Centre	200 x 100	20,000	Pit-run	1,500	30,000	---
	200 x 40	8,000	0-20 mm Crushed Gravel	50	---	400
Trade School and Heavy Equipment Training Ground	170 x 110	18,700	Pit-run	1,000	18,700	---
	70 x 110	7,700	0-20 mm Crushed Gravel	50	---	390

TABLE A-1: ESTIMATED VOLUMES OF AGGREGATE MATERIAL REQUIRED FOR NEXT 20 YEARS

PROJECT	SIZE (L x W) (m)	AREA (m^2)	MATERIAL	THICKNESS (mm)	PIT-RUN VOLUME (m^3)	CRUSHED GRAVEL VOLUME (m^3)
Addictions & Mental Health Regional Centre with Storage Facility & Parking	50 x 40	2,000	Pit-run	1,000	2,000	---
	50 x 20	1,000	0-20 mm Crushed Gravel	50	---	50
Municipal Solid Waste Landfill Cover - Annual 0.3 m Cover (2,500 m^2 per year)	2,500 x 20yrs	50,000	Pit-run (dry, sandy)	300	15,000	---
- Final 0.6 m Cover: 40,000 m^2 in short term :	-	40,000	Pit-run (dry, sandy)	600	24,000	---
40,000 m^2 in long term :	-	40,000	Pit-run (dry, sandy)	600	24,000	---
Airport runway shoulder overlay	2000 x 30	60,000	0-20 mm Crushed Gravel	300	---	18,000
Fuel Tank Farm Expansion (medium –term)	60 x 100	6,000	Pit-run	1,500	9,000	---
		6,000	0-20 mm Crushed Gravel	200	---	1,200
Baseball Diamond	$\pi(100)^2 / 4$	8,000	Pit-run (dry, sandy)	500	4,000	---
Graveyard Expansion	80 x 40	3,200	Pit-run (dry, sandy)	2,000	6,400	---
Other medium-size commercial buildings* (15 expected) + parking	50 x 80 (x 15)	60,000	Pit-run	1,000	60,000	---
		40,000	0-20 mm Crushed Gravel	75	---	3,000
			TOTALS (not including Road to Manitoba)		**563,750**	**73,575**

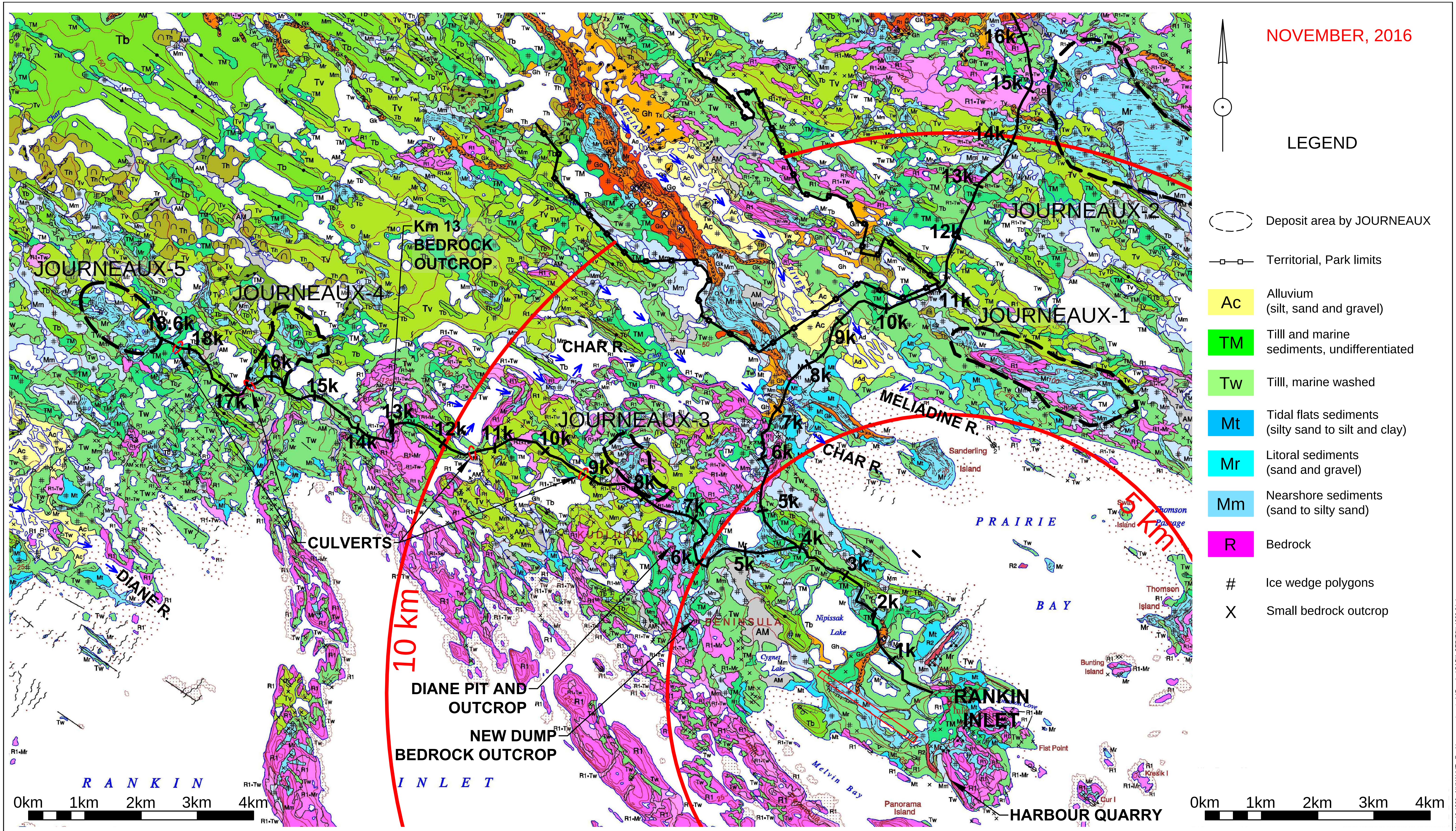
* includes recycling centre, elder care facility, medical boarding home, new daycare, homeless shelter, community freezer, airport terminal expansion, arts & crafts centre, youth centre expansion, friendship centre expansion, sewage treatment plant, Hamlet maintenance garage and parking garage, as identified in the ICISP (2016 update).

The Itivia upgrades/expansion and associated hamlet bypass road are not included in this assessment. According to the GN, this will likely be a private contract that includes sourcing material from the adjacent harbour quarry specifically to meet project needs.

Finally, the proposed road to Manitoba is not included, as the material for this project would be sourced along the route, and locating these sources would be part of extensive feasibility and engineering analyses specific to such a project.

APPENDIX B

Location Plans of Evaluated Granular Borrow Sources and Quarry Sites
&
Demarcated Site Boundaries with GPS Coordinates



NOTE:
BASED ON SURFICIAL GEOLOGY MAP RANKIN INLET NUNAVUT BY NATURAL RESOURCES CANADA

UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN METERS.

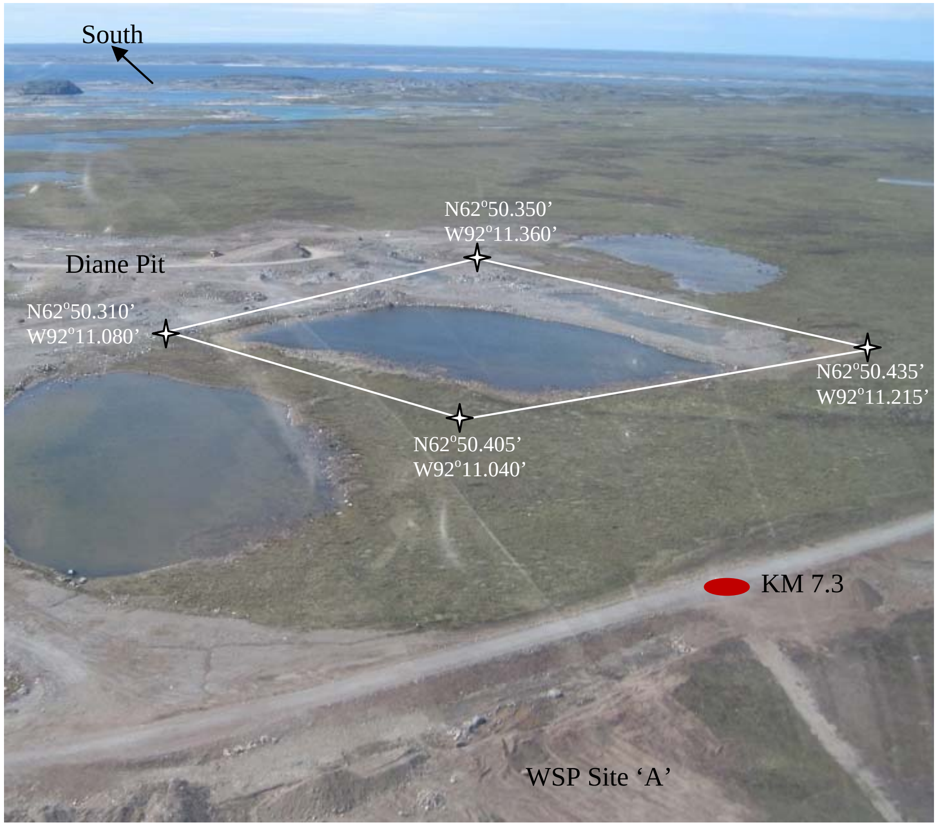
PRINTED DATE: 20161123142410

CLIENT: Nunavut

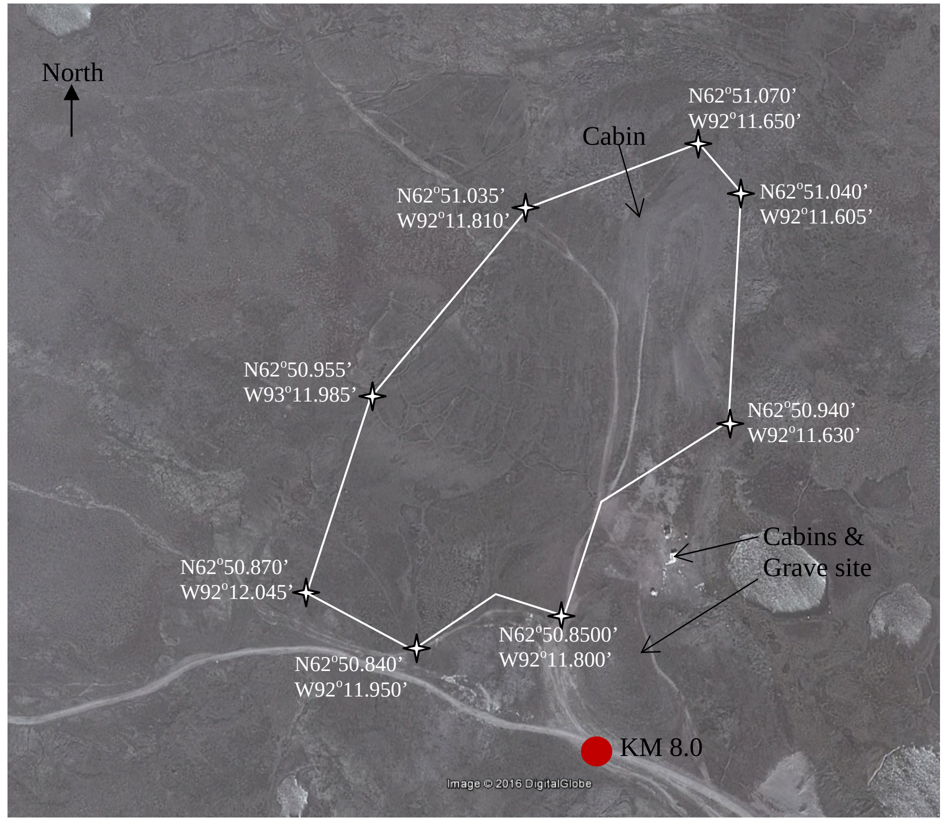
EVALUATED AGGREGATE BORROW SOURCES AND QUARRY SITES
RANKIN INLET, NUNAVUT

SCALE :	AS SHOWN
DRAWN BY :	A.B.
PROJECTED BY :	N.J.
APPROVED BY :	N.J.
DATE :	23-11-2016
PROJECT No. :	L-16-1860
DRAWING No. :	L1860-01
FIGURE No. :	- - -
REV. :	- - -

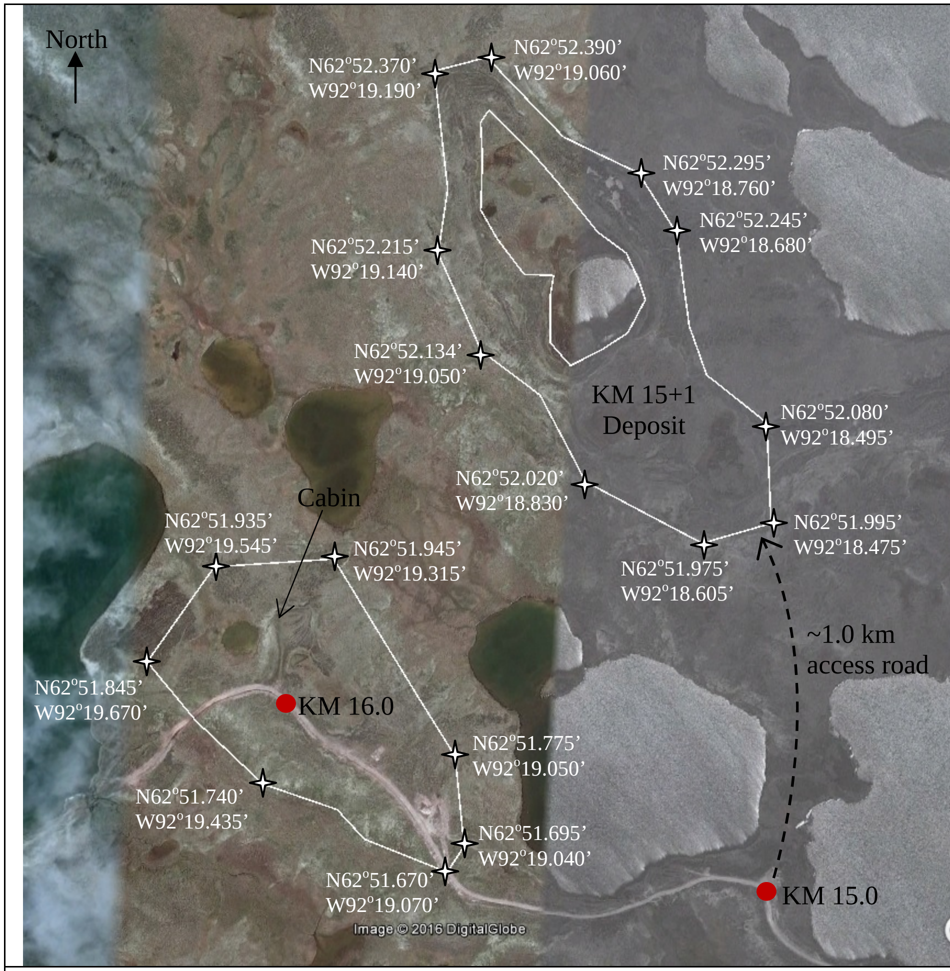
JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.
801 Bancroft Pointe-Claire, QC H9R 4L6
Tél.: 514.630.4997 info@journeauxassoc.com



KM 6.5 – Diane Pit Additional Area



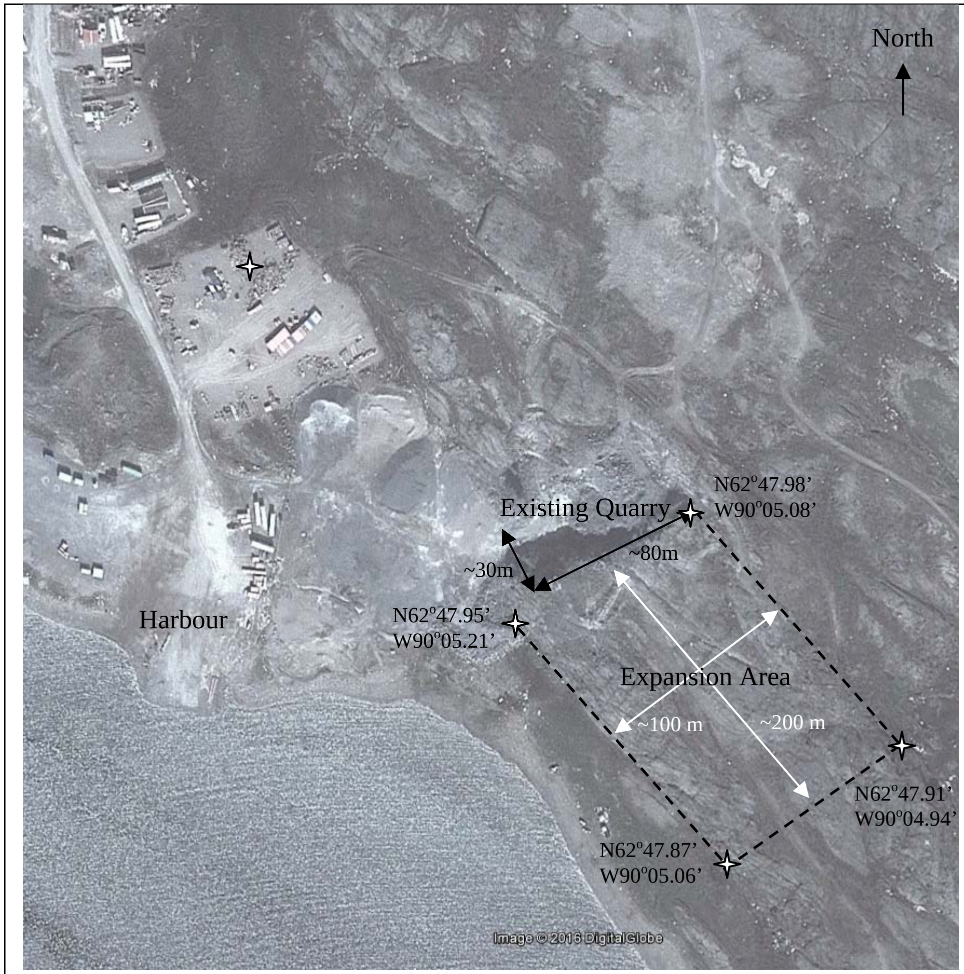
KM 8.0 – Diane River Road (Journeaux-3)



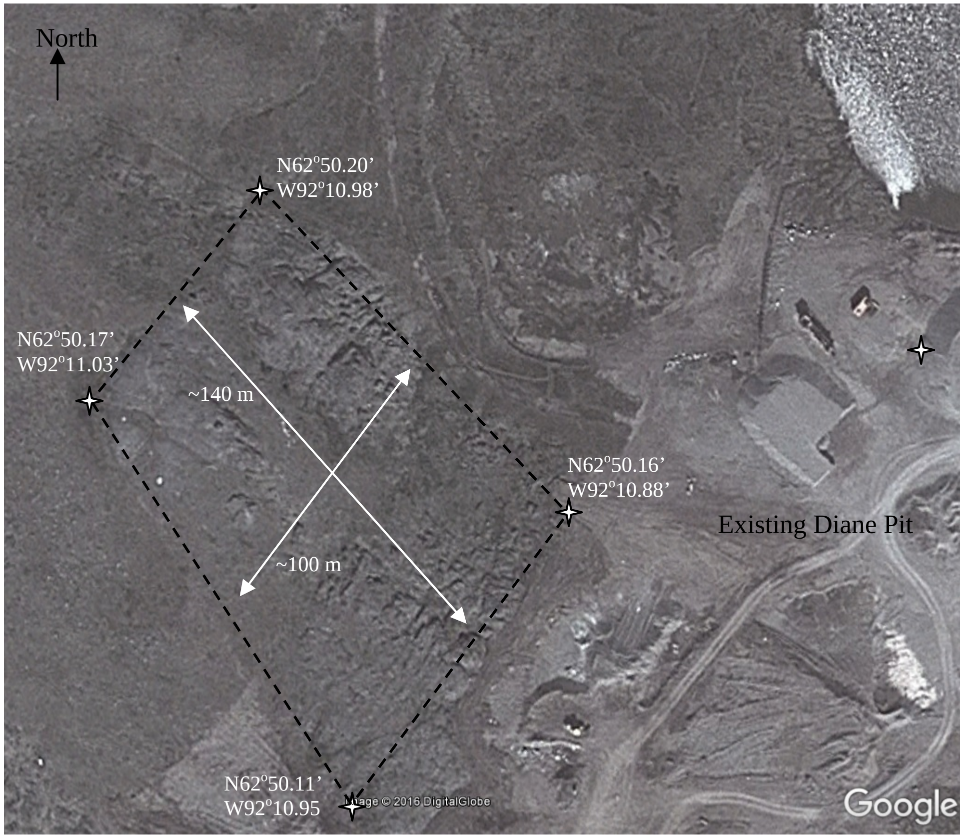
KM 16.0 and 15.0+1.0 – Diane River Road (Journeaux-4)

KM 18.0 – Diane River Road

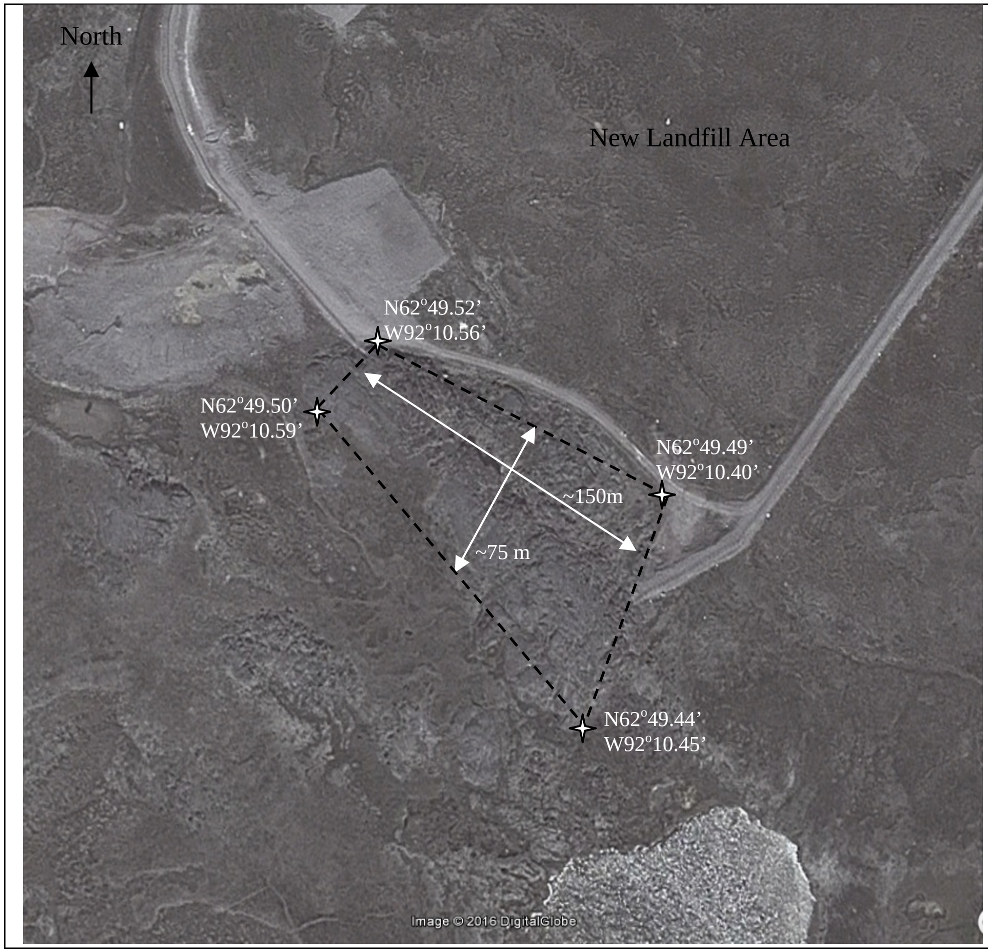
KM 18.5 – 21.0 – Diane River Road (Journeaux-5)



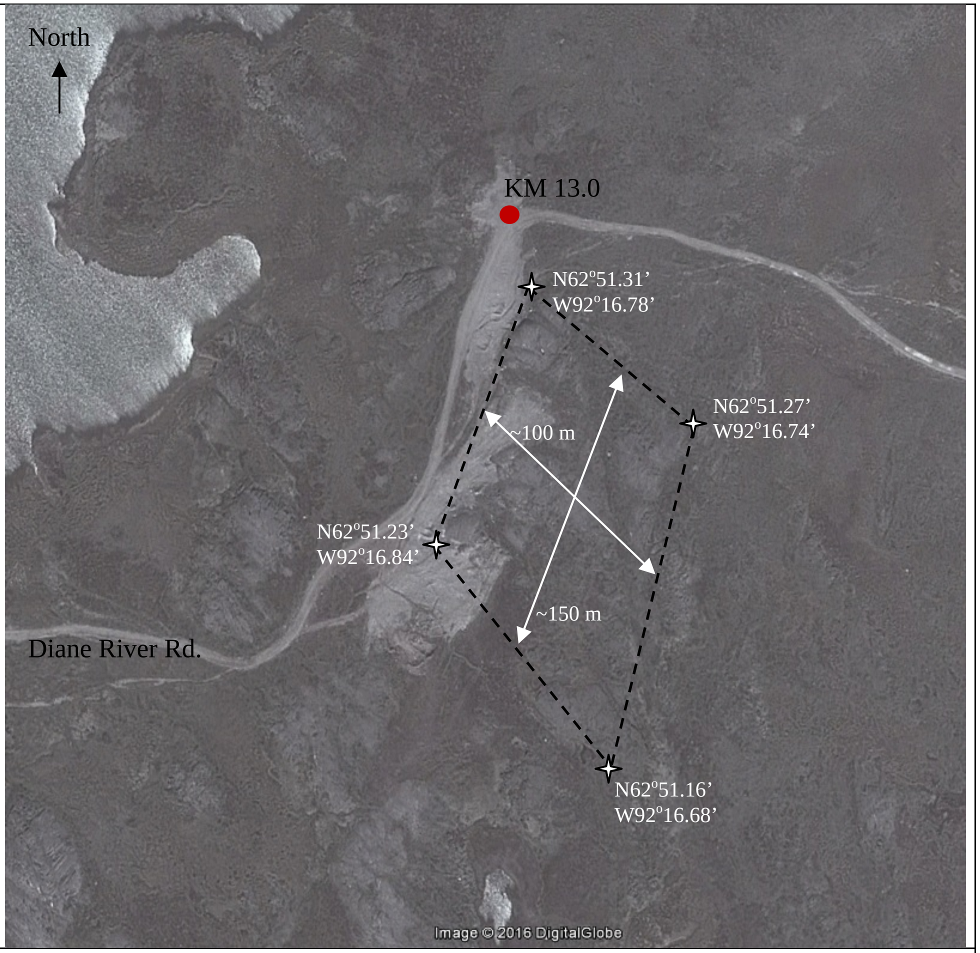
Harbour Quarry – possible quarry expansion area with coordinates



Diane Pit Bedrock Outcrop – potential quarry area with coordinates



New Dump Bedrock Outcrop – potential quarry area with coordinates



KM 13.0 Bedrock Outcrop – potential quarry area with coordinates

APPENDIX C

Test Pit and Bedrock Outcrop Additional Photos

KM 8.0 on Diane River Road - Test Pit J3-S1A: Gravelly Sand to 3'8". Medium to coarse grained sand with small, rounded gravel (<2") and trace to some shell fragments.

KM 8.0 on Diane River Road - Test Pit J3-S1B: Sand and Gravel between 3'8" and 3'11" (permafrost). Gravel is rounded and generally less than 2" diameter

KM 8.0 on Diane River Road - Test Pit J3-S2: Sand (fine to medium grain) with little gravel and cobbles to 2'10" (permafrost).

KM 8.0 on Diane River Road - Test Pit J3-S3: Coarse gravel and cobble (rounded) with some sand. Soil becomes similar to TP J3-S1 below 2'7"

KM 16.0 on Diane River Road - Test Pit J4-S1: Sandy gravel with cobbles. Gravel component is mix of rounded fragments and platy shale fragments. Silty sand till encountered at 2'10". Permafrost at 3'2".

KM 16.0 on Diane River Road - Test Pit J4-S1: Close-up of excavated material from between 0'10" and 2'10". Note the larger rounded cobbles and the flat shale fragments (~20%).

KM 16.0 on Diane River Road - Test Pit J4-S2: Coarse sand and gravel with large cobbles and boulders. More sand, shale fragments and large boulders than in TP J4-S1. Silty till/permafrost encountered at 3'0".

KM 16.0 on Diane River Road - Test Pit J4-S3: Sand and gravel with some cobble. Substantial shale component (~20%). Silt till/permafrost encountered at 2'8".

KM 16.0 on Diane River Road - Test Pit <u>J4-S4</u>: Sandy gravel to approximately 2’2” below grade, followed by grey silty sand till with trace gravel. Permafrost at 2’8”.

KM 16.0 on Diane River Road - Test Pit <u>J4-S5</u>: Sand and gravel with trace silt. Cobbles/ boulders close to surface (20% shale). Becomes grey sandy silt till at 1’8”. Permafrost at 2’9”.

KM 16.0 on Diane River Road - Test Pit <u>J4-S6</u>: Gravel with sand, some cobble, trace silt. Substantial shale component in gravel size range (20-30%). Permafrost encountered at 5’0”. No silt till encountered.

KM 16.0 on Diane River Road - Test Pit <u>J4-S7</u>: Coarse gravel and cobbles with some sand and trace silt. Significant shale component in gravel and cobble size range (30-40%). Permafrost and possible silty sand till encountered at 3’7”.

KM 16.0 on Diane River Road - Test Pit J4-S8: Gravel with some sand and cobble. Significant shale component in gravel size range (30-40%). Permafrost encountered at 2’10” in same material. No silty till encountered.

KM 16.0 on Diane River Road - Test Pit J4-S9: Sand (fine to medium grain) with some gravel and trace silt in upper 1’2”. Becoming silty sand till below 1’2”. Permafrost at 2’10”.

KM 18.0 on Diane River Road - Test Pit KM18-S1: South side of road. Sand and gravel with trace cobbles. Approximately 10-20% shale component in gravel size range. Permafrost at 3’11”. No silt till encountered.

KM 18.0 on Diane River Road - Test Pit KM18-S2: North side of road in previously excavated area. Same sand and gravel as in TP KM18-S1. Permafrost at 4’8”. No silt till encountered

KM 19.0 on Diane River Road - Test Pit J5-S1: Gravelly sand (medium grain). No flat shale fragments noted. Water table encountered at 5’0” below grade atop permafrost. No silty till encountered

KM 19.0 on Diane River Road - Test Pit J5-S2: Gravelly sand (similar to TP J5-S1), trace cobble and trace shale fragments in gravel component. Permafrost at 3’10”. No silty till encountered.

KM 19.0 on Diane River Road - Test Pit J5-S3: Gravelly sand with cobble. Very similar to J5-S1 and S2. Permafrost at 3’11”. No silty till encountered.

KM 19.0 on Diane River Road - Test Pit J5-S4: Sand (fine to medium grain) with some gravel and trace cobbles. Permafrost at 6’3”. No silty till.

KM 19.0 on Diane River Road - Test Pit J5-S5: Stratified sand with trace to some gravel. Very similar to material in J5-S4 but even higher sand component (~70%). Permafrost at 4’10”. Increased gravel can be seen at the permafrost table.

KM 19.0 on Diane River Road - Test Pit J5-S6: Sandy gravel with trace cobbles. Appears well graded. Generally minus 2” gravel. Permafrost at 4’0”. No silty till encountered.

KM 19.0 on Diane River Road - Test Pit J5-S7: Coarse gravel and cobble with some medium to coarse grain sand. Roughly 20% shale component in gravel and cobble size range. Permafrost at 5’6”. No silty till encountered.

KM 19.0 on Diane River Road - Test Pit J5-S8: This test pit in the bottom of a dry pond revealed sandy gravel similar to that of J5-S6 beneath 21” of peat and silt. Permafrost was shallow at 24” with groundwater perched atop it in the gravel.

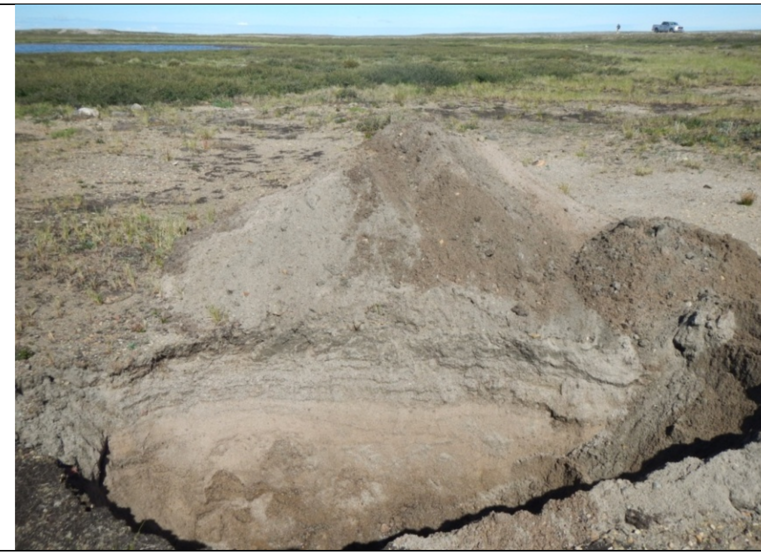
KM 19.0 on Diane River Road - Test Pit J5-S9: Grey sandy silt with trace-little gravel and cobble. Permafrost at 3’10”.

KM 19.0 on Diane River Road - Test Pit J5-S10: Reddish-brown sand with little gravel. Permafrost at 3’10”.

KM 19.0 on Diane River Road - Test Pit J5-S11: Grey silt with trace to some sand. Stopped test pit at 2’4”. Note distant gravel ridge below truck (area of J5-S7)

KM 19.0 on Diane River Road - Test Pit J5-S12: Sandy gravel with trace cobble. Generally minus 4” gravel. Appears well graded. Minimal shale component (<10%). Permafrost at 4’6”. No silty till encountered.

KM 19.0 on Diane River Road - Test Pit J5-S13: Gravel and cobble with medium to coarse grain sand. Roughly 10% shale component in gravel and cobble size range. Similar to J5-S7. Permafrost at 4'4". No silty till encountered.



KM 19.0 on Diane River Road - Test Pit J5-S14: Sand with trace to some gravel (~20%). Permafrost at 4'8". No silty till encountered. Test pit **J5-S15** was similar with increased minus 2" gravel component (~40%)

KM 6.5 Existing Diane Pit: Excellent remaining material at the north end of the existing Diane Quarry (Pit), adjacent to a small lake.

Harbour Quarry: the northwest corner of the quarry

Harbour Quarry: the south face of the quarry

Harbour Quarry: the north wall of the quarry

Harbour Quarry: the top of the bedrock outcrop

Diane Quarry Outcrop

Diane Quarry Outcrop

Diane Quarry Outcrop

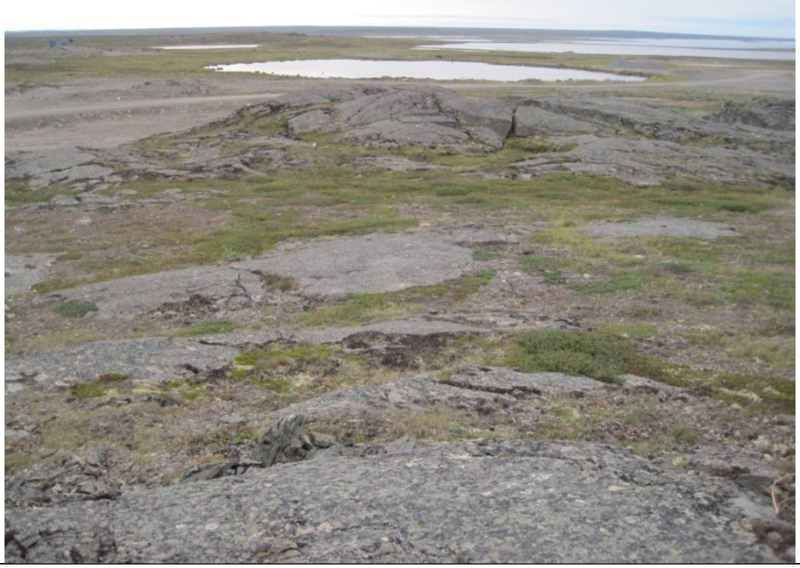
Diane Quarry Outcrop

Diane Quarry Outcrop (toe of outcrop)

Diane Quarry Outcrop (excavating at toe of outcrop)

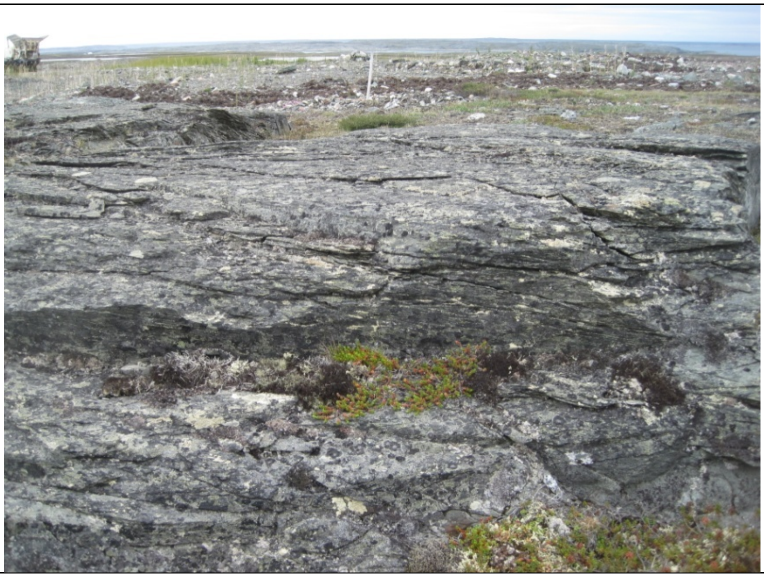
Diane Quarry Outcrop (near base of outcrop)

Diane Quarry Outcrop (near base of outcrop)


Diane Quarry Outcrop (view from top)

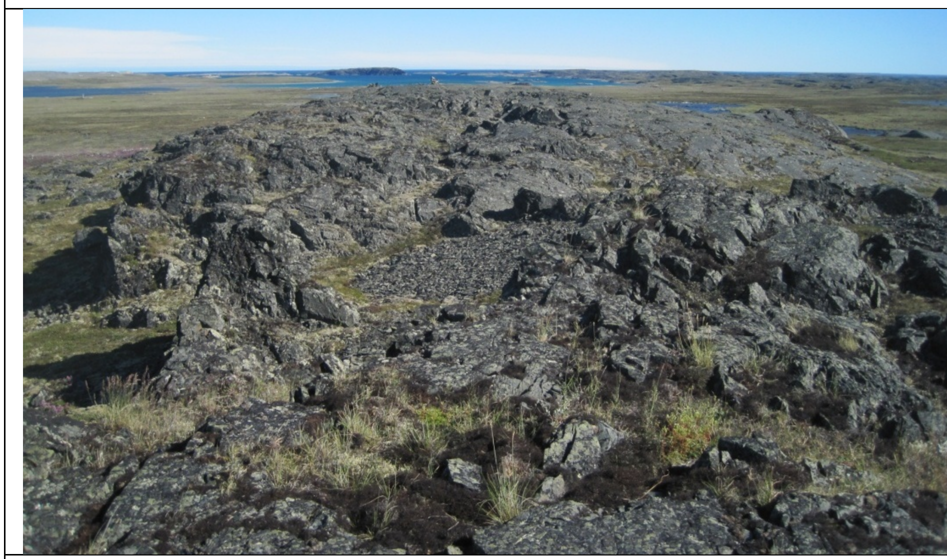

Diane Quarry Outcrop (excavating at top of outcrop)


Diane Quarry Outcrop (excavating at top of outcrop – very hard rock on left)


Diane Quarry Outcrop (top of outcrop)

New Dump Outcrop

New Dump Outcrop

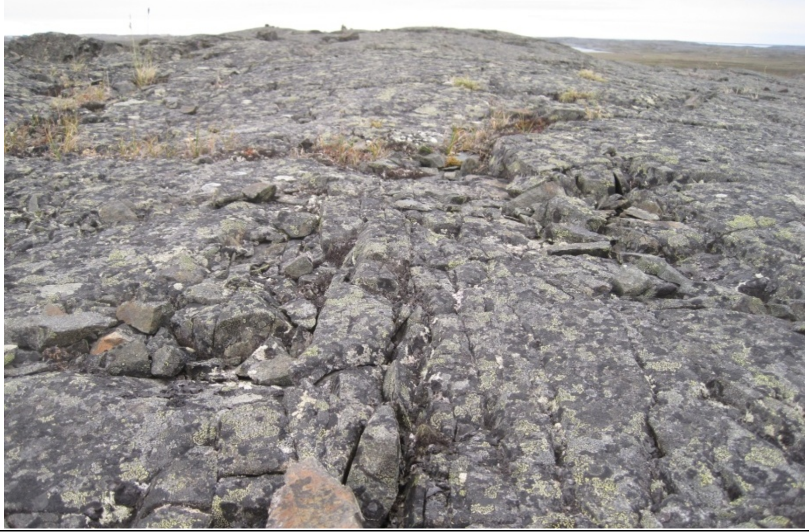


New Dump Outcrop (view south from the top)

New Dump Outcrop

New Dump Outcrop

New Dump Outcrop

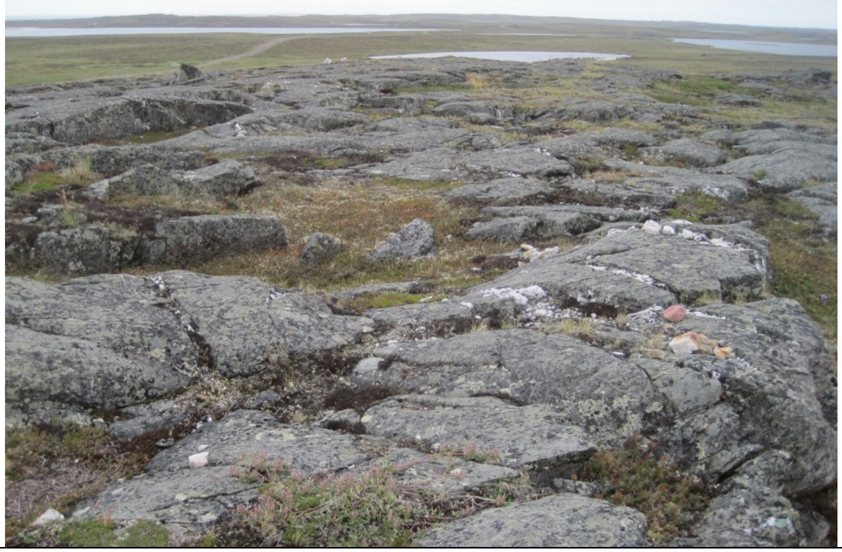


New Dump Outcrop (top)

New Dump Outcrop

KM 13.5 Outcrop on Diane River Road

KM 13.5 Outcrop on Diane River Road



KM 13.5 Outcrop on Diane River Road

KM 13.5 Outcrop on Diane River Road

Apache Pass Bedrock

Apache Pass Bedrock

Apache Pass Bedrock

Apache Pass Bedrock

APPENDIX D

Laboratory Results

JOURNEAUX ASSOC Division LAB JOURNEAUX INC.	GRAIN SIZE ANALYSIS CSA A23.2-2A	Project No. : L-16-1860 Deposit No. : KM-8.0 (J3) LJA No. : ---

Client : Government of Nunavut

Project : Aggregate study - Rankin

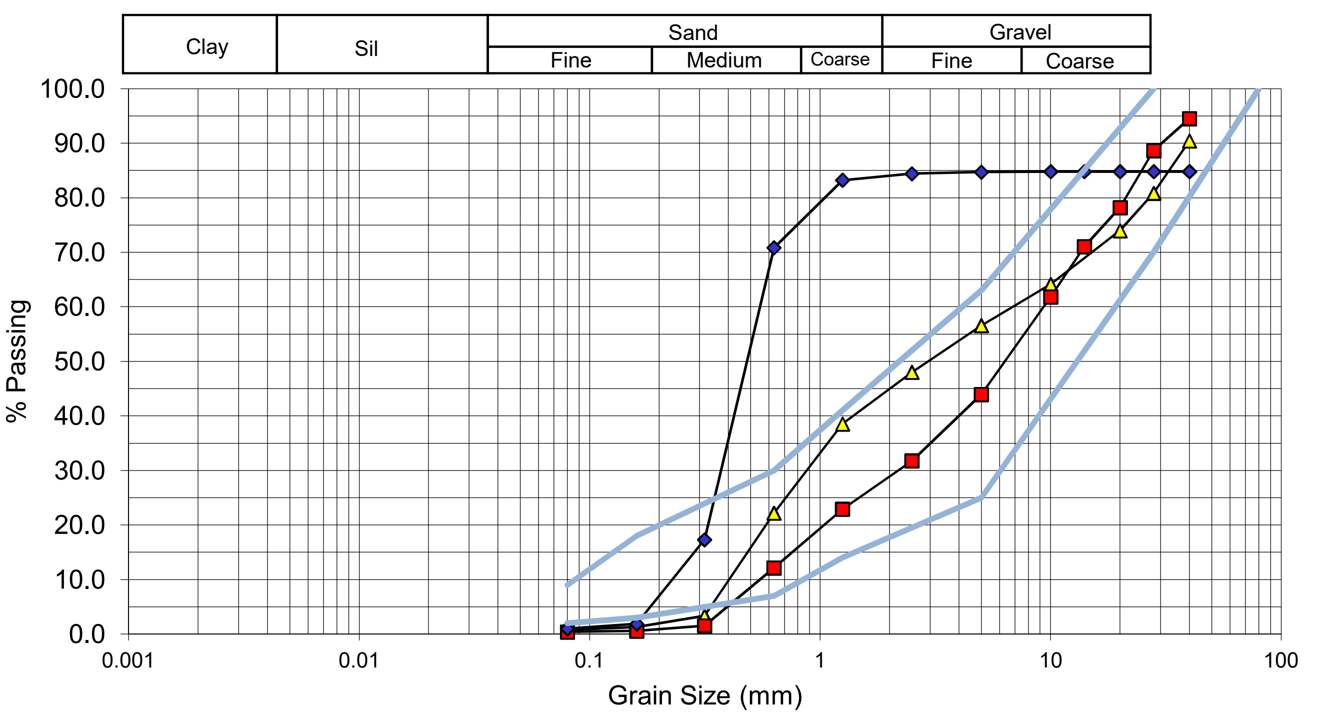
KM-8.0 (J3)

Results

Legend >>>	△	■	◆	▲	■	◆
Test Pit Sample No. :	S-1A	S-1B	S-2	---	---	---
Depth (m) :	1.10	1.20	0.86	---	---	---
Elevation (m) :	0.00	0.00	0.00	---	---	---
Moisture Content (%) :	7.56	3.45	4.00	---	---	---

Sieve (mm)	% Passing		
80			
56			
40	90.4	94.5	84.8
28	80.8	88.6	84.8
20	74.0	78.2	84.8
14		71.1	84.8
10	64.1	61.8	84.8
5	56.6	43.9	84.7
2.5	48.0	31.8	84.4
1.25	38.5	22.9	83.2
0.63	22.2	12.1	70.8
0.315	3.3	1.5	17.3
0.16	1.3	0.6	1.9
0.08	0.8	0.4	1.0

Sieve (mm)	Exig. (Pit Run)
80	
56	
40	
28	70-100
20	
14	
10	
5	25-63
2.5	
1.25	14-41
0.63	7-30
0.315	
0.16	3-18
0.08	2-9



Signature : ____________________

Sampled by : C.R. Date : --- Analyzed by : S.K. Date : 8/9/2016

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.

GRAIN SIZE ANALYSIS

CSA A23.2-2A

Project No. : L-16-1860
Deposit No. : KM-16.0 (J4)
LJA No. : ---

Client : Government of Nunavut
Project : Aggregate study - Rankin

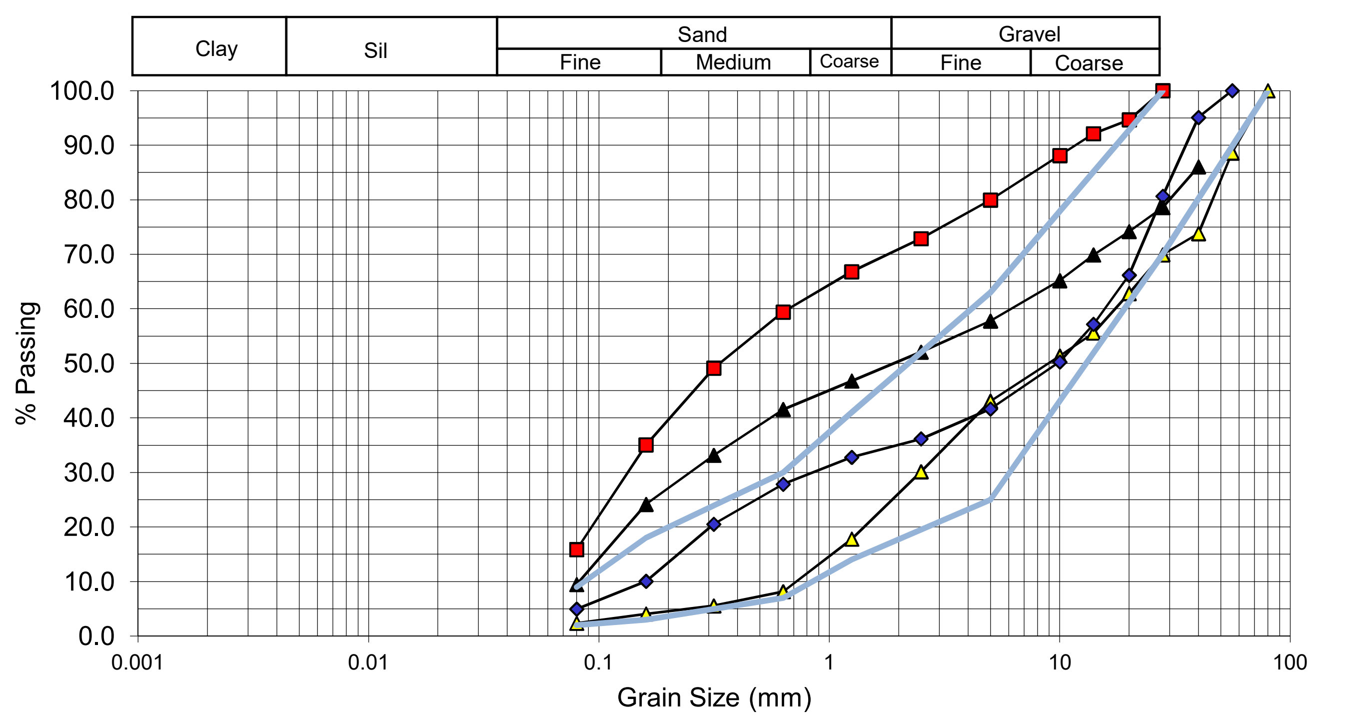
KM-16.0 (J4)

Results

Legend >>>	△	■	◆	▲	■	◆
Test Pit Sample No. :	S-1A	S-3A	S-4	S-5	---	---
Depth (m) :				0.84	---	---
Elevation (m) :				0.00	---	---
Moisture Content (%) :	13.98	7.39	4.69	6.41	---	---

Sieve (mm)	% Passing			
80	100.0			
56	88.6		100.0	
40	73.8		95.1	86.1
28	69.9	100.0	80.6	78.6
20	62.8	94.6	66.2	74.2
14	55.6	92.1	57.2	69.9
10	51.4	88.1	50.3	65.2
5	43.1	80.0	41.6	57.8
2.5	30.2	72.9	36.2	52.1
1.25	17.8	66.8	32.8	46.8
0.63	8.2	59.4	27.8	41.6
0.315	5.6	49.1	20.5	33.2
0.16	4.1	35.1	10.0	24.2
0.08	2.4	15.9	4.9	9.5

Sieve (mm)	Exig. (Pit Run)
80	
56	
40	
28	70-100
20	
14	
10	
5	25-63
2.5	
1.25	14-41
0.63	7-30
0.315	
0.16	3-18
0.08	2-9



Signature : ____________________

Sampled by : C.R. Date : --- Analyzed by : S.K. Date : ---

JOURNEAUX ASSOC Division LAB JOURNEAUX INC.	GRAIN SIZE ANALYSIS CSA A23.2-2A	Project No. : L-16-1860 Deposit No. : KM-16.0 (J4) LJA No. : ---

Client : Government of Nunavut

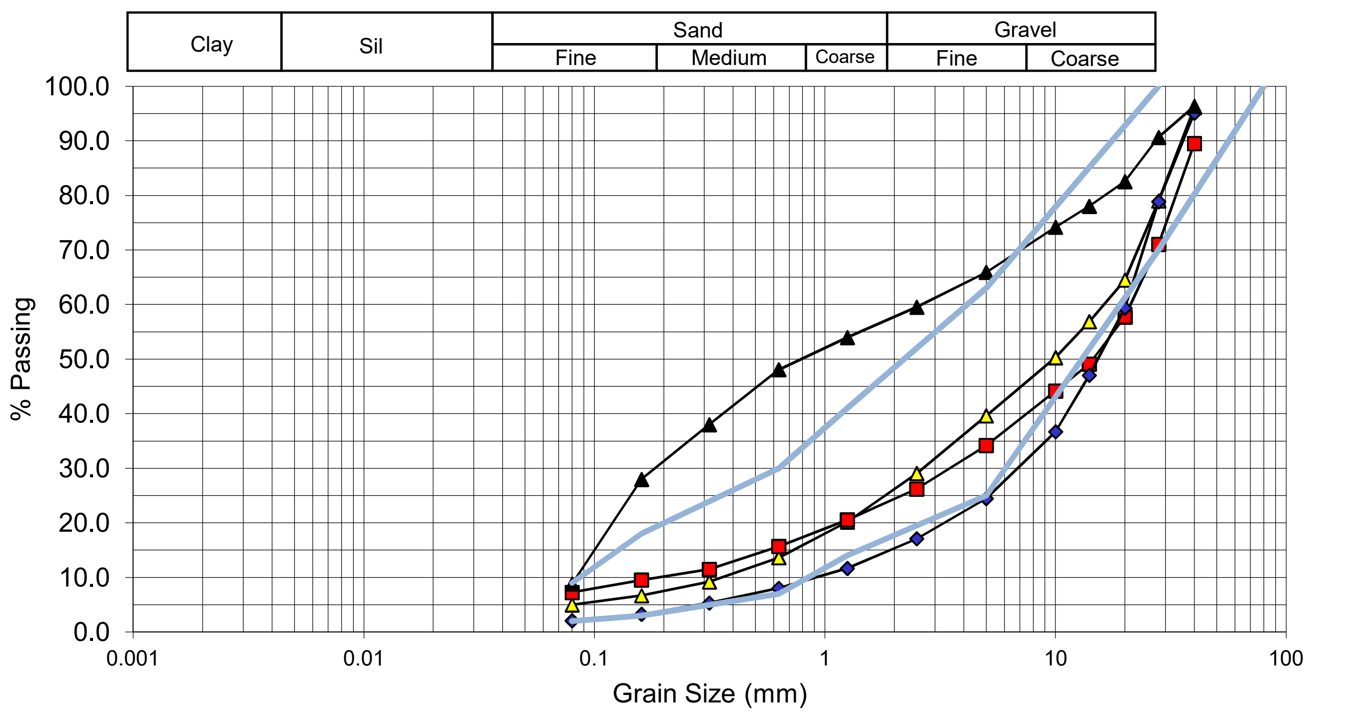
Project : Aggregate study - Rankin

KM-16.0 (J4)

Results

Legend >>>		△	■	◆	▲	■	◆
Test Pit Sample No. :		S-6	S-7	S-8	S-9	---	---
Depth (m) :		1.50	1.10	0.86	0.86	---	---
Elevation (m) :		0.00	0.00	0.00	0.00	---	---
Moisture Content (%) :		4.17	2.55	2.24	7.64	---	---
	Sieve (mm)	% Passing					
	80						
	56						
	40	96.1	89.5	95.1	96.4		
	28	79.0	71.0	78.9	90.6		
	20	64.5	57.7	59.4	82.6		
	14	56.9	49.1	47.0	78.0		
	10	50.3	44.1	36.7	74.2		
	5	39.6	34.2	24.5	65.9		
	2.5	29.1	26.2	17.1	59.5		
	1.25	20.2	20.5	11.7	54.0		
	0.63	13.6	15.7	8.0	48.1		
	0.315	9.2	11.5	5.3	38.0		
	0.16	6.7	9.5	3.3	28.0		
	0.08	5.0	7.3	2.1	8.8		

Sieve (mm)	Exig. (Pit Run)
80	
56	
40	
28	70-100
20	
14	
10	
5	25-63
2.5	
1.25	14-41
0.63	7-30
0.315	
0.16	3-18
0.08	2-9



Signature : ____________________

Sampled by : C.R. Date : --- Analyzed by : S.K. Date : 8/11/2016

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.

GRAIN SIZE ANALYSIS

CSA A23.2-2A

Project No. : L-16-1860
Deposit No. : KM-18
LJA No. : ---

Client : Government of Nunavut

Project : Aggregate study - Rankin

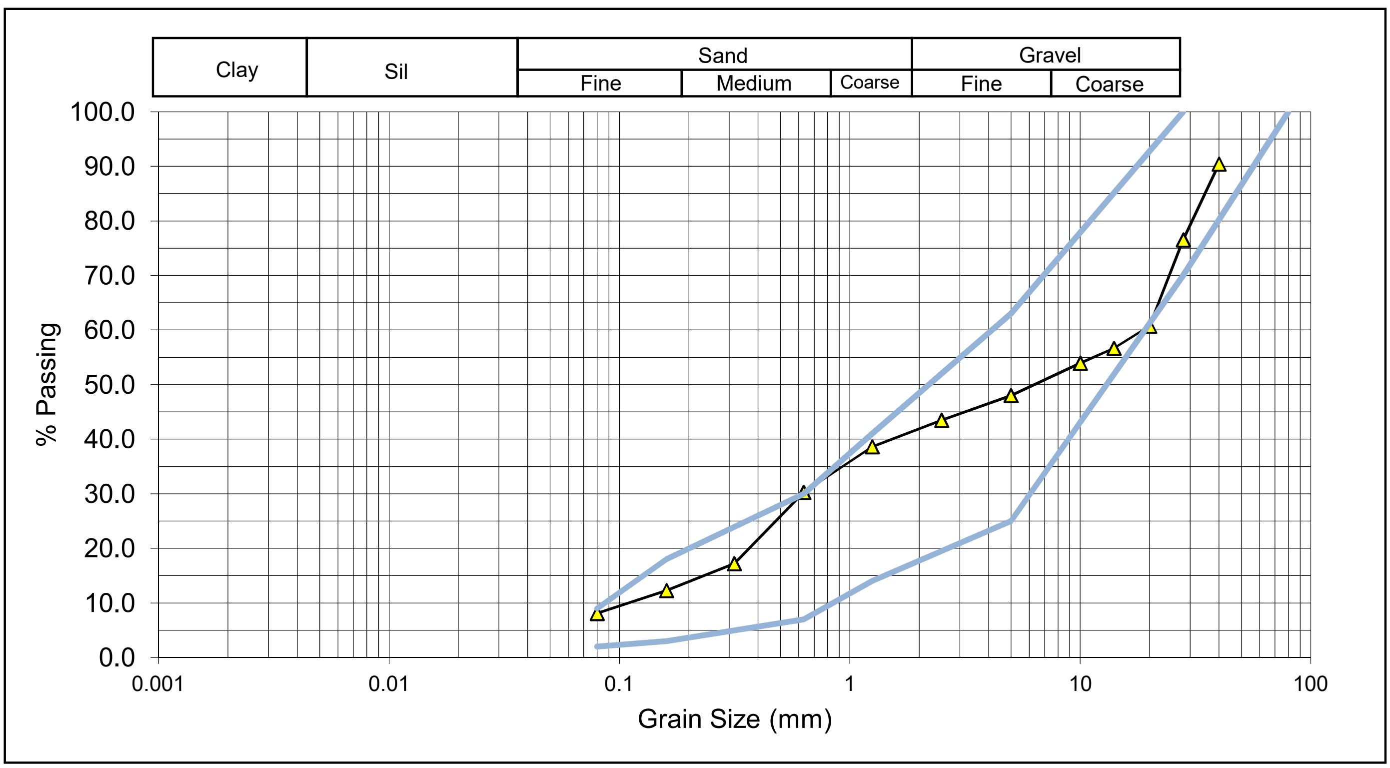
KM-18

Results

Legend >>>	△	■	◆	▲	■	◆
Test Pit Sample No. :	S-1	---	---	---	---	---
Depth (m) :	1.20	---	---	---	---	---
Elevation (m) :	0.00	---	---	---	---	---
Moisture Content (%) :	2.96	---	---	---	---	---

Sieve (mm)	% Passing
80	
56	
40	90.4
28	76.5
20	60.7
14	56.7
10	53.9
5	48.0
2.5	43.5
1.25	38.6
0.63	30.3
0.315	17.2
0.16	12.3
0.08	8.1

Sieve (mm)	Exig. (Pit Run)
80	
56	
40	
28	70-100
20	
14	
10	
5	25-63
2.5	
1.25	14-41
0.63	7-30
0.315	
0.16	3-18
0.08	2-9



Signature : ____________________

Sampled by : C.R. Date : --- Analyzed by : S.K. Date : 8/9/2016

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.

GRAIN SIZE ANALYSIS

CSA A23.2-2A

Project No. : L-16-1860
Deposit No. : KM-18.5-21.0 (J5)
LJA No. : ---

Client : Government of Nunavut
Project : Aggregate study - Rankin

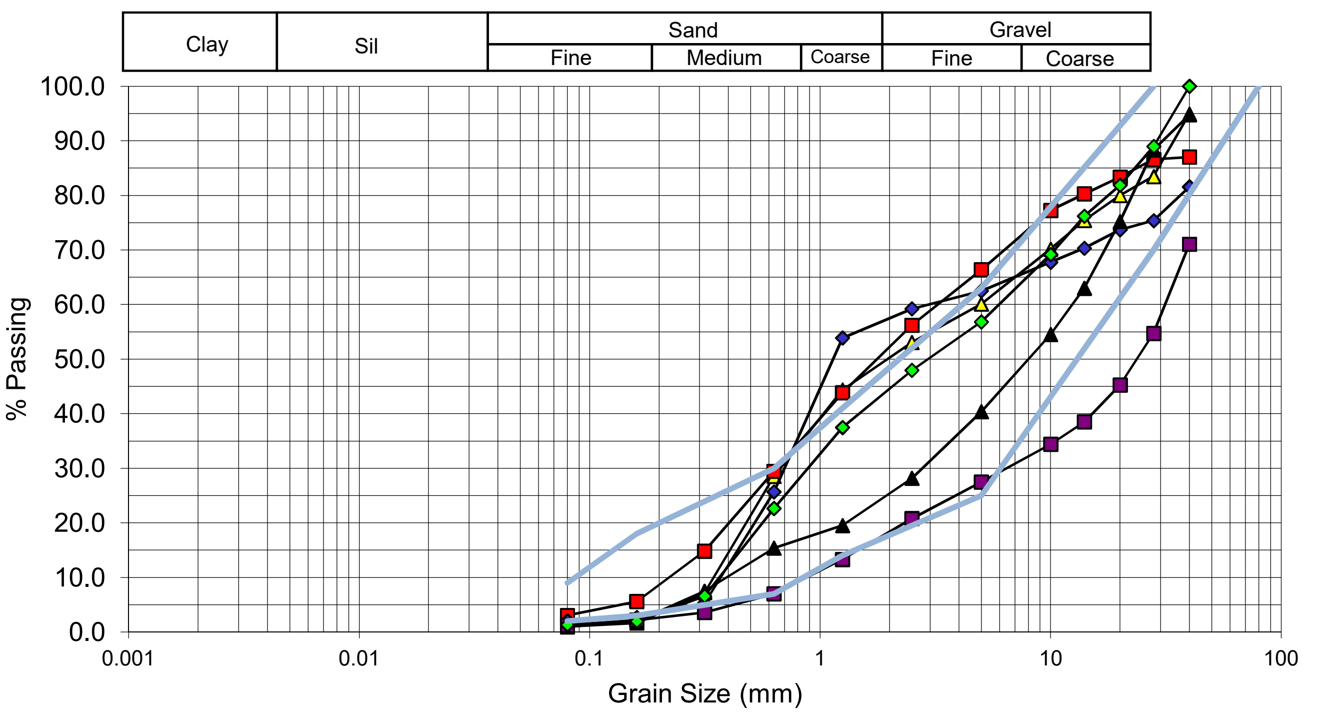
KM-18.5-21.0 (J5)

Results

Legend >>>	△	■	◆	▲	■	◆
Test Pit Sample No. :	S-1	S-2	S-4	S-6	S-7	S-15
Depth (m) :	1.50	0.00	1.90	1.20	1.68	1.30
Elevation (m) :	0.00	0.00	0.00	0.00	0.00	0.00
Moisture Content (%) :	1.94	6.82	1.76	2.22	1.40	2.05

Sieve (mm)	% Passing					
80						
56						
40	94.9	87.0	81.6	94.8	71.1	100.0
28	83.5	86.6	75.4	88.3	54.7	89.0
20	80.0	83.3	73.7	75.2	45.3	81.9
14	75.4	80.3	70.3	63.0	38.5	76.2
10	70.2	77.3	67.8	54.5	34.4	69.2
5	60.1	66.4	62.5	40.4	27.5	56.8
2.5	53.0	56.2	59.2	28.2	20.8	48.0
1.25	44.4	43.8	53.9	19.5	13.3	37.5
0.63	28.5	29.5	25.7	15.4	7.0	22.7
0.315	7.2	14.8	5.3	7.5	3.6	6.6
0.16	1.6	5.6	2.7	1.9	2.2	2.0
0.08	1.0	3.0	2.1	0.9	1.2	1.3

Sieve (mm)	Exig. (Pit Run)
80	
56	
40	
28	70-100
20	
14	
10	
5	25-63
2.5	
1.25	14-41
0.63	7-30
0.315	
0.16	3-18
0.08	2-9



Signature : ____________

Sampled by : C.R. Date : --- Analyzed by : S.K. Date : 8/9/2016