GREENING NORTHERN HOUSING

Pond Inlet, Nunavut

PROJECT MANUAL – VOL. 3

Appendices

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Parks Canada Parcs Canada

kobayashi+zedda

Desktop Geotechnical Evaluation

Residence on Lot 75
Pond Inlet, Nunavut
Project # EA16466

Prepared for:

Kobayashi+Zedda Architects Ltd.
26-1114 Front Street, Whitehorse, Yukon Y1A 1A3

26-Nov-21

Desktop Geotechnical Evaluation

Residence on Lot 75

Pond Inlet, Nunavut

Project # EA16466

Prepared for:
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26-Nov-21

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1.0 Introduction

1.1 General

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited (Wood), was retained by Kobayashi+Zedda Architects Ltd. (KZA) to conduct a desktop geotechnical evaluation for a residential house development in the Pond Inlet community, Nunavut (NU). The purpose of the present evaluation was to assess subsurface soil/permafrost conditions on the construction site and provide geotechnical recommendations for subgrade preparation, foundation design and other geotechnical aspects of the proposed development.

An initial report was prepared for for the previously selected site (Lot 477 located on Road R26) and submitted to KZA on September 17, 2021. However, the proposed development site was switched to Lot 75 on Road R29 recently. A present desktop geotechnical evaluation was required for the development on the new site.

This report summarizes the evaluation results and provides recommendations for the design and construction of the considered foundation system, site grading, and backfilling procedures for the proposed development on Road R29 in Pond Inlet, NU.

1.2 Project Description

Parks Canada is planning to construct a duplex residential house in the Pond Inlet community, NU. The proposed development will be located on the north side of Road R29 and on the southern end of the Pond Inlet community. The legal description of the site is Lot 75, CLSR number 96054. The subject lot is currently vacant. It is understood that the Triodetic foundation system is the preferred foundation system for the development.

A site plan showing the location of the subject site is presented on Figure 1, Appendix A.

2.0 Methodology

A review of available information was carried out to prepare the present report. The following reports and literature sources were reviewed:

- Geotechnical Site Investigation for Proposed Library Facility, Pond Inlet, NU, AMEC, 1991
- Geotechnical Investigation for Proposed Renewable Resources Office/Warehouse Facility, Pond Inlet, NU, AMEC, 1993
- Geotechnical Investigation for Proposed Nature Centre and Library, Pond Inlet, NU, AMEC, 1994
- Geotechnical Investigation for Proposed Hamlet Office and Firehall, Pond Inlet, NU, AMEC, 1994
- Grouted Rock Socket Pile Installation Monitoring Services, High School Addition, Pond Inlet, NU, AMEC, 1998
- Geotechnical Investigation for Ulajuuk Elementary School Addition, Pond Inlet, NU, AMEC, 2001
- Geotechnical Desktop Study for Community Health Centre, Pond Inlet, NU, AMEC, 2001
- Adfreeze Pile Installation Monitoring Services, Ulajuuk Elementary School Addition, Pond Inlet, NU, AMEC, 2002
- Geotechnical Desktop Study and Adfreeze Pile Installation Monitoring for New Air Terminal Building, Pond Inlet, NU, AMEC, 2004

- Geotechnical Desktop Study for New Coop Warehouse Building, Pond Inlet, NU, AMEC, 2005
- Establishment of Community-Based Permafrost Monitoring Sites, Baffin Region, Nunavut, Mark Ednie & Sharon L. Smith, 2010
- A Homeowner's Guide to Permafrost in Nunavut, Government of Nunavut, 2013
- Pile Installation Monitoring Summary for Five-Plexes, Pond Inlet, NU, Tetra Tech EBA, 2015
- Bedrock Geology, Pond Inlet, Nunavut, Part of NTS 38-B, Natural Resources Canada, 2018

The Google Earth imagery and Canadian Climate Historical Data were also reviewed during preparation of the present report.

It should be noted that no on-site investigation was carried out, and all recommendations provided in this report are based on the available information obtained from the general area of the subject site.

3.0 Site Description

3.1 Location

The Community of Pond Inlet is located on Eclipse Sound in the northeast portion of the Baffin Island at about 72°42' N and 77°59' W, approximately 525 air km southeast of Resolute Bay, 1050 air km north of Iqaluit, and 1883 air km northeast of Yellowknife.

As shown on Figure 1 and Figure 2, the subject site is located on the north side of Road R29, east of the Pond Inlet air strip, and on the southern end of the community.

3.2 Geology

The northeast corner of Baffin Island that is typified by steep snow-capped mountains, long U-shaped fiords and highland glaciers. The community of Pond Inlet is located on the tip of an extensive glacial moraine overlying bedrock. Both, bedrock outcrops and shallow bedrock could be encountered over various parts of the community. The typical bedrock composition in the region is Precambrian metamorphic gneiss. **Table 1** shows the depth to bedrock for previously investigated sites within Pond Inlet Community.

Table 1: Depth to Bedrock on Previous Investigation Sites

Site	Distance to Subject Site	Depth to Bedrock (m)	Terrain
Five-Plexes	About 200 m	> 11 m	
Nature Centre	About 1,500 m	0.9 to 1.4	Located near shoreline
Library	About 1,500 m	1.2 to 2.7	Located near shoreline
Hamlet Office	About 1,100 m	2.7 to 7.2	
Renewable Resources Office	About 1,500 m	7.5 to 7.6	Located near shoreline
Ulajuuk School	About 1,500 m	0.3 to over 10	Located near shoreline
High School Addition	About 900 m	4 to 6	

The glacial till consists mainly of sand with varying quantities of silt and gravel. Cobbles and boulders sized material within the unconsolidated soils also are common. Typical geological profile, representative for glacial deposits was encountered at the Hamlet Office and Ulajuuk School sites.

Marine deposits were possibly encountered at the Renewable Resources Office. These deposits consisted of sand and silt with variable amounts of gravel sized materials. The surface of the site was strewn with numerous large boulders, some as large as 1 m in diameter.

Glacial sand and silty sand at the Ulajuuk School site were found to contain almost no excess ice. However, ice interbeds, up to 0.4 m thick, were reported at the Renewable Resources Office site.

On the five- plexus site, which is about 200 m northeast of the subject site, interbedded glacial sand and silt layers were encountered during the pile installation in 2015. Gravel and cobbles were also encountered within the sand and silt layers. No bedrock was encountered within the maximum pile hole depth of 11.6 m below existing ground surface.

Ground temperatures measured at depths from 6 m to 10 m in various locations of the Pond Inlet Community were found to be in a range of –9.0°C to -12°C.

3.3 Surface Conditions

The subject site is located on the north side of Road R29. Based on the attached topographic survey data (Figure 2), the site is sloping from an elevation of 88 m on the east edge to an elevation of 85 m on the west edge over the distance of about 50 m. Slope stability is generally not a concern for construction activities on this site. Tundra vegetation covers the ground surface of the proposed construction site.

3.4 Climate

Environment Canada maintains a weather station in Pond Inlet with records available from 1922 to the present time. Based on the historical climate data available from Environment Canada website, over the period of record from 1976 to 2020 as shown on Figure 3 in Appendix A, the reported mean annual air temperature ranged from -16.5 °C to -10.8 °C. The average air temperature over the period of 1976 to 2020 was -14.1 °C with a linear temperature increasing trend of about 0.057 °C per year. The average freezing and thawing indices for the period of 1976 to 2020 were about 5569 degree-days and 446 degree-days, respectively.

3.5 Salinity

Reviewed reports indicate the porewater salinity values in a range from low salinity (3.5 part per thousand-ppt) to high (29.0 ppt, Renewable Resources Office/Warehouse) salinity. The average salinity, calculated as the mean arithmetic of the minimum and maximum values for all sites investigated, is about 15.5 ppt. Low salinity is considered to be less than about 5 ppt and high salinity is considered to be over 15 ppt. Salinity values in general have been noted to increase with depth.

3.6 Anticipated Subsurface Stratigraphy

The soil profile at the location of the subject site is expected to consist of sands and silt with varying amounts of gravel. Cobbles and boulders could be encountered in the sand layers. Based on the information from the site of five-plexus, bedrock may not be encountered at shallow depth.

3.7 Permafrost

Pond Inlet lies within the continuous permafrost zone. Based on The Homeowner's guide to Permafrost in Nunavut (2013), the permafrost thickness in Pond Inlet area is in the range of 600 m. The mean annual permafrost temperature at a depth of about 10 m is expected to be –9 °C to -12 °C, depending on the thickness of the snow cover and vegetation type. The thickness of the active layer will typically range from about 0.5 to 1.5 m. The minimum active layer could be encountered in moist/wet fine-grained deposits while the maximum active layer is typical for dry sandy deposits.

4.0 Geotechnical Recommendations

Based on the expected soil conditions, the Triodetic foundation system is a suitable foundation option for the proposed development on the subject site. Due to the uneven ground surface and uncertainty of the site, a gravel pad is recommended to be used to support the Triodetic foundation system.

4.1 Site Grading and Drainage

4.1.1 Grading

The areas of the proposed building footprints should be stripped of any organics. Where loose, soft, wet soils, or soils with excess ice content are identified at the footprint subgrade, such spots should be over excavated down to a stable subgrade and then should be backfilled with engineered granular fill material as outlined in Subsection 4.2.

The prepared subgrade of the building footprints should be proof-rolled with a loader, backhoe or other suitably sized construction equipment to confirm that soft, loose, or icy materials were not missed during stripping/backfilling.

4.1.2 Drainage

The prepared gravel pad should be outward shaped to reduce the potential for ponding water within the structure footprint. The finished grade within two meters from the building perimeter should be designed to provide surface drainage away from the structure at approximately a 3 percent slope. Roof and other drains should discharge runoff water at least 2 m away of the building perimeter.

4.2 Triodetic Foundation System

The Triodetic foundation system consists of an engineered steel/aluminum rigid tubular platform which is installed on the ground surface or gravel pad. The torsional tubular frame provides a reliable base for the building structure and is adjustable to accommodate an uneven settling/heaving ground surface.

For the proposed development, the Triodetic frame should be installed on a gravel pad of a minimum thickness of 200 mm. The subgrade for the granular pad should be prepared as outlined in Subsection 4.1.1. If the gravel pad surface will be higher than surrounding ground surface, a minimum gravel pad side slope of 2H:1V should be used for the construction.

Granular material for backfilling over-excavated loose/soft zones and for pad construction should be free of organics and ice, and contain less than 10 percent of fines. The gradation for gravel provided in **Table 2** is intended to serve as a guideline in specifying granular material.

Table 2: Gradation Requirement for Granular Backfill

Sieve Size (mm)	Percent Passing by Weight
25	100
20	95-100
10	60-80
4.75	40-60
2.36	28-48
0.6	13-29

0.3	9-21
0.15	6-15
0.075	4-10

All fill should be placed in lifts not exceeding 200 mm in loose thickness and should be compacted to not less than 98 percent of Standard Proctor Maximum Dry Density. The pad should be extended at least one meter beyond the perimeter of the building.

Construction of the gravel pad should be undertaken when the ambient air temperature is above 0 °C since adequate compaction of gravels cannot be readily obtained during freezing temperatures. If the gravel pad is planned to be constructed during the winter months, the gravel fill will need to be heated and the building footprint area hoarded. During periods of freezing temperatures, the required degree of compaction can only be achieved by using unfrozen gravel.

The unfactored ULS bearing capacity of the compacted granular pad may be taken as 600 kPa, and SLS bearing capacity may be taken as 200 kPa. Long term settlement of the granular pad may be expected to be in the order of 10 mm. The foundation bearing points can be supported on timber pads. The adequacy of the foundation against wind loads should be check by the project structural engineer.

The base of the buildings should be at least 600 mm above the final grade to permit air circulation under the structure. The building owners/operators should be advised that the air space should not be used for storage and should remain free and unobstructed year around. The air space should not be hoarded.

Frame leveling adjustments would be expected during the operation of the housing units.

4.3 Seismic Site Classification

In the National Building Code of Canada (NBCC, 2015), the seismic hazard is described by spectral acceleration values at various periods and the peak ground acceleration (PGA). The spectral acceleration is a measure of ground motion that takes into account the sustained shaking energy produced by an earthquake at a particular period. The spectral acceleration values for Pond Inlet under a 1 in 2,475-year earthquake were obtained from the Online Seismic Hazard Interpolator provided by Natural Resources Canada. **Table 3** summarizes the spectral acceleration for firm ground at the subject site.

Table 3: Spectral Acceleration (5% Damped) – NBCC 2015

Period (s)	PGA	Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)	Sa(10.0)
Acceleration	0.293g	0.447 g	0.231g	0.114g	0.054g	0.015g	0.005g

For foundation effects, the NBCC incorporates site effects by categorizing the subsoil into six types based on the average shear wave velocity (Vs) or standard penetration resistance (N60) for the upper 30 m.

The subsoil in Pond Inlet is generally frozen glacial moraine overlying shallow bedrock. In general, the shear wave velocity of frozen soil is estimated to be greater than 760 m/s. A site class B may be used for the design of the house unit.

5.0 Geotechnical Testing and Inspection

Recommendations presented in this report are preliminary and based on the present desktop geotechnical evaluation, using available geotechnical information close to the subject site. It is assumed that a geotechnical engineer will be required to confirm that the soil conditions encountered during preparation of the gravel pad subgrade are similar to these described in the present report. If encountered soil conditions will differ from the expected soil conditions, Wood should be informed as soon as possible, and adjustments to the foundation design will be made. Also, a geotechnical engineer should check a quality of granular material used for the pad construction and control level of the gravel (granular material) compaction. Recommendations presented herein may not be valid if an adequate level of inspection is not provided during construction, or if relevant building code requirements are not met.

All construction will be carried out by a suitably qualified contractor experienced in foundation and earthworks projects. Full time monitoring of the gravel pad construction and compaction testing is recommended.

Wood requests the opportunity to review the design drawings and review results of the earthwork, gravel pad construction and installation of the Triodetic foundation bearing points to confirm that the recommendations in the present desktop geotechnical evaluation have been correctly interpreted. Wood would be pleased to provide any further information that may be needed during design and to advise on the geotechnical aspects of specifications for inclusion in contract documents.

6.0 Closure

Soil conditions, by their nature, can be variable across a construction site. The placement of fill and prior construction activities on a site could contribute to variable near surface soil conditions. A contingency amount should be included in the construction budget to allow for the possibility of variations in soil conditions, which may result in modifications of the design, and/or changes in construction procedures.

The present desktop geotechnical evaluation has been prepared for the exclusive use of Kobayashi+Zedda Architects Ltd. for specific application to the proposed development. Any use that a third party makes of this report, or any reliance or decisions based on this report are the sole responsibility of those parties. The present geotechnical evaluation has been prepared in accordance with generally accepted soil and foundation engineering practices and is subject to the limitations outlined in Appendix B. No other warranty is expressed or implied.

Respectfully submitted,

Wood Environment & Infrastructure Solutions,
a division of Wood Canada Limited

REGISTERED PROFESSIONAL ENGINEER
LICENSEE
NT/NU

Nov 26, 2021

Yonggeng Ye, M.Sc., P.Eng.
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Reviewed by:

Nov. 26, 2021

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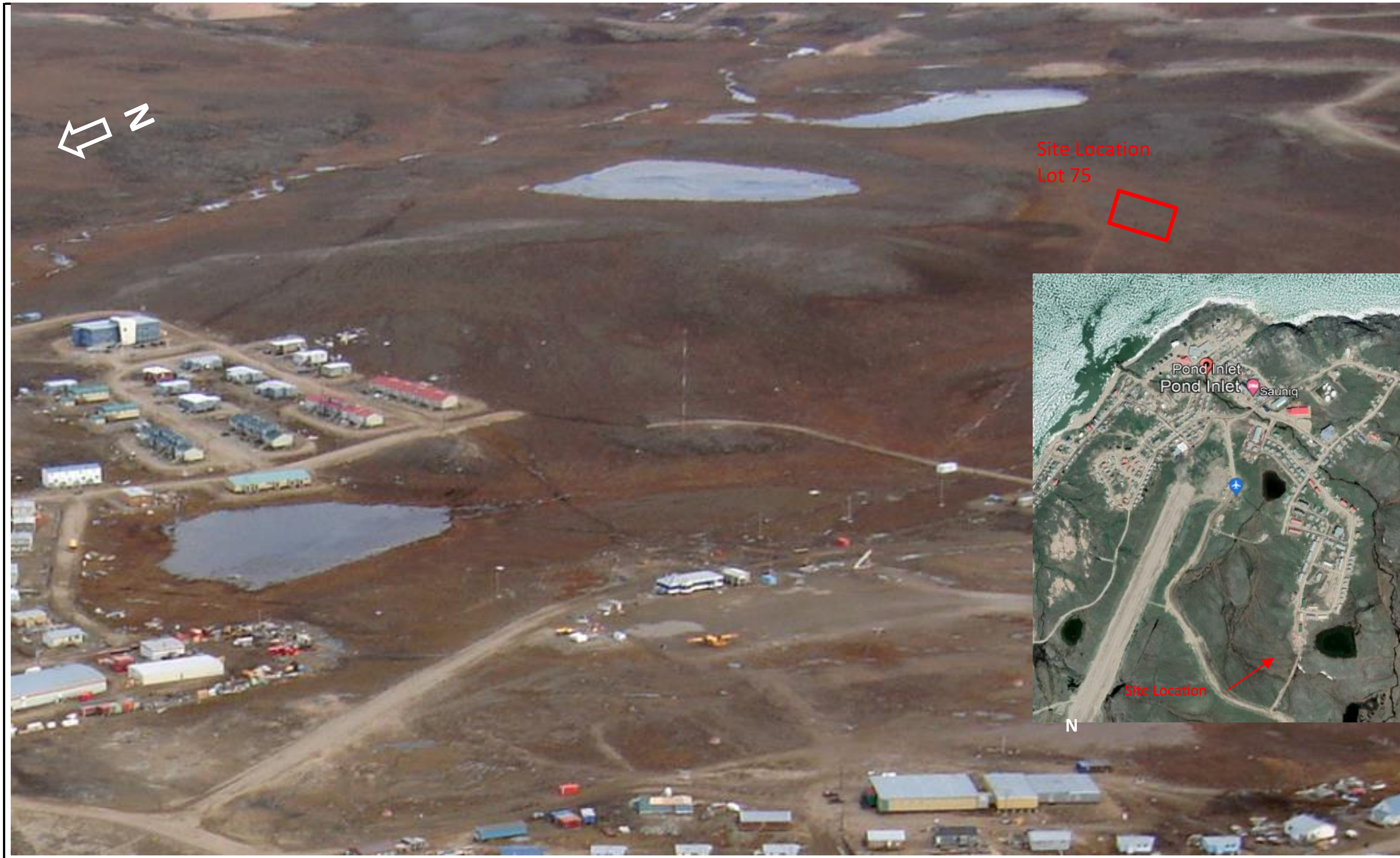
Senior Associate, Geotechnical and Permafrost Engineer

PERMIT TO PRACTICE
Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited
Signature
Date November 26, 2021
PERMIT NUMBER: P 047
NT/NU Association of Professional
Engineers and Geoscientists

Appendix A

Figures

Figure 1 - Site Location



wood.

CLIENT:

Kobayashi+Zedda Architects Ltd.

PROJECT:	**Pond Inlet Road R29 Residence**
TITLE:	**Site Location Plan**

DATE:	JOB No.:	FIGURE No.:	REV.
November 2021	EA16466	1	A

Figure 2 – Site Plan and Topography

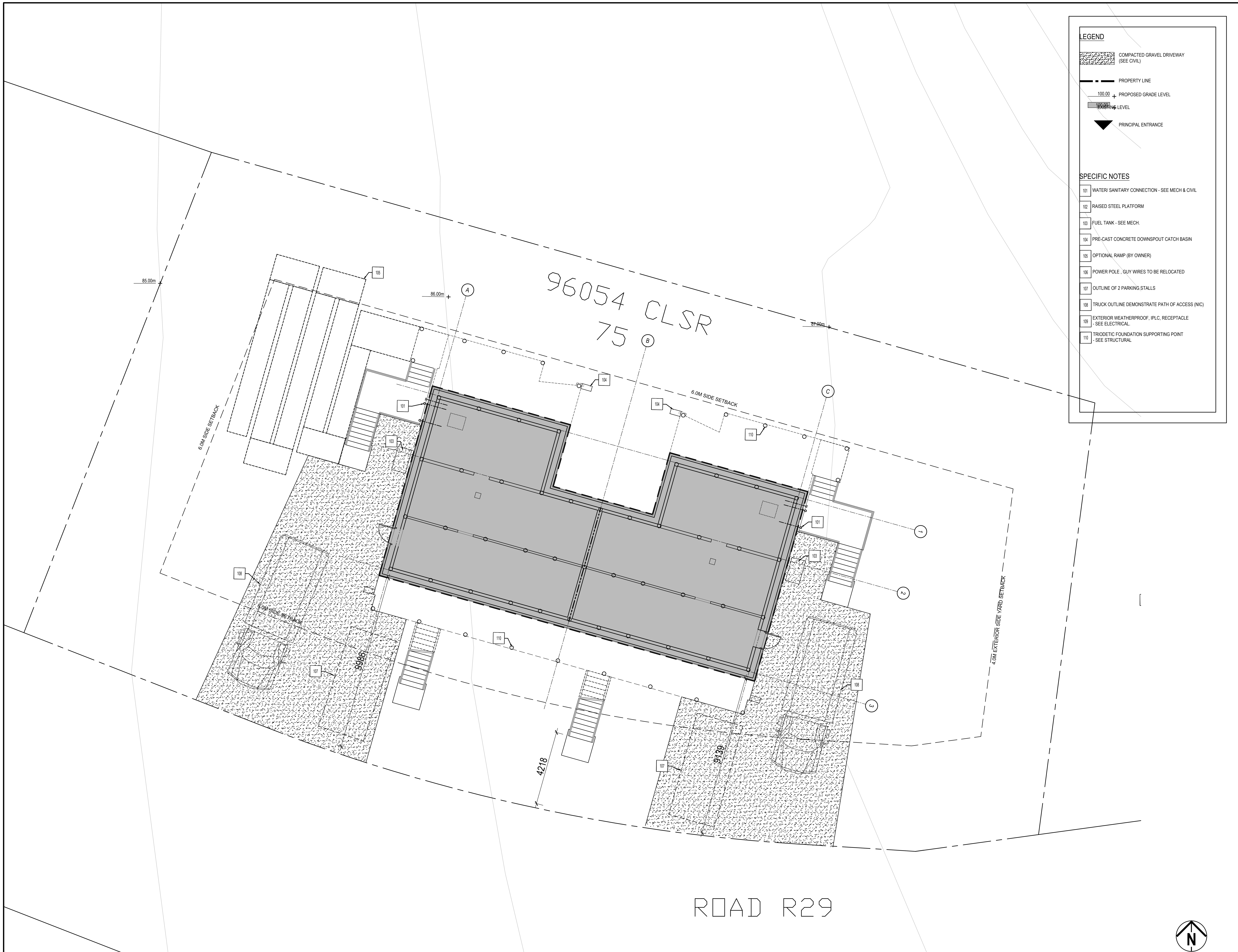


Figure 2 - Site Plan and Topography

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Revision	Description	Date
5		
4		
3		
2		
1		
0	66% CD SUBMISSION	2021/09/10

Client / client

PARKS CANADA AGENCY

Project title / Projet

GREENING NORTHERN HOUSING - POND INLET

Designed by / Conçu par
KOBAYASHI + ZEDDA ARCHITECTS LTD.

Drawn by / Dessiné par
SC

Approved by / Approuvé par

PWGSC Project Manager / Administrateur de Projets TPSGC

Drawing title / Titre du dessin

SITE PLAN

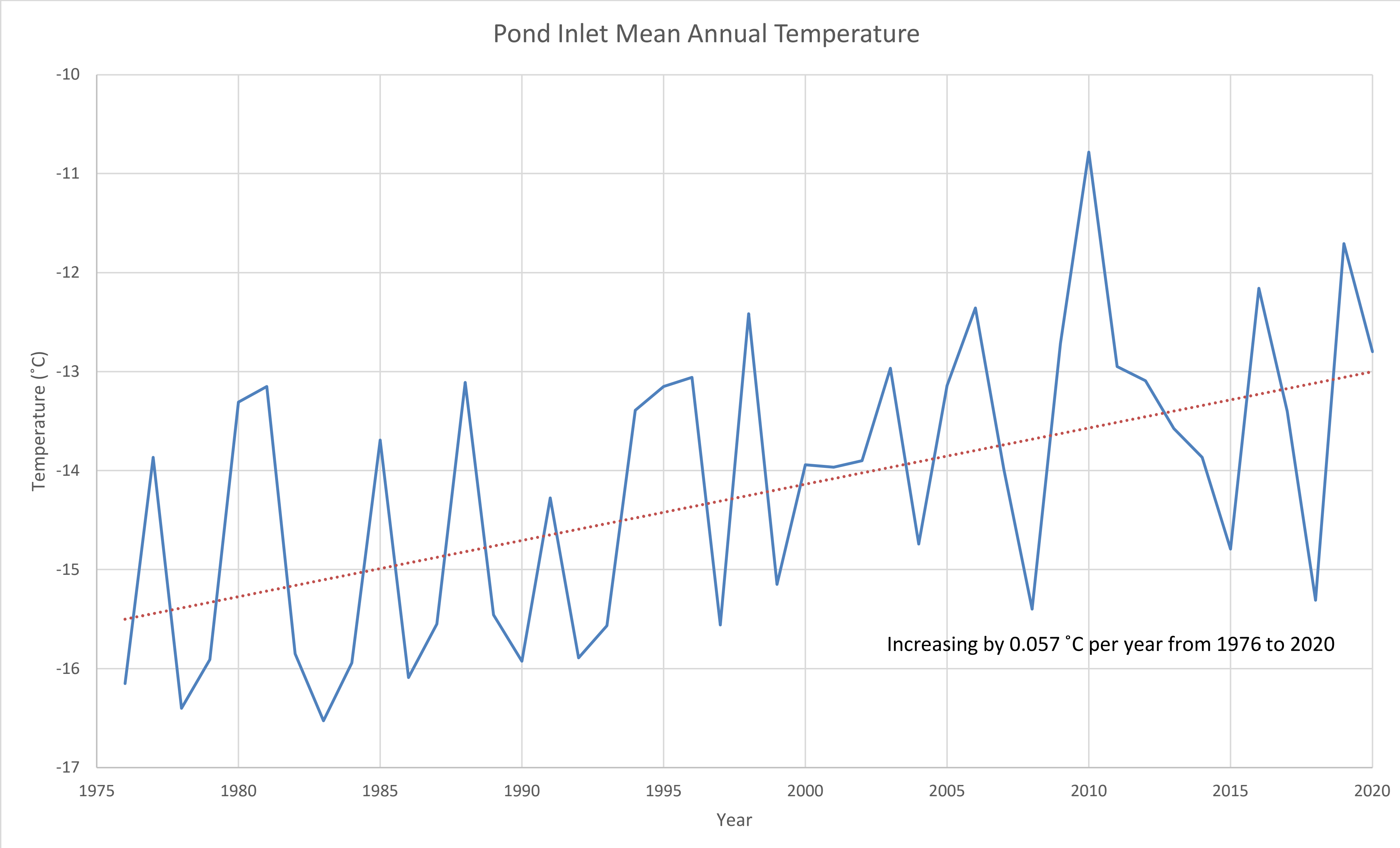
Project no./No. du projet	Drawing no./No. du dessin	Revision no.
	A1.01 OF XX	0

PWGSC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

A000

Figure 3 - Mean Annual Temperature of Pond Inlet



wood.

PROJECT:	**Pond Inlet Road R26 Residence**
TITLE:	**Pond Inlet Mean Annual Temperature**

CLIENT:

Kobayashi+Zedda Architects Ltd.

DATE:	JOB No.:	FIGURE No.:	REV.
November 2021	EA16466	3	A

Appendix B

Limitations

Limitations

The work performed in the preparation of this report and the conclusions presented herein are subject to the following:

a) The contract between Wood and the Client, including any subsequent written amendment or Change Order dully signed by the parties (hereinafter together referred as the "Contract");

b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by Wood to the Client in connection to the Contract; and

c) The limitations stated herein.

Standard of care: Wood has prepared this report in a manner consistent with the level of skill and care ordinarily exercised by reputable members of Wood's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guarantee, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.

Limited locations: The information contained in this report is restricted to the site and structures evaluated by Wood and to the topics specifically discussed in it, and is not applicable to any other aspects, areas or locations.

Information utilized: The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions and qualifications/limitations set forth in this report.

Accuracy of information: No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). Wood cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.

Report interpretation: This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by Wood.

No legal representations: Wood makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.

Decrease in property value: Wood shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.

No third-party reliance: This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or Contract. Any use or reproduction which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. Wood does not represent or warrant the accuracy, completeness, merchantability, fitness for purpose or usefulness of this document, or any information contained in this document, for use or consideration by any third party. Wood accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on this report or anything set out therein. including without limitation, any indirect, special, incidental, punitive or consequential loss, liability or damage of any kind.

Assumptions: Where design recommendations are given in this report, they apply only if the project contemplated by the Client is constructed substantially in accordance with the details stated in this report. It is the sole responsibility of the Client to provide to Wood changes made in the project, including but not limited to, details in the design, conditions, engineering or construction that could in any manner whatsoever impact the validity of the recommendations made in the report. Wood shall be entitled to additional compensation from Client to review and assess the effect of such changes to the project.

Time dependence: If the project contemplated by the Client is not undertaken within a period of 18 months following the submission of this report, or within the time frame understood by Wood to be contemplated by the Client at the commencement of Wood's assignment, and/or, if any changes are made, for example, to the elevation, design or nature of any development on the site, its size and configuration, the location of any development on the site and its orientation, the use of the site, performance criteria and the location of any physical infrastructure, the conclusions and recommendations presented herein should not be considered valid unless the impact of the said changes is evaluated by Wood, and the conclusions of the report are amended or are validated in writing accordingly.

Advancements in the practice of geotechnical engineering, engineering geology and hydrogeology and changes in applicable regulations, standards, codes or criteria could impact the contents of the report, in which case, a supplementary report may be required. The requirements for such a review remain the sole responsibility of the Client or their agents.

Wood will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Limitations of visual inspections: Where conclusions and recommendations are given based on a visual inspection conducted by Wood, they relate only to the natural or man-made structures, slopes, etc. inspected at the time the site visit was performed. These conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in Wood's opinion, for direct observation.

Limitations of site investigations: Site exploration identifies specific subsurface conditions only at those points from which samples have been taken and only at the time of the site investigation. Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions.

The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite this investigation, conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

Final sub-surface/bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports.

Bedrock, soil properties and groundwater conditions can be significantly altered by environmental remediation and/or construction activities such as the use of heavy equipment or machinery, excavation, blasting, pile-driving or draining or other activities conducted either directly on site or on adjacent terrain. These properties can also be indirectly affected by exposure to unfavorable natural events or weather conditions, including freezing, drought, precipitation and snowmelt.

During construction, excavation is frequently undertaken which exposes the actual subsurface and groundwater conditions between and beyond the test locations, which may differ from those encountered at the test locations. It is recommended practice that Wood be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered at the test locations, that construction work has no negative impact on the geotechnical aspects of the design, to adjust recommendations in accordance with conditions as additional site information is gained and to deal quickly with geotechnical considerations if they arise.

Interpretations and recommendations presented herein may not be valid if an adequate level of review or inspection by Wood is not provided during construction.

Factors that may affect construction methods, costs and scheduling: The performance of rock and soil materials during construction is greatly influenced by the means and methods of construction. Where comments are made relating to possible methods of construction, construction costs, construction techniques, sequencing, equipment or scheduling, they are intended only for the guidance of the project design professionals, and those responsible for construction monitoring. The number of test holes may not be sufficient to determine the local underground conditions between test locations that may affect construction costs, construction techniques, sequencing, equipment, scheduling, operational planning, etc.

Any contractors bidding on or undertaking the works should draw their own conclusions as to how the subsurface and groundwater conditions may affect their work, based on their own investigations and interpretations of the factual soil data, groundwater observations, and other factual information.

Groundwater and Dewatering: Wood will accept no responsibility for the effects of drainage and/or dewatering measures if Wood has not been specifically consulted and involved in the design and monitoring of the drainage and/or dewatering system.

Environmental and Hazardous Materials Aspects: Unless otherwise stated, the information contained in this report in no way reflects on the environmental aspects of this project, since this aspect is beyond the Scope of Work and the Contract. Unless expressly included in the Scope of Work, this report specifically excludes the identification or interpretation of environmental conditions such as contamination, hazardous materials, wild life conditions, rare plants or archeology conditions that may affect use or design at the site. This report specifically excludes the investigation, detection, prevention or assessment of conditions that can contribute to moisture, mold or other microbial contaminant growth and/or other moisture related deterioration, such as corrosion, decay, rot in buildings or their surroundings. Any statements in this report or on the boring logs regarding odours, colours, and unusual or suspicious items or conditions are strictly for informational purposes

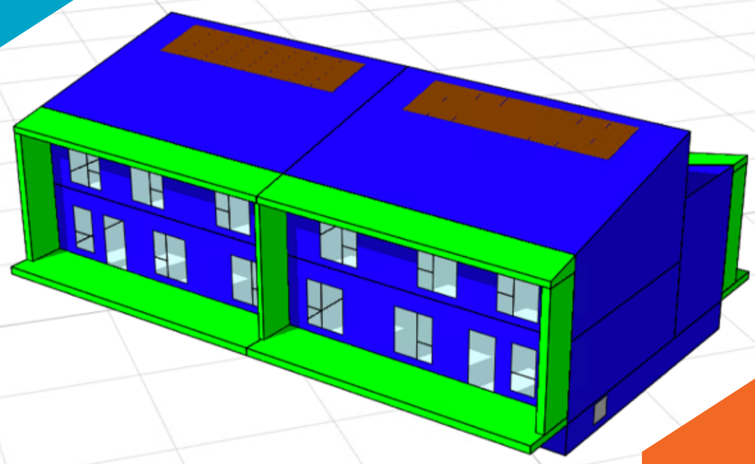
Sample Disposal: Wood will dispose of all uncontaminated soil and rock samples after 30 days following the release of the final geotechnical report. Should the Client request that the samples be retained for a longer time, the Client will be billed for such storage at an agreed upon rate. Contaminated samples of soil, rock or groundwater are the property of the Client, and the Client will be responsible for the proper disposal of these samples, unless previously arranged for with Wood or a third party.

Energy Modeling Report

Parks Canada Greening Northern Housing (99% Construction Documents)

Project No.: C20-895

Issued: December 23, 2021



ReNü ENGINEERING

Parks Canada Greening Northern Housing (99% Construction Documents)

Energy Modeling Report

Energy Modeler

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Revision	Notes	Date
0	Issued for client use	December 23, 2021

1 Executive Summary

ReNü Engineering was requested by Kobayashi + Zedda Architects to perform energy modeling on proposed new duplex housing buildings to be constructed in Inuvik, NT and Pond Inlet, NU.

Table 1: Annual estimated energy consumption in MWh

		Inuvik		Pond Inlet	
		This Analysis	DD Analysis	This Analysis	DD Analysis
Electricity	Pumps	0.2	0.2	0.2	0.2
	Fans	1.2	1.0	1.2	1.0
	Lighting/Plug Loads	10.2	10.2	10.2	10.2
Solar PV		-5.7	0.0	-5.0	0.0
Propane	Space Heating	23.8	24.6	31.8	34.7
	Domestic Hot Water	5.7	5.7	6.6	6.6
Total		35.3	41.7	45.0	52.7
TEDI (kWh/m^2)		55.7	57.6	69.4	75.7
MEUI (kWh/m^2)		82.0	83.7	105.8	112.9

TEDI for the Inuvik building is still below the target of 60 kWh/m^2 and the MEUI is still above the target of 75 kWh/m^2. The Pond Inlet building meets neither target due to the harsher climate and less efficient heating equipment.

Table 2: Annual estimated energy cost

		Inuvik	Pond Inlet
$	Fixed	$432	$432
	Electricity	$5,786	$8,315
	Natural Gas	$3,759	N/A
	Fuel Oil	N/A	$5,670
	Total	$9,977	$14,417

Table 3: Annual estimated greenhouse gas emissions (tCO_2e)

	Inuvik	Pond Inlet
Electricity	6.5	6.8
Propane	5.3	N/A
Fuel Oil	N/A	9.8
Total	10.1	15.2

Table of Contents

2 Introduction

2.1 Scope of Analysis

ReNü Engineering was requested by Kobayashi + Zedda Architects to perform energy modeling on proposed new duplex housing buildings to be constructed in Inuvik, NT and Pond Inlet, NU.

2.2 Information Provided

We have previously provided reports at the concept design (February 23, 2021), design variations (May 20, 2021), and design development (August 19, 2021) stages of the project. We have been provided with the following documentation for this update to the energy model:

- 99% design drawing set for Inuvik dated November 5, 2021
- 99% project manual for Inuvik dated November 5, 2021
- 99% design drawing set for Pond Inlet dated December 17, 2021
- 99% project manual for Pond Inlet dated December 17, 2021

2.3 Energy Modeling Software & Weather Data

IES VE 2021 energy modeling software was used to perform the energy modeling analysis. IES VE allows for calculation of building parameters such as space heating, space cooling, fans, pumps, lighting, hot water, plug loads, and human occupants in intervals of an hour or less and meets the requirements of ASHRAE 140 as required by the National Energy Code of Canada for Buildings (NECB) and Part 9.36.5 of the National Building Code of Canada (NBC) 2015.

The weather data below was used for each location.

Table 4: Location and climate information

	Inuvik	Pond Inlet
Location	Inuvik, NT	Pond Inlet, NU
Weather File[A]	2020 CAN_NT_INUVIK-A_2202571_CWEC.epw	2020 CAN_NU_POND-INLET-A_2403206_CWEC.epw
Heating Load Temp	-41.0°C	-42.1°C
Cooling Load Temp	29.0°C DB / 18.2°C WB	18.0°C DB / 12.9°C WB

[A] The model previously used weather data for Resolute Bay. 2020 weather files published by Environment Canada earlier this year expanded the list of locations in the territories and a weather file for Pond Inlet is now available. The Inuvik weather file was also updated to the most recent version.

3 Building Details

3.1 Building Geometry

The building's geometry is not significantly changed since our last report. The window & door at the rear entry have been separated where they were previously immediately adjacent. The site rotation for the Pond Inlet building was adjusted to match the new site.

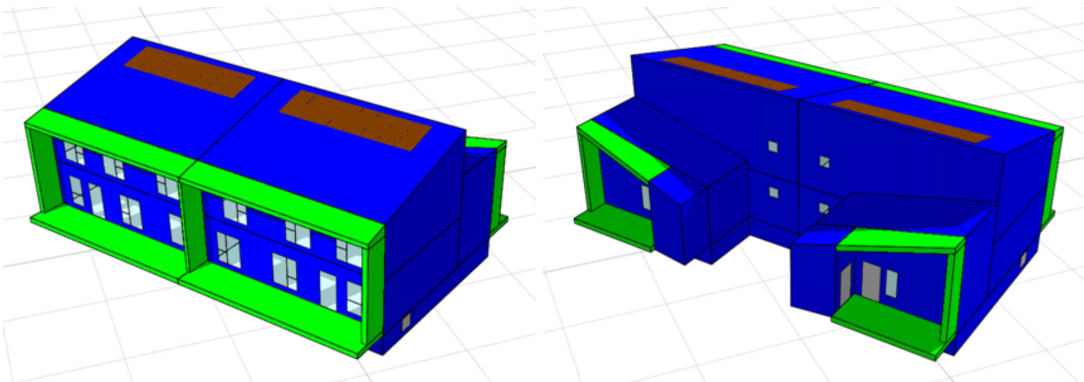

Figure 1: Building as modeled in this analysis.

Table 5: Building geometry summary

Wall Area[B]	571 m²
Roof Area	223 m²
Exposed Floor Area	216 m²
Window & Door Area	43 m²
Total Envelope Area	1009 m²
Floor Area	376 m²
Volume	1650 m³

[B] Excludes cold storage room exterior wall area, includes area of internal wall between main building and cold storage room.

3.2 Building Envelope

The building wall assemblies and resulting thermal transmittance values are summarized below. Components that provide negligible resistance to conductive heat transfer (e.g. air or vapour barrier membranes, metal cladding) are not included in the thermal transmittance calculation. The assignment of assemblies to the energy model is shown in Figure 1.

Table 6: Modeled assembly U-values

<table>
<tr><th></th><th></th><th>Inuvik</th><th>Pond Inlet</th></tr>
<tr><td rowspan="2">Wall</td><td>EW1</td><td colspan="2">Metal cladding
38 mm horizontal wood strapping (modeled as air cavity)
38 mm vertical wood strapping (included in air cavity above)
102 mm semi-rigid mineral wool (R-16)
311 mm structural insulated panel (R-54.7)
13 mm plywood
140 mm fiberglass batt (R-24 nominal) w/wood studs @ 400 mm OC (-25% insulating value)
16 mm gypsum
Base wall U-value: 0.062 (R-91.6)
Thermal bridging calculated as shown in Table 7
Overall U-value: 0.067 (R-84.8)</td></tr>
<tr><td>EW2</td><td colspan="2">Metal cladding
38 mm wood strapping (modeled as air cavity)
13 mm plywood
140 mm wood studs @ 400 mm OC without insulation (modeled as air cavity)
13 mm plywood
U-value: 1.44 (R-3.9)</td></tr>
<tr><td>Roof</td><td>R1</td><td colspan="2">Metal cladding
76 mm wood strapping (modeled as air cavity)
102 mm semi-rigid mineral wool (R-16)
311 mm structural insulated panel
13 mm plywood
140 mm fiberglass batt (R-24 nominal) w/wood joists @ 400 mm OC (-25% insulating value)
95 mm air cavity w/wood joists as above (modeled as air cavity)
16 mm gypsum
Base roof U-value: 0.061 (R-92.7)
Thermal bridging calculated as shown in Table 8
Overall U-value: 0.063 (R-90.2)</td></tr>
</table>

<table>
<tr><th></th><th></th><th>Inuvik</th><th>Pond Inlet</th></tr>
<tr><td>Exposed Floor</td><td>F1</td><td colspan="2">19 mm plywood
311 mm structural insulated panel (R-54.7)
203 mm semi-rigid mineral wool (nominal R-32) w/thermally broken clip system (-25% insulating value)
19 mm air cavity
Metal paneling
U-value: 0.070 (R-81.6)</td></tr>
<tr><td rowspan="2">Interior Wall</td><td>W2</td><td colspan="2">16 mm drywall
13 mm plywood
140 mm fiberglass batt w/wood studs @ 400 mm OC
16 mm drywall
Overall U-value: 0.322 (R-17.7)</td></tr>
<tr><td>W3</td><td colspan="2">16 mm drywall
13 mm plywood
89 mm fiberglass batt w/wood studs @ 400 mm OC
25 mm air space
89 mm fiberglass batt w/wood studs @ 400 mm OC
13 mm plywood
16 mm drywall
U-value: 0.244 (R-23.3)</td></tr>
<tr><td>Interior Floor</td><td>F2</td><td colspan="2">19 mm plywood
Air cavity
16 mm drywall
U-value: 1.55 (R-3.7)</td></tr>
<tr><td rowspan="3">Window</td><td>Fixed</td><td colspan="2">Triple pane, 2x low-e (180/180), argon fill, SS spacer
Glass U-value: 0.74, SHGC: 0.56
Cascadia Universal series framing
Overall U-value: 0.85</td></tr>
<tr><td>Awning</td><td colspan="2">Same glass and framing as above
Overall U-value: 0.97</td></tr>
<tr><td>Casement</td><td colspan="2">Same glass and framing as above
Overall U-value: 0.91</td></tr>
<tr><td rowspan="2">Door</td><td>Glazed Door</td><td colspan="2">Same glass and framing as above
Overall U-value: 0.85</td></tr>
<tr><td>Opaque</td><td colspan="2">Insulated steel slab with wood edge in wood frame[C]
U-value: 0.91</td></tr>
</table>

[C] Obtained from ASHRAE Handbook – Fundamentals 2017, Chapter 15.

		Inuvik	Pond Inlet
	Crawlspace Entry	51 mm polyurethane insulated metal door w/metal frame[C] U-value: 1.59 (R-3.6)	
Air Leakage	House	0.4 ACH @ 50 Pa blower door test pressure Equivalent to 0.1 ACH @ 5 Pa 46 L/s	
	Cold Storage	Assumed 2.0 ACH @ 50 Pa Equivalent to 0.5 ACH @ 5 Pa	

Calculation of thermal bridging associated with windows/doors and penetrations through the building envelope is done using the method in the Building Envelope Thermal Bridging Guide v1.5. A linear transmittance for wall corner, roof-to-wall, and wall-to-floor transitions is not included because the model geometry is measured to the exterior of the building. This will result in negative linear transmittances for these details if finite element analysis was performed. Leaving them out will overestimate heat loss through the envelope.

Table 7: Wall assembly EW1 thermal bridging calculation

Transmittance Type	Description	Quantity		Transmittance		Heat Flow (W/K)	% Total
Clear Field	EW1 wall assembly	553	m²	0.062	W/m²·K	34.3	93%
Linear Interface	Window frame	95	m	0.021	W/m·K	2.0	5%
Linear Interface	Door frame	25	m	0.022	W/m·K	0.5	1%
				0.067	W/m²·K	36.8	100%

Table 8: Roof assembly R1 thermal bridging calculation

Transmittance Type	Description	Quantity		Transmittance		Heat Flow (W/K)	% Total
Clear Field	R1 roof assembly	223	m²	0.061	W/m²·K	13.6	98%
Point Interface	Roof anchor (to represent chimney)	1	ea	0.340	W/K	0.3	2%
				0.063	W/m²·K	13.9	100%

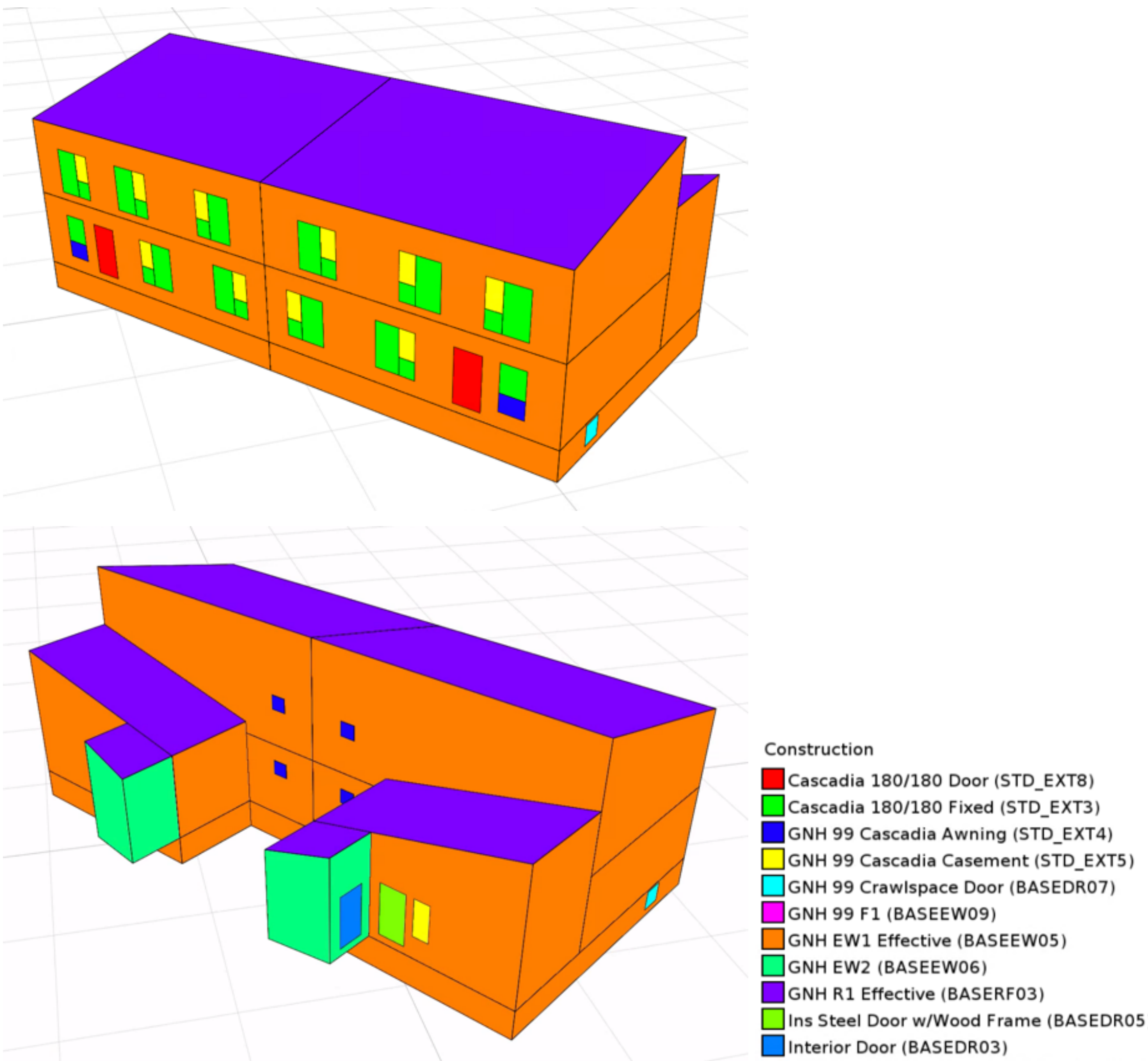

Figure 2: Building energy model showing proposed building assemblies.

3.3 Internal Gains & Electrical Consumption/Production

Table 9: Modeled internal gains

	Inuvik	Pond Inlet
Internal Gains	993 W/suite peak to represent lighting and plug loads Variation profile as shown in BCBC 2018 Table 9.36.5.4	
Exterior Lighting Car Plugs Electrical Heat Trace	Not included in model	
Solar PV System	System sized for at least 5,409 kWh annual production (results in system size of 6.4 kW in model)	System sized for at least 4,833 kWh annual production (results in system size of 5.2 kW in model)

3.4 HVAC

Table 10: Modeled HVAC systems

	Inuvik	Pond Inlet
Heating	88% efficient propane combi boiler	82% efficient fuel oil combi boiler
	Heating set to 21±0.5°C in main areas, 15±0.5°C in entry/crawlspace	
Boiler Pump	Variable speed ECM pump	
Ventilation	85% sensible/70% latent effective heat recovery, no preheat required, hydronic reheat to 20°C 45 L/s per suite operating 8 h/day 2.32 W per L/s per fan Ventless heat pump dryer Ventless recirculating kitchen range hood	
Air Conditioning	Not provided, cooling by operable windows opening at 25°C	

3.5 Hot Water

Table 11: Modeled hot water systems

	Inuvik	Pond Inlet
Hot Water Use	140 L/d per suite Variation profile as shown in BCBC 2018 Table 9.36.5.8 4.3°C cold water temp, 55°C hot water temp	
Water Heating	95% efficient propane combi boiler[D]	82% efficient fuel oil combi boiler
Hot Water Recovery	Drain water heat recovery 30% efficient Assume 15% reduction in hot water heating energy	

[D] This differs from the efficiency stated for building heating because the boiler efficiency varies depending on boiler water return temperature. When operating to meet hot water demands the water entering the boiler will be cooler, allowing operation in condensing mode and increasing efficiency.

4 Energy Model Results

4.1 Energy Consumption

Table 12: Annual estimated energy consumption in MWh

		Inuvik		Pond Inlet	
		This Analysis	DD Analysis	This Analysis	DD Analysis
Electricity	Pumps	0.2	0.2	0.2	0.2
	Fans	1.2	1.0	1.2	1.0
	Lighting/Plug Loads	10.2	10.2	10.2	10.2
Solar PV		-5.7	0.0	-5.0	0.0
Propane	Space Heating	23.8	24.6	31.8	34.7
	Domestic Hot Water	5.7	5.7	6.6	6.6
Total		35.3	41.7	45.0	52.7
TEDI (kWh/m²)		55.7	57.6	69.4	75.7
MEUI (kWh/m²)		82.0	83.7	105.8	112.9

Energy use, TEDI, and MEUI have all decreased as a result of updating to the latest 2020 weather files published this year by Environment Canada.

TEDI for the Inuvik building is still below the target of 60 kWh/m² and the MEUI is still above the target of 75 kWh/m². The Pond Inlet building meets neither target due to the harsher climate and less efficient heating equipment.

4.2 Energy Costs

Table 13: Annual estimated energy cost

		Inuvik	Pond Inlet
$	Fixed	$432	$432
	Electricity[E]	$5,786	$8,315
	Natural Gas	$3,759	N/A
	Fuel Oil	N/A	$5,670
	Total	$9,977	$14,417

Cost for each type of energy are summarized below. Unless otherwise noted, rates are from Arctic Energy Alliance's Winter 2020 Fuel Cost Library.

Table 14: Energy content and cost for energy sources

Energy Source	Inuvik Rate	Pond Inlet Rate	Unit	Energy Content	Note
Electricity	$36[F]	$36	Per month	-	Inuvik rate from NTPC
	$0.727[G]	$1.029	kWh	0.001 MWh/kWh	Pond Inlet rate from Qulliq Energy Corporation
Solar PV	$0.00	$0.00	kWh	0.001 MWh/kWh	Assumed that there is no credit for electricity sent to the grid
Natural Gas	$35.44	N/A	GJ	0.278 MWh/GJ	Equates to $127/MWh
Fuel Oil	$1.57	$1.60	L	0.011 MWh/L	Pond Inlet rate based on Ulukhaktok

[E] This cost for electricity is the expected cost including savings from onsite PV production.

[F] Assumes there is a separate meter for each unit.

[G] Rate assumes that Parks Canada is not eligible for the GNWT Territorial Power Support Program.

4.3 Greenhouse Gas Emissions

Table 15: Annual estimated greenhouse gas emissions (tCO_2e)

	Inuvik	Pond Inlet
Electricity	6.5	6.8
Propane	5.3	N/A
Fuel Oil	N/A	9.8
Total	10.1	15.2