Highway 1 Jean Marie River Bridge Replacement Northwest Territories Geotechnical Investigation

Prepared for: Government of the Northwest Territories Department of Infrastructure

Prepared by: Maskwa Engineering Ltd.

MASKWA ENGINEERING LTD
Yellowknife 867-873-6319
Hay River 867-874-2207
Fort Smith 867-872-2812

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1. INTRODUCTION

Maskwa Engineering Ltd. (Maskwa) has teamed with Jacob's Engineering (Jacob's) to provide engineering services to the Government of the Northwest Territories Department of Infrastructure (Client), for the replacement of the Jean Marie River Bridge Located at Km 411.2 on Mackenzie Highway No. 1, Approximately 65km South of Fort Simpson. The objective of this report is to document the site conditions during the time of drilling and provide subsurface soil, groundwater, and permafrost conditions. Based on drilling, in-situ, and laboratory testing; geotechnical comments and recommendations will be made to aid in the foundation design and selection.

Note: Use of this report is subject to conditions outlined in the Important Information and Limitations that follow the main text and form an integral part of the report.

1.1 Project Information

The existing structure is a single-span half-through pony truss bridge over the Jean Marie River, originally constructed in 1969. Based on the structural analysis for the pony truss system, the superstructure has been deemed to have insufficient capacity for CL625 and CL800 Loads. It has been evaluated to be more beneficial to replace the structure vs strengthening the existing structure. (GNWT RFP Architectural and Engineering Services)

The current structure spans approximately 40m and is supported by driven wooden piles located under concrete abutments at either end. Maskwa's understanding is that the replacement structure is to consist of a single span similar to the existing bridge, with abutments located in similar locations to that of the current structure.

1.2 Scope of Work

Maskwa's understanding of the required geotechnical scope is listed below:

- Drill up to 8 boreholes within proximity to the bridge abutments and approaches.
- Monitor drilling and collect samples for laboratory testing.
- Conduct laboratory testing for the determination of soil classification and material properties.
- Prepare a report to document the subsurface conditions encountered at the site.
- Provide soil parameters to aid in the design of the foundation.
- Provide recommendations for the bridge foundation system.
- Provide recommendations for the embankment reconstruction.

2. SITE DESCRIPTION AND GEOTECHNICAL OBJECTIVES

2.1 Site Description

The site can be described as well-drained on both the North and South approaches, with light to moderate vegetation beginning to grow within the road right of way. On the Southeast approach is an access ramp that is believed to be used as a boat launch, and on the Northeast approach is an access road to a bed and breakfast which operates seasonally in the summer months. To the Northwest of the bridge is an environmental monitoring station. See Appendix A for a site map indicating the above-mentioned site features.

The surficial geology of the above-mentioned site can be described as an alluvial flood plain consisting of silt, sand, and gravel which typically ranges from 1-8m in thickness before encountering bedrock. (Canadian Geoscience Map)

2.2 Climate

The mean annual air temperature has been recorded to be -3.2℃ from 1976 to 2005. The mean annual air temperature is expected to increase to 0℃ on the low end and to 1.5℃ on the high end from 2051 to 2080. The mean annual precipitation has been recorded to be 351mm from 1976 – 2005 and is expected to increase to 412mm from 2051 – 2080. (Climate Atlas of Canada Fort Simpson)

2.3 Permafrost Conditions

The Jean Marie River Bridge is located in a sporadic discontinuous permafrost zone where 10-50% of the land is underlain by permafrost. Due to the site having had vegetation removed for a long period, permafrost is not expected to be present, however; seasonal frost is expected and should be accounted for in the design of the foundation. (Environment and Climate Change State of Permafrost)

2.4 Geotechnical objectives

The objectives maintained by the drilling program consist of:

- Determining the subsurface soil strata.
- Determining Depth, Type, and Quality of bedrock.
- Observing the seasonal frost depth.
- Measuring the groundwater depth.
- Obtaining soil samples for laboratory analysis.
- Determining soil consistency throughout the site.
- Performing field tests on Insitu soils such as temperature readings, vane shear testing, pocket pen readings, and standard penetration testing where applicable.

3. METHODOLOGY

3.1 Site Investigation

Before geotechnical drilling, an initial site visit was made on March 13, 2023, to arrange for snow removal, verify the feasibility of target borehole locations, and identify/locate existing survey control monuments. During the site visit 1.0 – 1.2m of snow was observed throughout the ditches, approximately 76mm of ice thickness was measured on the bridge deck, and the river ice thickness appeared to be 200 – 300mm until the riverbed as rocks and areas of the riverbed were observed to be exposed both upstream and downstream.

3.2 Geotechnical Drilling

The geotechnical drilling program was conducted on March 17, 18, and 19, 2023 using a tracked drill rig operated by Mobile Augers under the direction of Maskwa representatives Clell J. Crook (CET B.Eng) and Robert Johnson (P.Eng Senior Geotechnical Engineer). The rig was equipped with a 100mm solid stem continuous flight auger with 1.5m auger flights, a Tricone drill bit, a rock drill bit, NQ coring capabilities, and an auto hammer for Standard Penetration Testing (SPT) compliant with ASTM D1586.

A total of 5 boreholes were drilled in depths ranging from 5.2 meters below ground surface (mbgs) to 12.7mbgs. The boreholes were drilled at the NW approach, NE abutment, SW abutment, SE Temporary bridge location, and SW approach. All borehole locations are shown on the Borehole Location Map in Appendix A.

Drill Monitoring

The above-noted Maskwa representatives monitored drilling for changes in drill behavior as the holes were advanced until their completion depths. Changes encountered during drilling were noted such as seasonal frost depth, or the slowing of drill advancement due to encountering hard spots. Comments regarding seasonal frost depth are documented on the borehole logs in Appendix A.

Temperature Readings

Temperature readings were typically taken at regular 1.5m intervals using a Raytek MT6 laser temperature gun as the holes were advanced to their completion depths. There are some cases where temperature readings are not recorded until 3.0mbgs due to having to advance using the tricone bit and no representative soil recovered as a result of seasonal frost.

Error:

- Increased heat in temperature readings due to friction during rock coring.
- Decreased heat in temperature readings due to exposure to ambient air.

Standard Penetration Testing

SPTs typically occurred in 1.5m intervals where practical using a split barrel sampler and core catchers for sample recovery. No testing was conducted in frozen soil, or after refusal was encountered as long as there was not a change in soil/bedrock conditions.

Sampling

Grab samples were retrieved off of the solid stem auger flights or using the split barrel sampler while performing SPTs and rock core samples were retrieved at the abutment locations after encountering bedrock.

Borehole Advancement Descriptions:

BH-01: (NW Approach)

Borehole 1 was drilled approximately 0.5m off the Northwest shoulder of the road to a completion depth of 5.2mbgs using a solid stem auger and performing SPTs at regular 1.5m intervals.

BH-02: (NE Abutment)

Borehole 2 was advanced using a tricone drill bit due to hard drilling conditions as a result of seasonal frost. Drill casing was installed to prevent sloughing of material for more accurate SPT results. The hole was advanced to 6.0mbgs using the tricone bit until bedrock was encountered where the drilling method was switched to rock coring until a completion depth of 11.2mbgs.

BH-03: (SW Abutment)

Borehole 3 was advanced using a tricone drill bit due to hard drilling conditions as a result of seasonal frost. Drill casing was installed to prevent sloughing of material for more accurate SPT results. The hole was advanced to 7.5mbgs using the tricone bit until bedrock was encountered where the drilling method was switched to rock coring until a completion depth of 12.7mbgs.

BH-04: (SE Temporary Bridge)

Borehole 4 was drilled to the East of the bridge at the boat launch area to a completion depth of 6.0mbgs using a solid stem auger and performing SPTs at regular 1.5m intervals.

BH-05: (SW Approach

Borehole 5 was drilled approximately 1.0m off the Southwest shoulder of the road to a completion depth of 7.6mbgs using a solid stem auger and performing SPTs at regular 1.5m intervals.

3.3 Laboratory Testing

All Laboratory testing was performed by Clifton Engineering in a CCIL Certified laboratory. Descriptions of the test standards used can be viewed on the test result sheets in Appendix C.

Tests conducted on the retrieved samples during drilling consist of the following:

- Moisture Contents.

- Particle size Analysis (Sieve and Hydrometer).
- Atterberg Limits.
- Density and unit weight analysis.
- Axial and Diametral Point Load Testing.
- Soluble Sulfate analysis.
- Corrosion Testing.

4. GEOTECHNICAL DRILLING

4.1 Site Conditions

During drilling activities the majority of the site was covered with 1.0 - 1.2m of snow, however; in areas where the snow had been removed, it was observed that there was a light to moderate layer of vegetation with shrubs beginning to grow over top of the typical alluvial flood plain area of the site. Approximately 76mm of ice was recorded to be covering the existing bridge deck, and the river conditions appeared to be generally low as rocks were observed to be exposed throughout the river both upstream and downstream of the bridge location. It has been identified by Northwestel that fiberoptic utility lines run parallel on both the East and West sides of the bridge. The weather and temperatures recorded during drilling are listed below

- March 17: Slight overcast in the morning to sunny in the afternoon (-17C to 0.4C)
- March 18: Sunny (-18.3C to 2.5C)
- March 19: Sunny (-13C to 2.2C)

4.2 Subsurface Conditions

The subsurface soil conditions remained generally consistent at all borehole locations and are briefly described below. This section describes the typical soil profile that was observed at all borehole locations, however; for more specific details regarding each borehole location refer to the borehole logs in appendix A and soil lab results in appendix C. Please refer to Appendix B for photos taken during drilling.

Silty Sand Mixed with Fractured Granular

For all boreholes drilled along the highway BH-01, BH-02, BH-03 a well graded silty sand mixed with fractured granular from approximately 0-3.0mbgs.

Grey Clay Till

A layer of grey clay till with varying thickness was encountered from 3.0 - 4.5mbgs. Pocket pen readings range from 2.0 – 3.5 kg/cm^2, depths of readings can be viewed on the borehole logs.

Alluvial deposits

Alluvial deposits in the form of brown sand mixed with rounded gravel and trace organics were encountered at depths ranging from 3.0 to 7.5 mbgs.

Bedrock

Bedrock was encountered at all borehole locations. The bedrock starting depth ranges from 4.6 mbgs to 7.6 mbgs and continues to the end of each borehole location. The bedrock encountered can be described as a fine-grained light grey to greyish-brown mudstone. For further information refer to the borehole logs in Appendix A and the core logging report in Appendix C.

4.3 Groundwater Conditions

The groundwater table (GWT) was encountered at approximately 6.0 mbgs (200.73 meters above mean sea level (MAMSL)) at BH-03 and 2.4 mbgs (200.84 MAMSL) at BH-04. A groundwater monitoring well was installed at BH-04 so groundwater conditions can be monitored. Due to low permeability conditions of the bedrock, soils below the ground water table remain unsaturated.

4.4 Ground Ice Conditions

During drilling no permafrost was encountered in any of the holes, however; seasonal frost on untraveled surfaces was recorded up to 0.75mbgs, and seasonal frost on traveled surfaces was recorded up to 3.0mbgs. It is important that uplift forces as a result of seasonal frost be accounted for in the design at the discretion of the design engineer based on the soil conditions provided.

5. GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

5.1 General

The geotechnical comments and recommendations made in this section of the report outline soil parameters to be used in the design of the foundation based on data obtained through Insitu and laboratory testing. It is intended that the recommendations made are to aid the design of foundation elements and embankment reconstruction.

5.2 Limit States Design

Maskwa recommends using resistance factors from the 2019 Canadian Highway Bridge Design Code (CSA S6:19) when selecting resistance factors for both Ultimate Limit States Design (ULS) and Serviceability Limit States (SLS). Below is a table summarizing Table 6.2 of CSA S6:19 for the geotechnical resistance factors to be used for deep foundations. Based on Maskwa's understanding of the soils present at the site typical resistance factors are adequate for the design of the foundation.

Geotechnical Resistance Factors For Deep Foundation Design			
	Degree of Understanding		
Limit State	Low (ϕ)	Typical (ϕ)	High (ϕ)
Compression (Static Analysis)	0.35	0.4	0.45
Compression (Static Test)	0.5	0.6	0.7
Compression (Dynamic Analysis)	0.35	0.4	0.45
Compression (Dynamic Test)	0.45	0.5	0.55
Tension (Static Analysis)	0.2	0.3	0.4
Tension (Static Test)	0.4	0.5	0.6
Lateral (Analysis)	0.45	0.5	0.55
Lateral (Static Test)	0.45	0.5	0.55
Settlement or Lateral Deflection (Static Analysis)	0.7	0.8	0.9
Settlement or Lateral Deflection (Static Test)	0.8	0.9	1

Table 1: Geotechnical Resistance Factors

Note: For further detail refer to CSA S6:19

5.3 Suggested Soil Parameters

Based on the field and lab testing results obtained throughout the geotechnical program the below table highlights the recommended unfactored geotechnical parameters to be used in the design of the foundation.

Soil Parameters			
Parameters	Silty Sand	Clay Till	Alluvial Deposits
Depth Range (mbgs)	0-3.0	3.0-4.5	3.0-7.5
Unit Weight (KN/M^3)	16.0-20.5	12.5-17.5	12.5-21
Effective Friction Angle (Degrees)	27-32	27-30	31-34

Table 2: Soil Design Parameters

Suggested/Estimated Bed Rock Parameters	
Parameters	Bed Rock
Depth Range (mbgs)	4.6-12.7
Unit Weight (KN/M^3)	22-24
Diametral Point Load (mPa)	0.10-0.18
Axial Point Load (mPa)	0.14-1.44
Effective Friction Angle (Degrees)	17-19
Rock Quality Designation (RQD) %	38-58
Total Core Recovery (TCR) Meters	2.1-4.1

Table 3: Bedrock Parameters

5.4 Foundation Recommendations

Based on the soil conditions at the Jean Marie River Bridge site, driven steel H piles are recommended to be used as the foundation system. Suggested pile parameters are presented in Table 4 and are based on the assumption that the piles are installed with the top of the pile at a similar elevation to that of the existing base of the abutments (205.00 MAMSL).

Unfactored Suggested Pile Design Parameters			
Layer	Depth (m)	Skin Friction (kPa)	End Bearing (kPa)
1	0-5	-10	
2	5-6	0	
3	6-9	120	
4	9-12	140	
5	12-15	140	1250

Table 4: Suggested Pile Design Parameters

Maskwa recommends a minimum pile embedment depth of 15.2m from the assumed installation elevation. Pile monitoring coordinated by a geotechnical engineer shall occur during the installation to ensure piles achieve theoretical capacity. Pile design shall be performed by an experienced engineer.

Please note the following design considerations:

- Follow design procedures in CSA S6 19 Canadian Highway Bridge Design Code and other relevant codes of the area.

- Boulders or large objects may be encountered during pile driving resulting in pile deflection and this shall be considered during the design to ensure there is a reasonable tolerance for the pile-to-abutment connection in such case.

- Pile corrosion shall be accounted for so that the piles maintain sufficient structural capacity throughout their design life.

- The closest the piles should be spaced is 2.5 times the pile diameter.

- The piles shall not be driven past practical refusal to avoid damage, where practical refusal is 10 blows per 25mm for the last 250mm or as specified in the field by a qualified engineer.

- Use pile-driving shoes to reduce damage to the pile ends.

- Pile installation monitoring is to be performed by qualified personnel.

- Compare Field Measured Pile Capacity to theoretical pile capacity, where the pile capacity can be determined by the application of the following formula:

$$Qa = \frac{2WrH}{S+C}$$

Equation 1:

Where:

Qa = allowable pile capacity
Wr = Weight of Hammer
H = Drop height of hammer
S = Penetration per blow
C = 1.0 for drop hammer (25 for SI units)
C = 0.1 for steam hammer (2.5 for SI Units)
Note: Other pile monitoring methods and techniques may be implemented at the time of pile installation for the determination of pile field capacity.

5.5 Pile Group Effects

Typically, piles must be spaced a minimum of 2.5 times the pile diameter for friction piles and 3 times the pile diameter for end-bearing piles to act as an individual pile and minimize group effects. When piles are spaced closer than mentioned above pile group reduction factors must be accounted for in the design. Pile group reduction factors depend on soil types, loading, method of installation overall shape of piles, and layout of the pile group. Based on the above mentioned a qualified engineer should review the final design and recommend reduction factors to account for pile group effects if pile spacing is less than mentioned above.

5.6 Seismic Site Classification

The bridge shall be designed so that it is capable of withstanding the minimum live load encountered during an earthquake. Based on data obtained during the geotechnical drilling and selection from the Canadian Highway Bridge Design Code CSA S6:19 and the National Building Code of Canada 2020 the site at the Jean Marie River Bridge Location can be described as Class C (Very dense soil and soft rock).

5.7 Liquefaction and Sediment Release

Liquefaction is not a concern for the soils that are proposed to be supporting bridge foundation, however; at the North abutment location between 3.0 – 6.0mbgs is a clay which poses the potential for sediment release during pile installation. The south abutment between 3.0 – 7.5mbgs is a silty sand which also poses the potential for sediment release during pile installation. Sediment release into the Jean Marie River during pile installation can be noted as a potential environmental hazard and if deemed necessary by the project environmental specialist, an environmental control shall be put in place to mitigate any environmental impacts that may occur as a result of sediment release during pile installation.

5.8 Source Material

Based on the provided quarry permits and soils data km 388.8 appears to have a sufficient quality and quantity of material to be used as the source material for Subbase, Base Course, and Chip seal aggregates. It should be noted that due to the nature of the limestone in the area materials that are softer than sufficient may be encountered and it is the contractor's responsibility to ensure the material produced for use in the embankment reconstruction is of sufficient quality and gradation. The contractor shall be responsible for the selection of source material and overall quality of material to be used in the embankment reconstruction and erosion protection materials.

5.9 Embankment Reconstruction Criteria

The embankment reconstruction of the bridge approaches shall conform to typical road embankment benching and compaction methods so that uniform compaction is achieved in each layer of the road. The following features are recommended for the construction of the new embankment:

- Minimum stripping depth to be 200mm or so that no organics are present.

- Side slopes to be 3:1 or 2:1 with the use of Guard rails not to impede on final usable road width.

- The subbase is to be 500mm thick (50mm minus).

- Base to be 300mm thick (20mm minus).

- Chip seal to be 32mm thick, each layer to be 16mm thick (Based on Maximum Particle Size).

- The minimum Head Slope to the river is to be 1.75:1 with a Woven Geotextile pinned to the embankment Head Slope as per the manufacturer's recommendations.

The maximum lift thickness of base and subbase material shall not exceed 150mm and be compacted to 100% of the standard proctor value according to ASTM D698 before being approved to place the following lift of material. Final design widths and slopes shall be designed and detailed by the project transportation engineer. Material placed outside of the specified top lifts of engineered fill to consist of a pit run type material with a maximum particle size of 300mm to be placed in maximum lifts of 300mm.

Please note:

- Required material gradation, Fractured Face percentage, and L.A. Abrasion Values can be seen in the tables below.

- A tolerance of 3% oversized material for each material gradation mentioned below is permitted, provided all oversized material passes the next standard larger sieve size.

Granular Subbase Requirements (50mm Minus)	
Sieve Size (mm)	Percent Passing
50	100
37.5	87-100
20	60-95
12.5	46-80
5	35-60
2	25-45
0.4	10-25
0.08	2-12
Additional Values	
%Fractures by Weight (2 Faces)	50+
L.A. Abrasion Max Loss %	50

Table 5: Subbase Requirements

Granular Base Course Requirements (20mm Minus)	
Sieve Size (mm)	Percent Passing
20	100
10	63-86
5	40-67
1.25	20-43
0.63	14-34
0.315	9-26
0.16	5-18
0.08	2-10
Additional Values	
%Fractures by Weight (2 Faces)	60+
L.A. Abrasion Max Loss %	50

Table 6: Base Course Requirements

Granular Chip Seal Requirements (16mm Minus)	
Sieve Size (mm)	Percent Passing
16	100
12.5	55-92
10	18-80
5	7-30
2	0-20
0.08	0-4
Additional Values	
%Fractures by Weight (2 Faces)	60+
L.A. Abrasion Max Loss %	30

Table 7: Granular Chip Seal Requirements

Maskwa recommends a well-graded Granular Base Course (20mm minus) be placed under the first 0.5m of either abutment compacted to 100% of the standard proctor value and place a granular subbase (50mm minus) or Base Course (20mm minus) 2.0m behind both abutments compacted to 100% of the standard proctor value.

5.10 Erosion Protection

Maskwa Recommends stockpiling the existing rip rap on site used for the current structure before demolition. The rip rap recommended by the hydro-technical team should be used as the selected erosion protection and capped with the rip rap that has been stockpiled on site.

5.11 Culvert Installation Criteria

Maskwa recommends that experienced quality control personnel be present during the installation of any new culvert so that the base of the excavation can be inspected before placement, and to ensure uniform compaction. Lift thickness should not exceed 150mm, and the material shall be compacted to 100% of the standard proctor value. For more details regarding culvert installation please refer to drawing in Appendix D.

5.12 Climate Change Considerations

The impacts of climate change shall be considered in the design of the Jean Marie Replacement Bridge. A procedure for estimating the vulnerability of a development to climate change is described by the Canadian Standards Association (CSA, 2010).

5.13 Temporary Bridge

Based on the soil conditions observed on site, both the East and West sides of the bridge appear to be suitable to be used as locations for the temporary bridge. The soil-bearing capacity on either side of the bridge at potential temporary bridge locations is estimated to be 75 kPa. Before installation of the temporary bridge, Maskwa recommends all organics be removed and an inspection of the existing soil conditions be performed by qualified personnel before the installation of any structural elements.

6. ADDITIONAL SERVICES

The comments and recommendations presented in this report are based on the assumption that an adequate level of construction monitoring will occur by a qualified Engineer or Technologist. It is also recommended that Maskwa inspect all bearing surfaces before material placement. Quality assurance monitoring should be carried out by qualified persons, on behalf of the owner, independent of the contractor.

7. CLOSURE

This investigation was carried out under the accepted practice of Geotechnical Engineering. It should be understood that a soil investigation is based on limited access to a site. Changes in the site's condition, for instance, unrevealed permafrost, may be encountered. Should this occur, Maskwa requires notification immediately to permit re-assessment of our recommendations.

We trust that the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

MASKWA ENGINEERING LTD.
Prepared by

Clell Crook, CET, B.Eng

Reviewed by

REGISTERED PROFESSIONAL ENGINEER
GREGORY G. HAIST
NWT

Date: October 30, 2023

Greg Haist P.Eng
Civil Engineer

Reviewed by

REGISTERED PROFESSIONAL ENGINEER
R.E. JOHNSON
N.W.T.

Date October 30, 2023

Bob Johnson, P. Eng
Geotechnical Engineer

PERMIT TO PRACTICE
Maskwa Engineering Ltd.
Signature _____
Date October 30, 2023
PERMIT NUMBER: P 347
The Association of Professional Engineers, Geologists and Geophysicists of the NWT/NU

8. IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Maskwa Engineering Ltd. (Maskwa) has prepared this report in a manner consistent with the level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development, and purpose described to Maskwa by the Client. The factual data, interpretations, and recommendations pertain to a specific project as described in this report and do not apply to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Maskwa cannot be responsible for the use of this report, or portions thereof unless Maskwa is requested to review and, if necessary, revise the report.

The information, recommendations, and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Maskwa's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Maskwa may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Maskwa. The report, all plans, data, drawings, and other documents as well as all electronic media prepared by Maskwa are considered its professional work product and shall remain the copyright property of Maskwa, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Maskwa. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration, and incompatibility and therefore the Client cannot rely upon the electronic media versions of Maskwa's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Maskwa by the Client, communications between Maskwa and the Client, and any other reports prepared by Maskwa for the Client relative to the specific site described in the report. To properly understand the suggestions, recommendations, and opinions expressed in this report, reference must be made to the whole of the report. Maskwa cannot be responsible for the use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations, and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the

relevant conditions that may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their investigations, as well as their interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and capabilities of equipment.

Soil, Rock, and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock, or geologic types or units may be transitional rather than abrupt. Accordingly, Maskwa does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling, and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical, and hydrogeologic conditions that Maskwa interprets to exist between and beyond sampling points may differ from those that exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal, and meteorological conditions. The condition of the soil, rock, and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or adjacent sites. Excavation may expose the soils to changes due to wetting, drying, or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Maskwa will dispose of all uncontaminated soil and/or rock samples 30 days following the issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. If actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Maskwa's report. Maskwa should be retained to review the final design, project plans, and documents before construction, to confirm that they are consistent with the intent of Maskwa's report.

During construction, Maskwa should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Maskwa's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations, and opinions contained in Maskwa's report. Adequate field review, observation, and testing during construction are necessary for Maskwa to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Maskwa's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Maskwa be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Maskwa be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Maskwa takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

9. THIRD-PARTY DISCLAIMER

This report has been prepared by Maskwa Engineering Ltd. (Maskwa) for the benefit of the client to whom it is addressed. The information and data contained herein represent Maskwa's best professional judgment in light of the knowledge and information available to Maskwa at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers, and employees. Maskwa denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss, or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of Maskwa and the client.

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11. APPENDICES

Appendix A

Site Features

Legend
- Feature 1
- information

information

Bed and Breakfast

Envronmental Monitoring Station

Boat Launch

Google Earth

Image © 2023 Airbus

N

100 m

Legend	
◆	Benchmark
◉	Borehole

N

Point Table				
Point #	Elevation	Northing	Easting	Description
1	206.55	6813590.94	593981.66	BM–1
2	208.56	6813676.41	593990.85	BM–2
101	207.60	6813743.86	593966.79	BH–01
102	206.72	6813645.50	593976.10	BH–02
103	206.73	6813594.42	593973.07	BH–03
104	203.24	6813593.24	594014.07	BH–04
105	205.76	6813383.88	593970.35	BH–05

0 50 100 Meters

MASKWA ENGINEERING LTD

Project No.:	0000005729
Dwg No.:	1
Revision	
DRAWING TITLE:	BOREHOLE LOCATION MAP
PROJECT:	JEAN MARIE RIVER BRIDGE REPLACEMENT ENGINEERING SERVICES
CLIENT:	GNWT
MASKWA JOB No.:	22–062

No.	Date	Description	Chkd

DRAWN BY:	CJC
CHECKED BY:	BJ
DATE:	MAY 2023

Bore Hole #1

PROJECT: JMR BRIDGE GEOTECHNICAL	CLIENT: GNWT	PROJECT No.: 22-062
ADDRESS: HIGHWAY 1	DRILL:	BOREHOLE No.: BH-01
LOCATION: JEAN MARIE RIVER BRIDGE	STATION: NW APPROACH	DATUM NAD 83 ZONE 10

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTING | SAND

DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	TEMP C	SPT (N)	WATER CONTENT (%) Wp 5 10 15 20 Wl	ADDITIONAL DESCRIPTION	ELEVATION (M)
0	– DARK GREY SILTY SAND MIXED WITH FRACTURED GRANULAR. – TRACE CLAY			-8.0			– APROX. 2.5M OF SEASONAL FROST OBSERVED – DRILLED USING 4" SS WITH FISH TAIL BIT.	207.60
1								206.60
				-1.2	N/A			
2								205.60
3				0.6	32			204.60
4	– CLAY TILL							203.60
	– CLAY TILL MIXED WITH BED ROCK IN RECOVERY – REFUSAL AT BED ROCK AT 5.2M			4.8	58			
5				6.4	61			202.60
	* END HOLE AT 5.2M * NO GROUND WATER ENCOUNTERED							
6								201.60
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
18								

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LOGGED BY: CJC	COMPLETION DEPTH 5.2M
REVIEWED BY: BJ	COMPLETE: MARCH 17, 2023
DRAWING No.:	PAGE: 1 of 5

Bore Hole #2

PROJECT: JMR BRIDGE GEOTECHNICAL	CLIENT: GNWT	PROJECT No.: 22-062
ADDRESS: HIGHWAY 1	DRILL:	BOREHOLE No.: BH-02
LOCATION: JEAN MARIE RIVER BRIDGE	STATION: NE ABUTMENT	DATUM NAD 83 ZONE 10

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTING | SAND

DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	TEMP C	SPT (N)	WATER CONTENT (%) Wp 5 10 15 20 Wl	ADDITIONAL DESCRIPTION	ELEVATION (M)
0	– BROWNISH GREY SAND WITH FRACTURED GRANULAR OBSERVED IN CUTTINGS.			-7.4			– APROX. 2.7M OF SEASONAL FROST OBSERVED	206.72
1							– DRILLED USING TRICONE BIT UNTIL 6.0M.	205.72
2				N/A	N/A		– SWITCHED TO CORING AT 6.0M.	204.72
3	– STIFF DARK BROWN CLAY TILL IN SPT RECOVERY. – PP = 2.0 – 3.5 KG/CM^2			1.6	57		– INSTALLED 1.5" NON PERFORATED THERMISTOR STAND PIPE WITH FLUSH MOUNTED CAP.	203.72
4								202.72
5	– DARK GREY PLASTIC CLAY IN SPT RECOVERY .			7.2	21			201.72
6	– DARK GREY CLAY CHANGING TO MUDSTONE IN SPT RECOVERY at 6.0M. – DARK GREY CLAY MIXED WITH MUDSTONE IN CORE RECOVERY. PP READINGS = 2.5 – MAX > 4.0 KG/CM^2			9.6	37			200.72
7	– DARK GREY MUDSTONE IN CORE RECOVERY. PP READINGS = MAX > 4.0 KG/CM^2			14.1	78			199.72
8								198.72
9				10.6	N/A			197.72
10	– UNABLE TO SCRATCH MATERIAL WITH FINGER NAIL FROM 10-11.2M							196.72
11								195.72
12	* END HOLE AT 11.2M							
13								
14								
15								
16								
18								

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LOGGED BY: CJC	COMPLETION DEPTH 11.2M
REVIEWED BY: BJ	COMPLETE: MARCH 17, 2023
DRAWING No.:	PAGE: 2 of 5

Bore Hole #3

PROJECT: JMR BRIDGE GEOTECHNICAL	CLIENT: GNWT	PROJECT No.: 22-062
ADDRESS: HIGHWAY 1	DRILL:	BOREHOLE No.: BH-03
LOCATION: JEAN MARIE RIVER BRIDGE	STATION: SW ABUTMENT	DATUM NAD 83 ZONE 10

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTING | SAND

DEPTH (M)	SOIL DESCRIPTION	TEMP C	SPT (N)	ADDITIONAL DESCRIPTION	ELEVATION (M)
0	– BROWNISH GREY SAND WITH FRACTURED GRANULAR OBSERVED IN CUTTINGS.	-8.2		– APROX. 3.0M OF SEASONAL FROST OBSERVED – DRILLED USING TRICONE BIT UNTIL 7.5M. – SWITCHED TO CORING AT 7.5M.	206.73
1					205.73
2		N/A	N/A		204.73
3	– BROWN SAND MIXED WITH PEA GRAVEL AND TRACE FRACTURED GRANULAR IN SPT RECOVERY.	-0.4	76		203.73
4					202.73
5	– ORGANICS IN SPT RECOVERY AT 4.5M. – VERY SOFT SILTY SAND IN CUTTINGS.	6.4	11		201.73
6	– NO RECOVERY IN SPT AT 6M.	6.5	5		200.73
7					199.73
8	– DARK GREY CLAY/MUDSTONE IN SPT RECOVERY.	6.8	39		198.73
9	– DARK GREY CLAY/MUDSTONE IN CORE RECOVERY, CONSISTENT TILL END OF HOLE.				197.73
10	– SPT REFUSAL AT 9.7M 6"=19 BLOWS, 12" = 48 BLOWS, 18" = 53 BLOWS FOR 3" ADVANCEMENT.	5.8	REFUSAL		196.73
11					195.73
12					194.73
13	* END HOLE AT 12.7m				193.73
14					
15					
16					
18					

WATER CONTENT (%): Wp 5 10 15 20 Wl

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LOGGED BY: CJC	COMPLETION DEPTH 12.7M
REVIEWED BY: BJ	COMPLETE: MARCH 18, 2023
DRAWING No.:	PAGE: 3 of 5

Bore Hole #4

PROJECT: JMR BRIDGE GEOTECHNICAL	CLIENT: GNWT	PROJECT No.: 22–062
ADDRESS: HIGHWAY 1	DRILL:	BOREHOLE No.: BH–04
LOCATION: JEAN MARIE RIVER BRIDGE	STATION: SE SIDE OF BRIDGE	DATUM NAD 83 ZONE 10

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTING | SAND

DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	TEMP C	SPT (N)	WATER CONTENT (%) Wp 5 10 15 20 Wl	ADDITIONAL DESCRIPTION	ELEVATION (M)
0	– BROWN SILTY SAND WITH TRACE ORGANICS AND PEA GRAVEL			-8.2			– APROX. 0.9M OF SEASONAL FROST OBSERVED	203.24
1							– DRILLED USING 4" SS WITH FISHTAIL BIT.	202.24
2				0.4	9			201.24
3	– DARK GREY MOIST SILTY SAND WITH TRACE GRAVEL			0.4	11		– INSTALLED 2.5" PERFORATED GROUND WATER MONITORING WELL WITH FLUSH MOUNTED CAP.	200.24
4	– DARK GREY DRY SILT (POWDERY)			0.6	57			199.24
5	– MUDSTONE IN SPT RECOVERY, SPT ADVANCED 5" WITH 50 BLOWS (REFUSAL AT 6.0M)							198.24
6	– MUDSTONE IN SPT RECOVERY, SPT ADVANCED 5" WITH 50 BLOWS (REFUSAL AT 6.0M)			6.4	REFUSAL			197.24
7	* END HOLE AT 6.0m							
8								
9								
10								
11								
12								
13								
14								
15								
16								
18								

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LOGGED BY: CJC	COMPLETION DEPTH 6.0M
REVIEWED BY: BJ	COMPLETE: MARCH 19, 2023
DRAWING No.:	PAGE: 4 of 5

Bore Hole #5

PROJECT: JMR BRIDGE GEOTECHNICAL	CLIENT: GNWT	PROJECT No.: 22-062
ADDRESS: HIGHWAY 1	DRILL:	BOREHOLE No.: BH-05
LOCATION: JEAN MARIE RIVER BRIDGE	STATION: SW APPROACH	DATUM NAD 83 ZONE 10

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTING | SAND

DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	TEMP C	SPT (N)	WATER CONTENT (%) Wp 5 10 15 20 Wl	ADDITIONAL DESCRIPTION	ELEVATION (M)
0	– BROWN SILTY SAND WITH TRACE ORGANICS			-6.2			– APROX. 0.75M OF SEASONAL FROST OBSERVED	205.76
1							– DRILLED USING 4" SS WITH FISHTAIL BIT.	204.76
2				3.4	11			203.76
3	– DARK GREY MOIST SILT/CLAY PP = 2.5 kg/cm², VS = 2.5 kg/cm² @ 2.1m PP = 3.5 kg/cm², VS = 3.5 kg/cm² @ 2.7m			4.2	14			202.76
4	– MOVING TO LIGHT GREY SILT/CLAY SHALE IN SPT RECOVERY – LIGHT GREY POWDERY SILT ON AUGER.			8.6	23			201.76
5								200.76
6				5.2	49			199.76
7								198.76
8	– SPT 6" = 32 BLOWS, 12" = 50 BLOWS FOR 5.5"ADVANCEMENT. * END HOLE AT 7.6M * NO GROUND WATER ENCOUNTERED.			10.6	REFUSAL			197.76
9								
10								
11								
12								
13								
14								
15								
16								
18								

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LOGGED BY: CJC	COMPLETION DEPTH 12.7M
REVIEWED BY: BJ	COMPLETE: MARCH 19, 2023
DRAWING No.:	PAGE: 5 of 5

Appendix B

Figure 1: BH-01 (0 – 1.5mbgs)

Figure 2: BH-01 (1.5 - 3.0mbgs)

Figure 3: BH-01 SPT Recovery at 3.0mbgs

Figure 4: BH-01 (3.0 - 4.5mbgs)

Figure 5: BH-01 SPT Recovery at 4.5mbgs

Figure 6: BH-01 SPT Recovery at 5.2mbgs

Figure 7: BH-02 Drill Location

Figure 8: BH-02 SPT Recovery at 3.0mbgs

Figure 9: BH-02 SPT Recovery at 4.5mbgs

Figure 10: BH-02 SPT Recovery at 6.0mbgs

Figure 11: BH–02 Core Recovery 6.0 – 6.5mbgs

Figure 12: BH-02 SPT Recovery at 6.7mbgs

Figure 13: BH-02 Core Recovery 7.2 - 8.2mbgs

Figure 14: BH-02 Core Recovery 7.2 - 8.2mbgs

Figure 15: BH-02 Core Recovery 7.2 – 11.2mbgs

Figure 16: BH-03 Drill Location

Figure 17: BH-03 SPT Recovery at 3.0mbgs

Figure 18: BH-03 SPT Recovery at 4.5mbgs

Figure 19: BH-03 SPT Recovery at 7.5mbgs

Figure 20: BH-03 SPT Recovery at 9.7mbgs

Figure 21: BH-03 Core Recovery

Figure 22: BH-04 Drill Location

Figure 23: BH-04 (0 – 1.5mbgs)

Figure 24: BH-04 SPT Recovery at 1.5mbgs

Figure 25: BH-04 (1.5 – 3.0mbgs)

Figure 26: BH -04 SPT Recovery at 3.0mbgs

Figure 27: BH-04 (3.0 - 4.5mbgs)

Figure 28: BH-04 SPT Recovery at 4.5mbgs

Figure 29: BH-04 (4.5 – 6.0mbgs)

Figure 30: BH-04 SPT Recovery at 6.0mbgs

Figure 31: BH-04 Drill Location

Figure 32: BH-05 (0 - 1.5mbgs)

Figure 33: BH-05 SPT Recovery at 1.5mbgs

Figure 34: BH-05 (1.5 - 3.0mbgs)

Figure 35: BH-05 SPT Recovery at 3.0mbgs

Figure 36: BH-05 (3.0 - 4.5mbgs)

Figure 37: BH-05 SPT Recovery at 4.5mbgs

Figure 38: BH-05 (4.5 – 6.0mbgs)

Figure 39: BH-05 SPT Recovery at 6.0mbgs

Figure 40: BH-05 (6.0 – 7.5mbgs)

Figure 41: BH-05 SPT Recovery at 7.5mbgs

Figure 42: Existing Structure

Figure 43: Existing Structure

Appendix C

Water Content Determination

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Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT
Date Tested	4-Apr-23
Technician	Insun Joo

Borehole	Sample No.	Depth (ft)	Sample Type	Weight of Tare (g)	Wet Sample & Tare (g)	Dry Sample & Tare (g)	Weight of Water (g)	Weight of Dry Sample (g)	Water Content (%)
BH-01	1	1 to 5	G	30.70	149.40	138.60	10.80	107.90	10.0
BH-01	2	10	SPT	30.30	79.20	74.30	4.90	44.00	11.1
BH-01	3	15	SPT	29.70	117.00	110.70	6.30	81.00	7.8
BH-01	4	17	SPT	30.10	118.30	112.40	5.90	82.30	7.2
BH-02	1	9	SPT	25.30	80.90	74.80	6.10	49.50	12.3
BH-02	2	14.5	SPT	22.80	81.50	74.00	7.50	51.20	14.6
BH-02	3	19.5	SPT	30.50	100.60	94.00	6.60	63.50	10.4
BH-02	4	22	SPT	30.10	90.80	86.00	4.80	55.90	8.6
BH-02-1	5	-	Core	7.28	195.12	186.99	8.13	179.71	4.5
BH-03	1	9.5	SPT	21.70	86.10	78.20	7.90	56.50	14.0
BH-03	2	14.5	SPT	19.30	139.30	125.50	13.80	106.20	13.0
BH-03	3	14.5	SPT (org)	30.30	58.80	54.10	4.70	23.80	19.7
BH-03	4	24.5	SPT	21.60	63.30	60.30	3.00	38.70	7.8
BH-03	5	32	SPT	30.00	117.50	111.10	6.40	81.10	7.9
BH-03	6	-	Core	7.74	140.71	133.88	6.83	126.14	5.4
BH-04	1	0-5	G	21.90	87.20	78.50	8.70	56.60	15.4
BH-04	2	5-10	G	31.10	110.80	100.10	10.70	69.00	15.5
BH-04	3	10-15	G	40.60	74.80	69.00	5.80	28.40	20.4
BH-04	4	15-20	G	30.70	81.80	77.90	3.90	47.20	8.3
BH-04	5	20	SPT	21.90	59.90	57.30	2.60	35.40	7.3
BH-05	1	0-5	G	41.30	115.40	107.80	7.60	66.50	11.4
BH-05	2	10	SPT	29.80	99.80	91.20	8.60	61.40	14.0
BH-05	3	15	SPT	30.20	72.90	68.90	4.00	38.70	10.3
BH-05	4	20	SPT	19.20	92.00	83.60	8.40	64.40	13.0
BH-05	5	25	SPT	22.10	91.30	85.10	6.20	63.00	9.8

Mechanical Sieve Analysis

Sample No.	-	Date Received	-
Date Sampled	17-Mar-23	Date Tested	15-May-23
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ/SP/MP
Sample Description	Silty, clayey		
Sample Location	BH-01: 0-1.5m (0'-5')		

Moisture Content (%)	9.7	Gravel PI (%)	-
Lightweights (%)	-	Fineness Modulus (%)	-
Fracture Aggregate (%)	100.0	Sand Equivalent (%)	-

Sieve Size (mm)	Percent Passing	Sieve Size (mm)	Spec. Minimum %	Spec. Maximum %
20.000	100.0	20.000		
16.000	100.0	16.000		
12.500	100.0	12.500		
9.500	100.0	9.500		
4.750	97.7	4.750		
2.000	91.8	2.000		
1.180	87.8	1.180		
0.600	82.1	0.600		
0.425	78.3	0.425		
0.300	74.4	0.300		
0.150	66.6	0.150		
0.075	59.8	0.075		

Approved By

Clifton

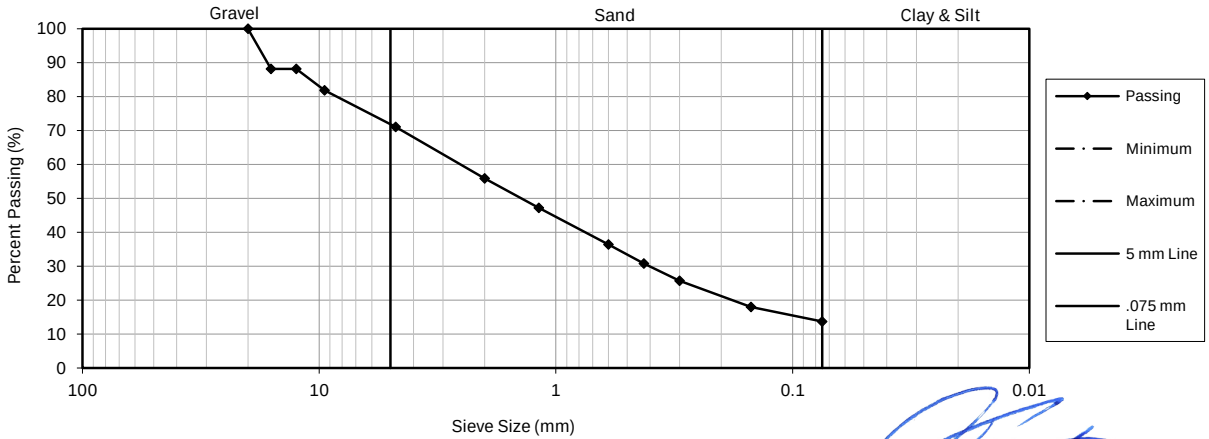
Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Mechanical Sieve Analysis

Sample No.	-	Date Received	-
Date Sampled	17-Mar-23	Date Tested	15-May-23
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ/SP/MP
Sample Description	Silty, clayey		
Sample Location	BH-01: 3m (10')		

Moisture Content (%)	4.1	Gravel PI (%)	-
Lightweights (%)	-	Fineness Modulus (%)	-
Fracture Aggregate (%)	100.0	Sand Equivalent (%)	-

Sieve Size (mm)	Percent Passing	Sieve Size (mm)	Spec. Minimum %	Spec. Maximum %
20.000	100.0	20.000		
16.000	88.2	16.000		
12.500	88.2	12.500		
9.500	81.8	9.500		
4.750	71.1	4.750		
2.000	55.9	2.000		
1.180	47.2	1.180		
0.600	36.4	0.600		
0.425	30.8	0.425		
0.300	25.7	0.300		
0.150	18.0	0.150		
0.075	13.7	0.075		



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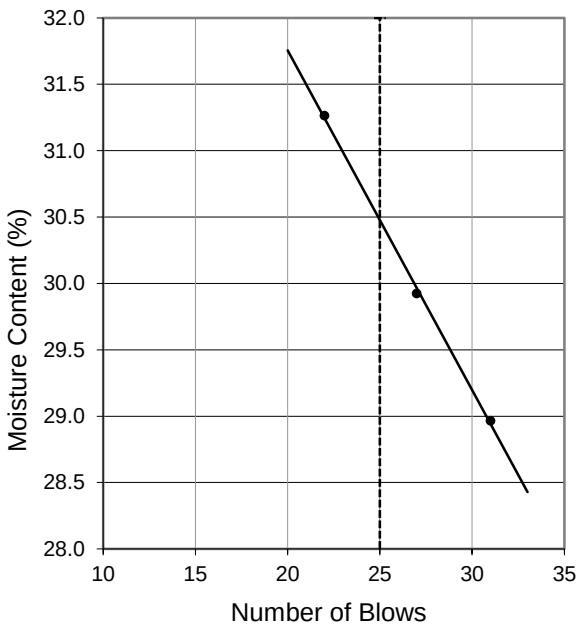
Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

ATTERBERG LIMITS PLASTICITY INDEX

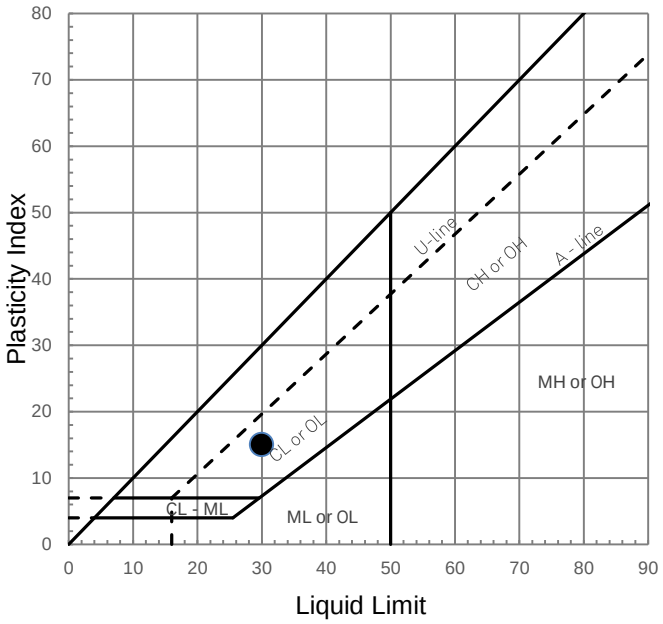
ASTM D4318 Method A

Sample Date	17-Mar-23	Liquid Limit	30		
Sample No	BH-01 S003 4.6m (15ft)	Plastic Limit	15	Soil type	Clay
Technician	IJ	Plasticity Index	15	Classification	CL

Liquid Limit



Plasticity Index



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Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

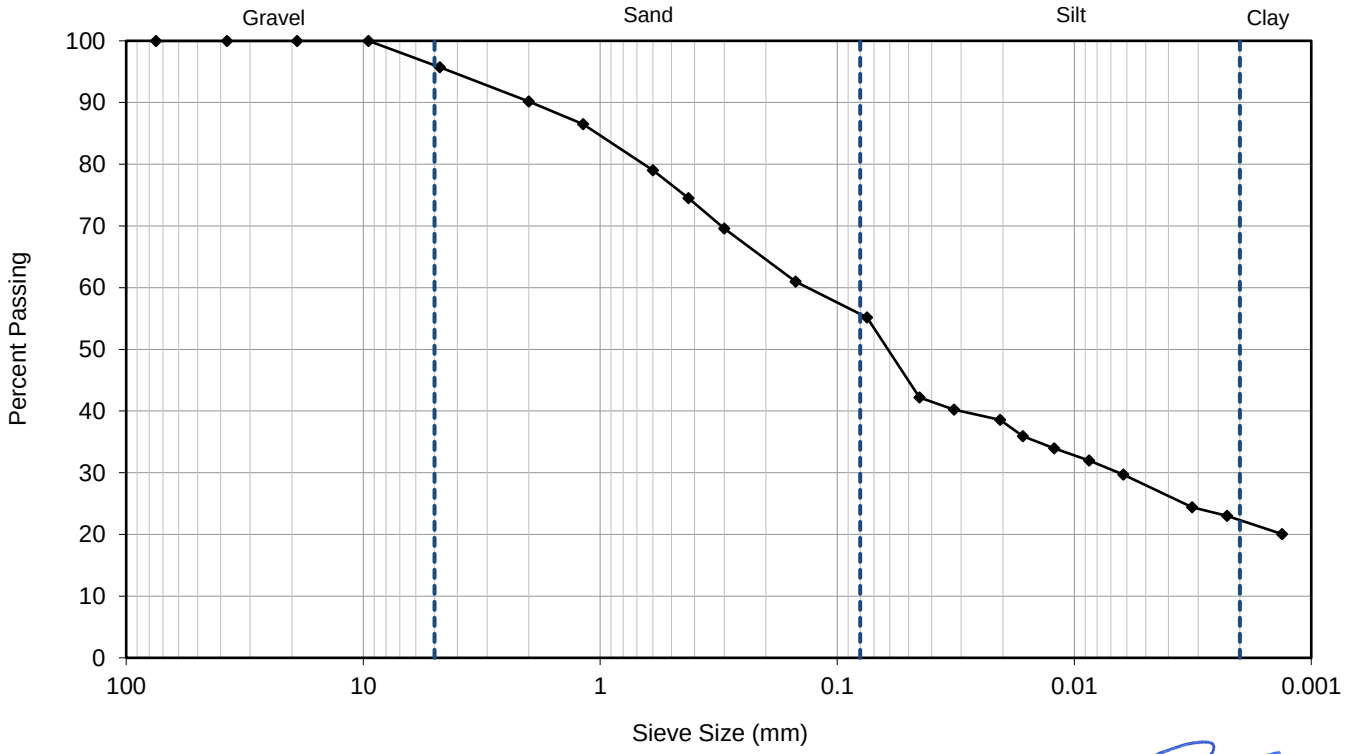
ASTM D7928

Sample Information

Sample No.	3	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty clayey trace gravel		
Sample Location	BH-01 4.6m (15')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
4.3 %	19	100.0
>5	9.5	100.0
	4.75	95.7
Sand	2	90.2
40.6 %	1.18	86.5
0.08 to 5	0.6	79.0
	0.425	74.5
Silt	0.3	69.6
32.9 %	0.15	61.0
0.002 to 0.08	0.075	55.1
	0.0450	42.2
Clay	0.0322	40.2
22.2 %	0.0205	38.6
<0.002	0.0165	35.9
	0.0121	34.0
	0.0087	32.0
	0.0062	29.7
Hydrometer	0.0032	24.4
Sample MC	0.0023	23.0
0.6 %	0.0013	20.1



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Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

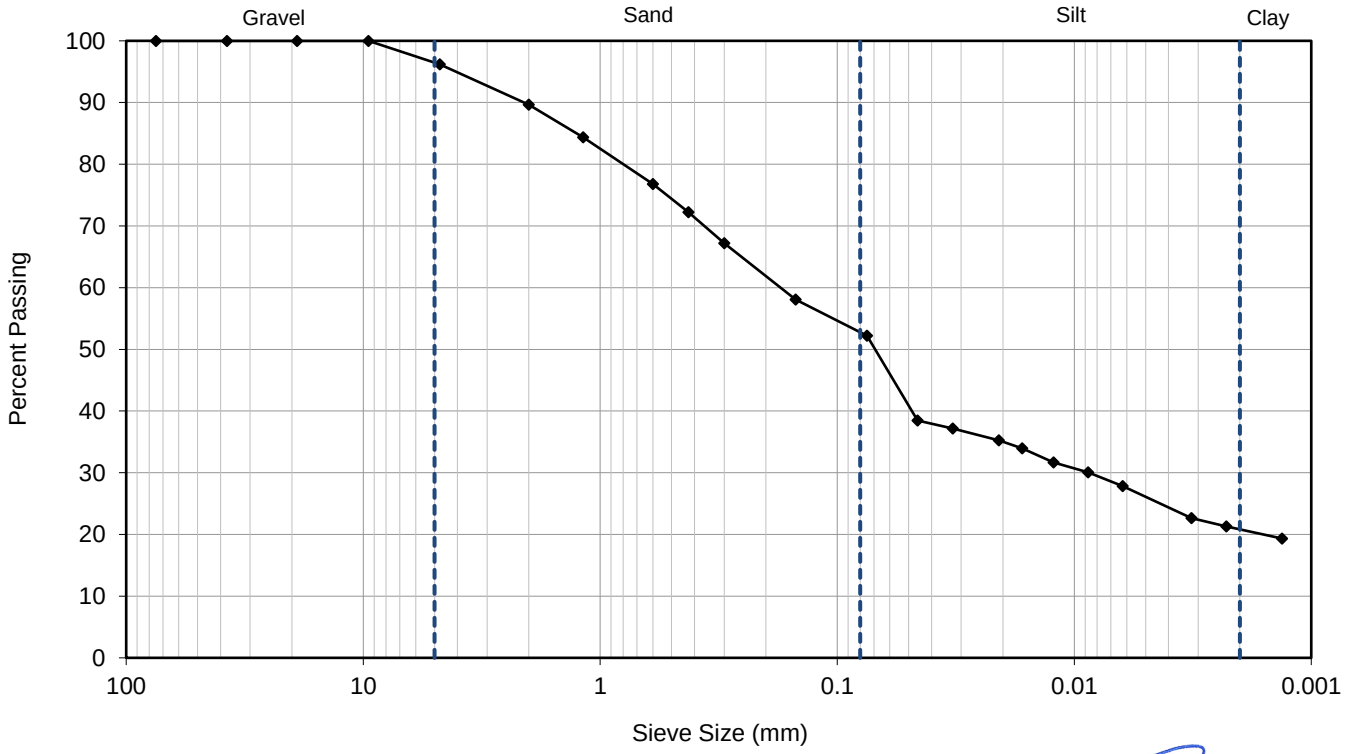
ASTM D7928

Sample Information

Sample No.	4	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty clayey trace gravel		
Sample Location	BH-01 5.2m (17')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
3.8 %	19	100.0
>5	9.5	100.0
	4.75	96.2
Sand	2	89.7
44.0 %	1.18	84.4
0.08 to 5	0.6	76.8
	0.425	72.2
Silt	0.3	67.2
31.5 %	0.15	58.1
0.002 to 0.08	0.075	52.2
	0.0458	38.5
Clay	0.0326	37.2
20.7 %	0.0208	35.2
<0.002	0.0166	34.0
	0.0122	31.7
	0.0087	30.1
	0.0062	27.8
Hydrometer	0.0032	22.6
Sample MC	0.0023	21.3
0.7 %	0.0013	19.3



Approved by

Clifton

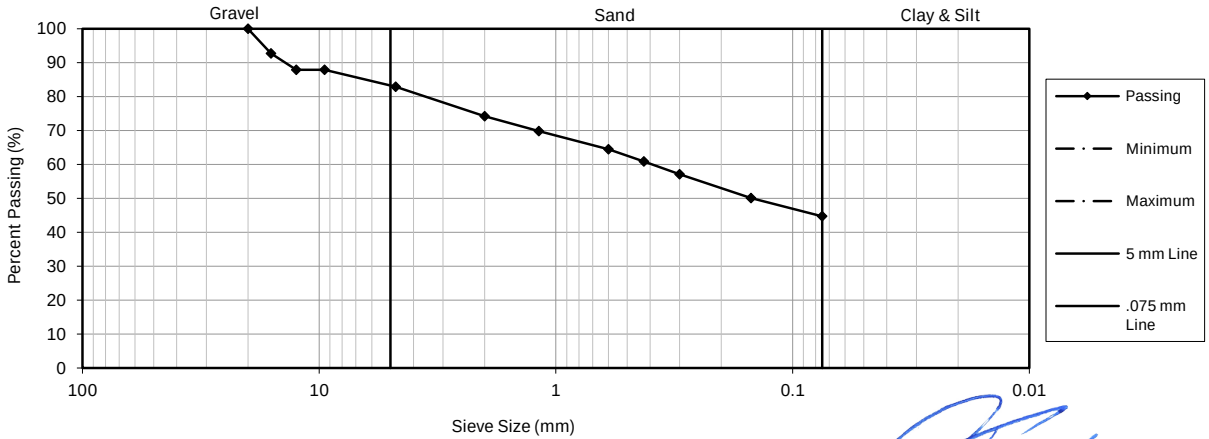
Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Mechanical Sieve Analysis

Sample No.	-	Date Received	-
Date Sampled	17-Mar-23	Date Tested	15-May-23
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sandy, gravelly, clayey		
Sample Location	BH-02: 2.7m (9')		

Moisture Content (%)	10.7	Gravel PI (%)	-
Lightweights (%)	-	Fineness Modulus (%)	-
Fracture Aggregate (%)	100.0	Sand Equivalent (%)	-

Sieve Size (mm)	Percent Passing	Sieve Size (mm)	Spec. Minimum %	Spec. Maximum %
20.000	100.0	20.000		
16.000	92.8	16.000		
12.500	87.9	12.500		
9.500	87.9	9.500		
4.750	82.9	4.750		
2.000	74.2	2.000		
1.180	69.9	1.180		
0.600	64.4	0.600		
0.425	60.9	0.425		
0.300	57.1	0.300		
0.150	50.1	0.150		
0.075	44.7	0.075		



Approved By

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

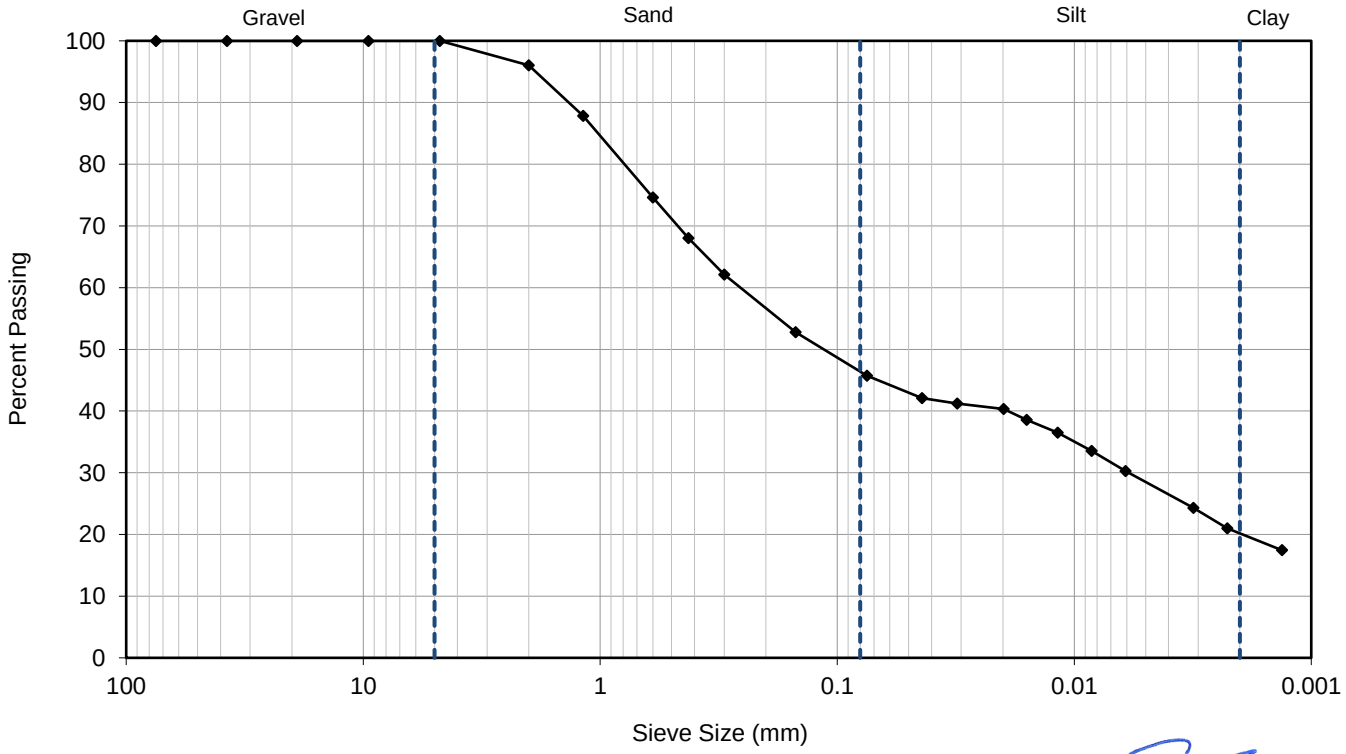
ASTM D7928

Sample Information

Sample No.	2	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 18, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty clayey		
Sample Location	BH-02 4.4m (14.5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
	19	100.0
>5	9.5	100.0
	4.75	100.0
Sand	2	96.0
54.3 %	1.18	87.8
0.08 to 5	0.6	74.6
	0.425	68.0
Silt	0.3	62.1
25.7 %	0.15	52.8
0.002 to 0.08	0.075	45.7
	0.0439	42.1
Clay	0.0312	41.2
20.0 %	0.0198	40.3
<0.002	0.0159	38.6
	0.0117	36.5
	0.0084	33.5
	0.0061	30.3
Hydrometer	0.0031	24.3
Sample MC	0.0023	21.0
1.0 %	0.0013	17.4



Approved by

Clifton

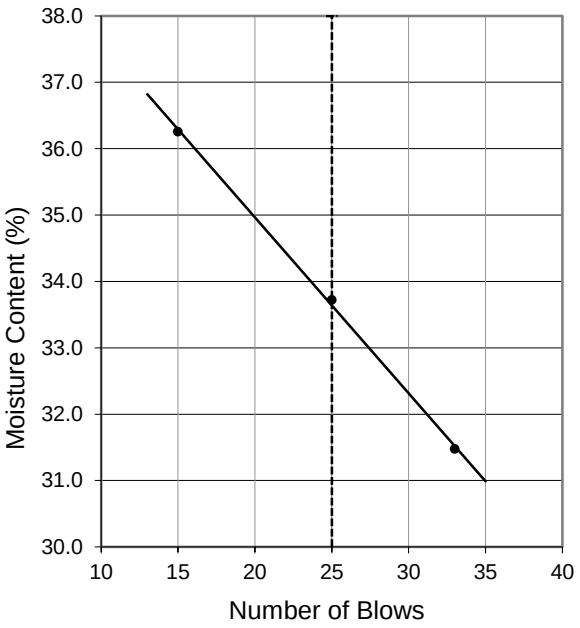
Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

ATTERBERG LIMITS PLASTICITY INDEX

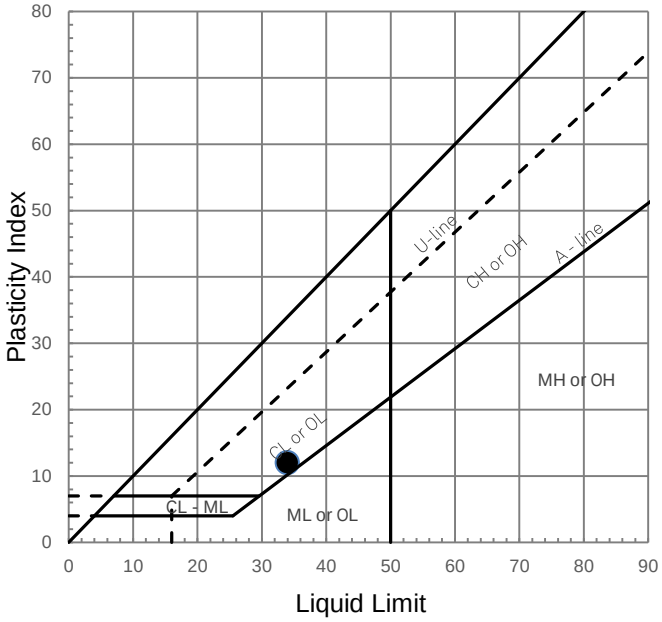
ASTM D4318 Method A

Sample Date	17-Mar-23	Liquid Limit	34		
Sample No	BH-02 S004 6.7m	Plastic Limit	22	Soil type	Clay
Technician	IJ	Plasticity Index	12	Classification	CL

Liquid Limit



Plasticity Index



Approved by

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

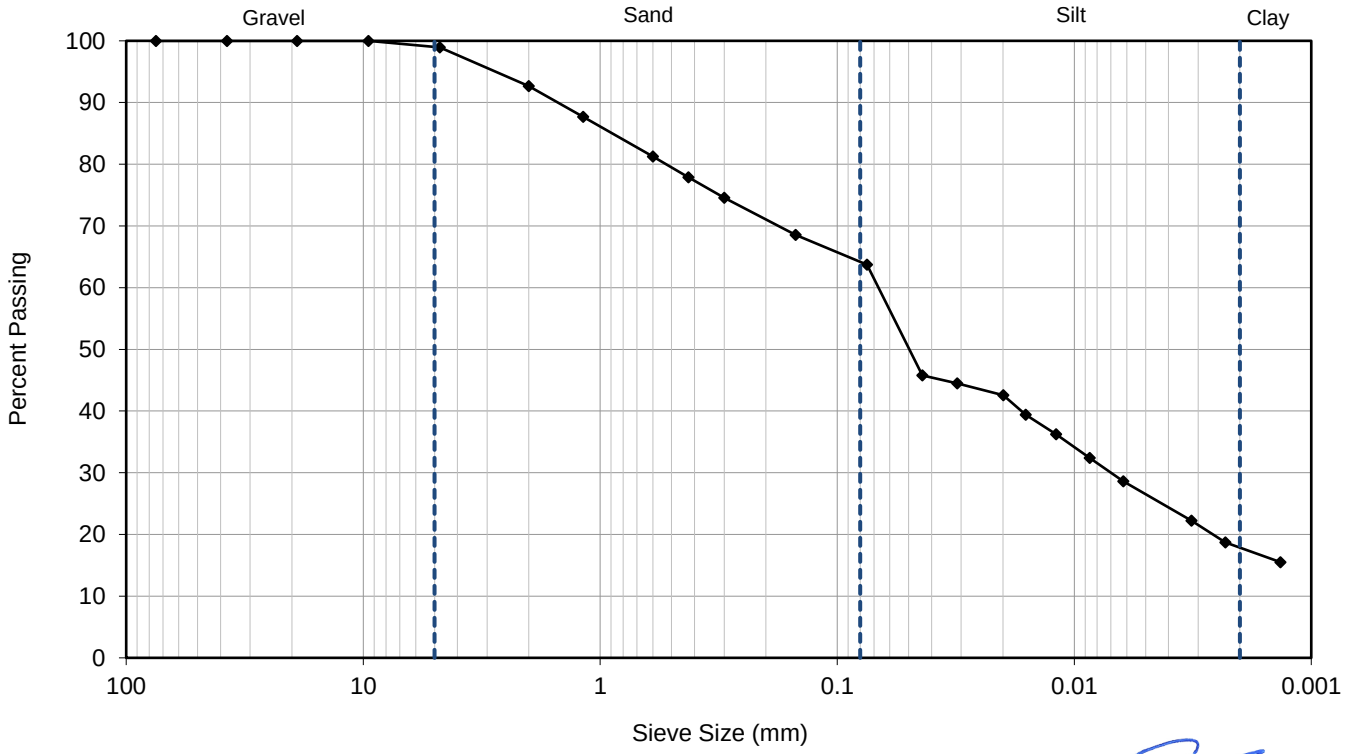
ASTM D7928

Sample Information

Sample No.	4	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 18, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silt and sand some clay trace gravel		
Sample Location	BH-02 6.7m (22')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
1.1 %	19	100.0
>5	9.5	100.0
	4.75	98.9
Sand	2	92.7
35.2 %	1.18	87.7
0.08 to 5	0.6	81.2
	0.425	77.9
Silt	0.3	74.6
46.0 %	0.15	68.5
0.002 to 0.08	0.075	63.7
	0.0437	45.8
Clay	0.0311	44.5
17.7 %	0.0199	42.6
<0.002	0.0160	39.4
	0.0119	36.2
	0.0086	32.4
	0.0062	28.6
Hydrometer	0.0032	22.3
Sample MC	0.0023	18.7
1.3 %	0.0013	15.5



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

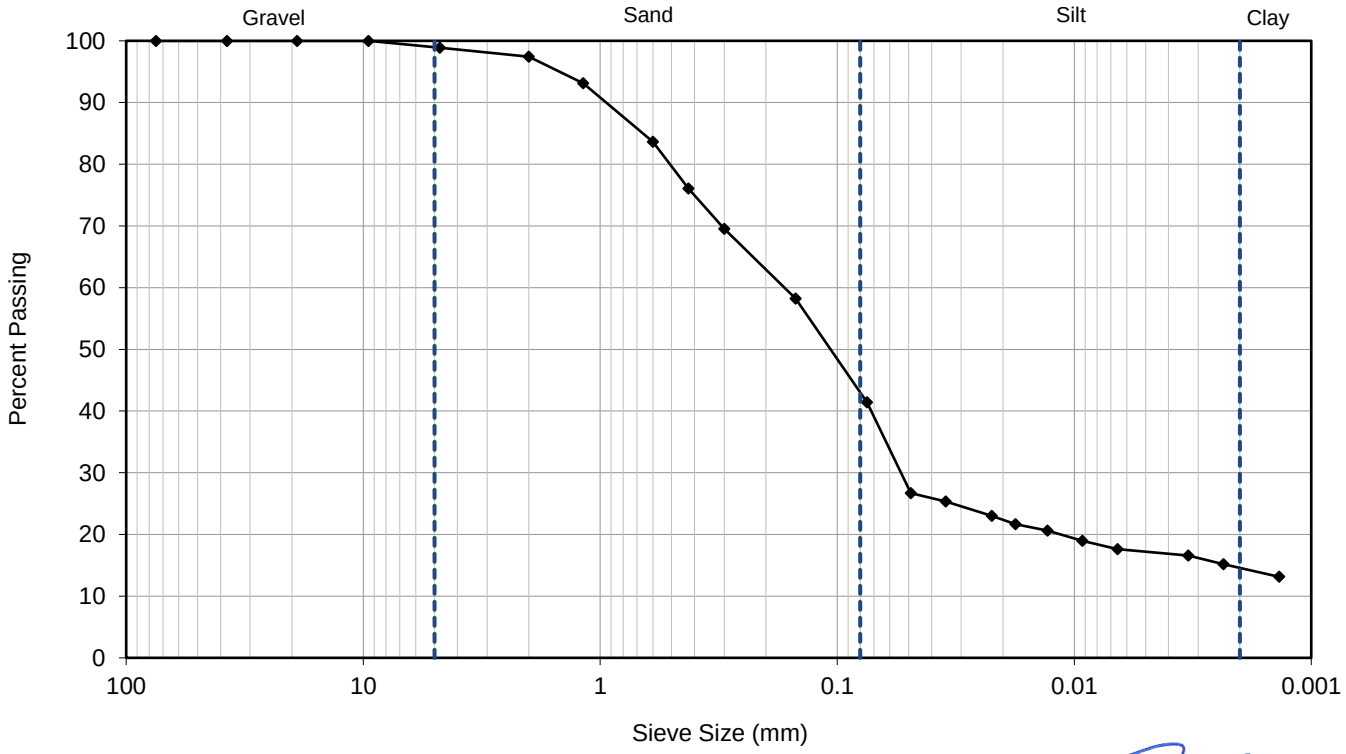
ASTM D7928

Sample Information

Sample No.	1	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty some clay trace gravel		
Sample Location	BH-03 2.9m (9.5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
1.1 %	19	100.0
>5	9.5	100.0
	4.75	98.9
Sand	2	97.5
57.5 %	1.18	93.1
0.08 to 5	0.6	83.6
	0.425	76.0
Silt	0.3	69.6
27.0 %	0.15	58.2
0.002 to 0.08	0.075	41.4
	0.0489	26.7
Clay	0.0348	25.4
14.4 %	0.0223	23.0
<0.002	0.0177	21.7
	0.0130	20.6
	0.0092	19.0
	0.0066	17.6
Hydrometer	0.0033	16.6
Sample MC	0.0023	15.2
0.9 %	0.0014	13.1



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

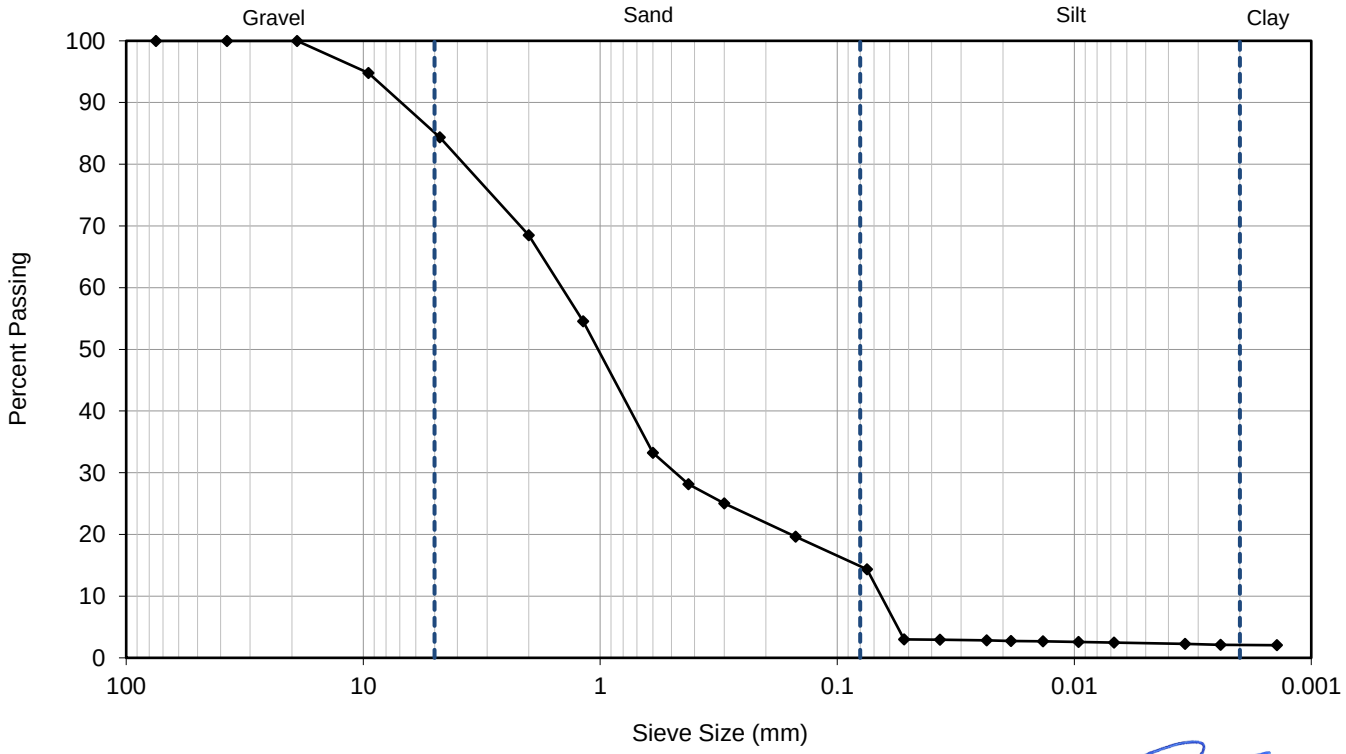
ASTM D7928

Sample Information

Sample No.	2	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand some gravel some silt trace clay		
Sample Location	BH-03 4.4m (14.5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
15.6 %	19	100.0
>5	9.5	94.8
	4.75	84.4
Sand	2	68.5
70.0 %	1.18	54.6
0.08 to 5	0.6	33.2
	0.425	28.1
Silt	0.3	25.0
12.3 %	0.15	19.6
0.002 to 0.08	0.075	14.3
	0.0521	3.0
Clay	0.0369	2.9
2.1 %	0.0234	2.8
<0.002	0.0185	2.8
	0.0135	2.7
	0.0096	2.6
	0.0068	2.5
Hydrometer	0.0034	2.2
Sample MC	0.0024	2.1
0.1 %	0.0014	2.0



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

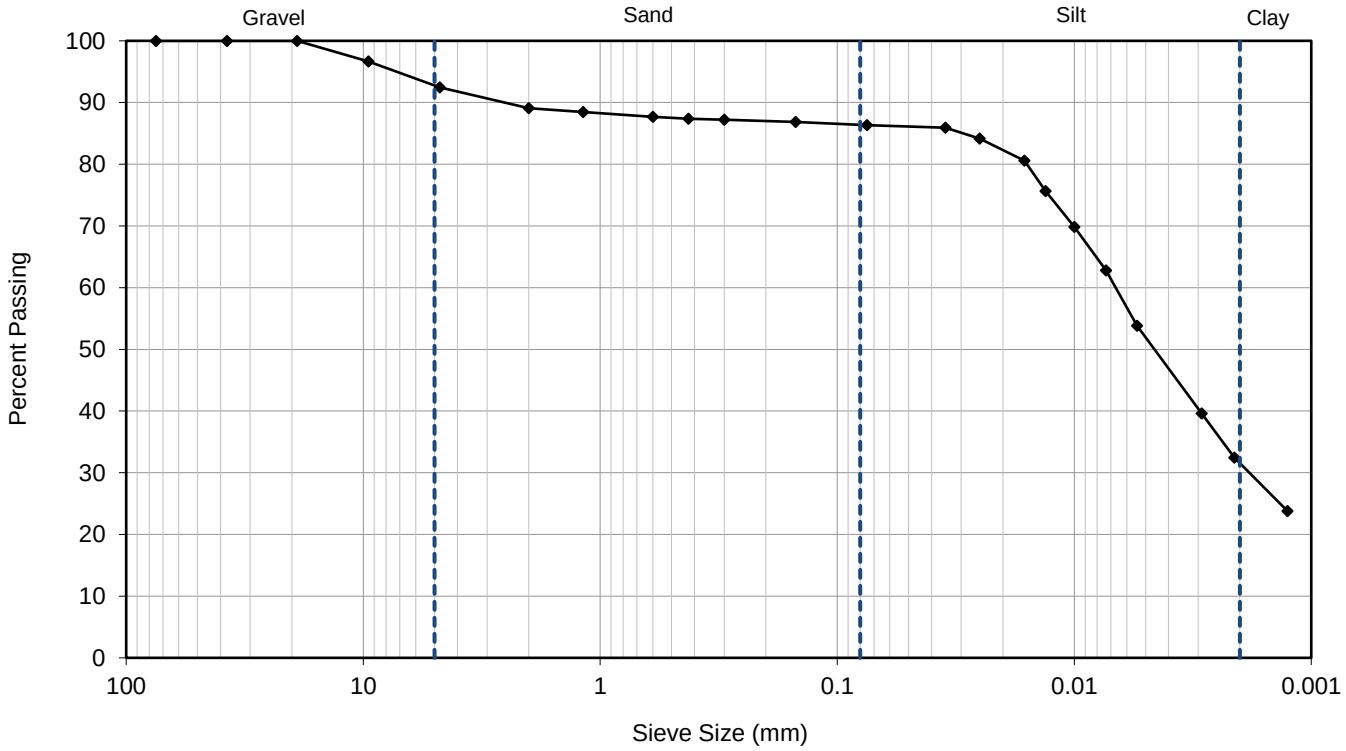
ASTM D7928

Sample Information

Sample No.	BH23-03 S3 @ 34.1'	Date Received	Thursday, April 20, 2023
Sample Date	Thursday, April 20, 2023	Date Tested	Wednesday, April 26, 2023
Time Sampled	-	Supplied by	Client
Sampled by	Client	Tested by	FG
Sample Description	Clayey silt, trace sand and gravel		
Sample Location	BH23-03 S3 10.4m (34.1')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
7.5 %	19	100.0
>5	9.5	96.6
	4.75	92.5
Sand	2	89.1
6.1 %	1.18	88.4
0.08 to 5	0.6	87.7
	0.425	87.4
Silt	0.3	87.2
55.1 %	0.15	86.9
0.002 to 0.08	0.075	86.3
	0.0350	85.9
Clay	0.0250	84.1
31.3 %	0.0162	80.6
<0.002	0.0132	75.6
	0.0100	69.8
	0.0073	62.8
	0.0054	53.8
Hydrometer	0.0029	39.6
Sample MC	0.0021	32.4
2.0 %	0.0013	23.8



Approved by: Kyle Zobell

Clifton

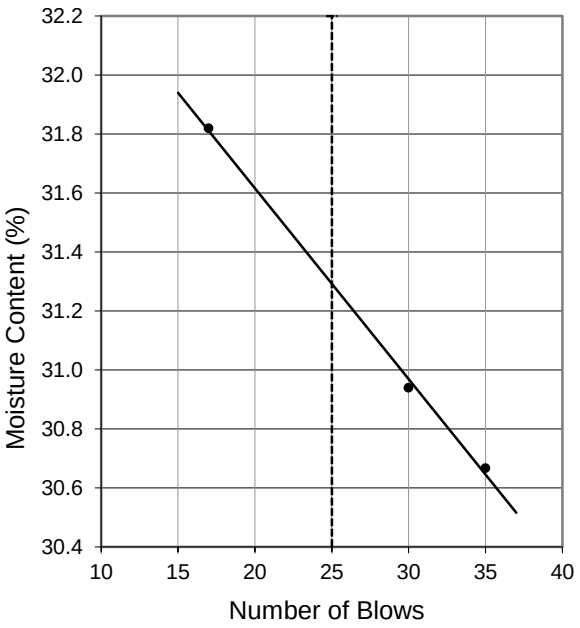
Project No	E589
Client	Maskwa Engineering
Project	2023 Geo Lab Services
Location	Jean Marie, NWT

ATTERBERG LIMITS PLASTICITY INDEX

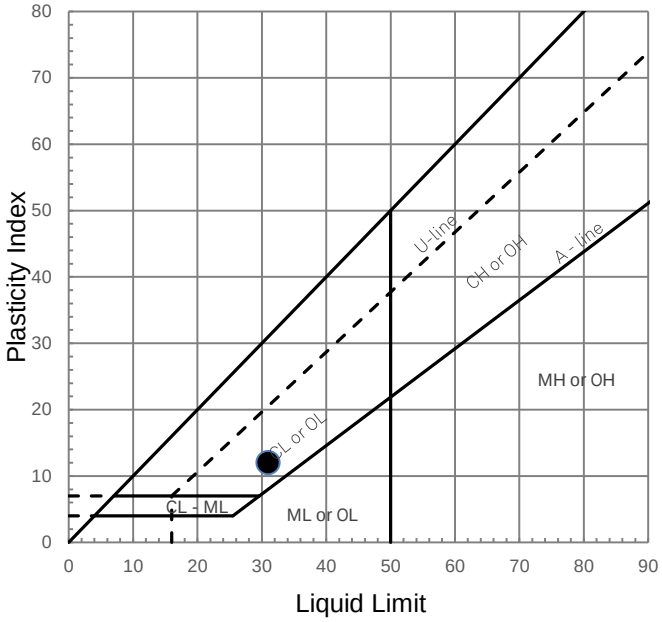
ASTM D4318 Method A

Sample Date	17-Mar-23	Liquid Limit	31		
Sample No	BH-03 S004 7.5m (24.5ft)	Plastic Limit	19	Soil type	Clay
Technician	SP	Plasticity Index	12	Classification	CL

Liquid Limit



Plasticity Index



Approved by

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

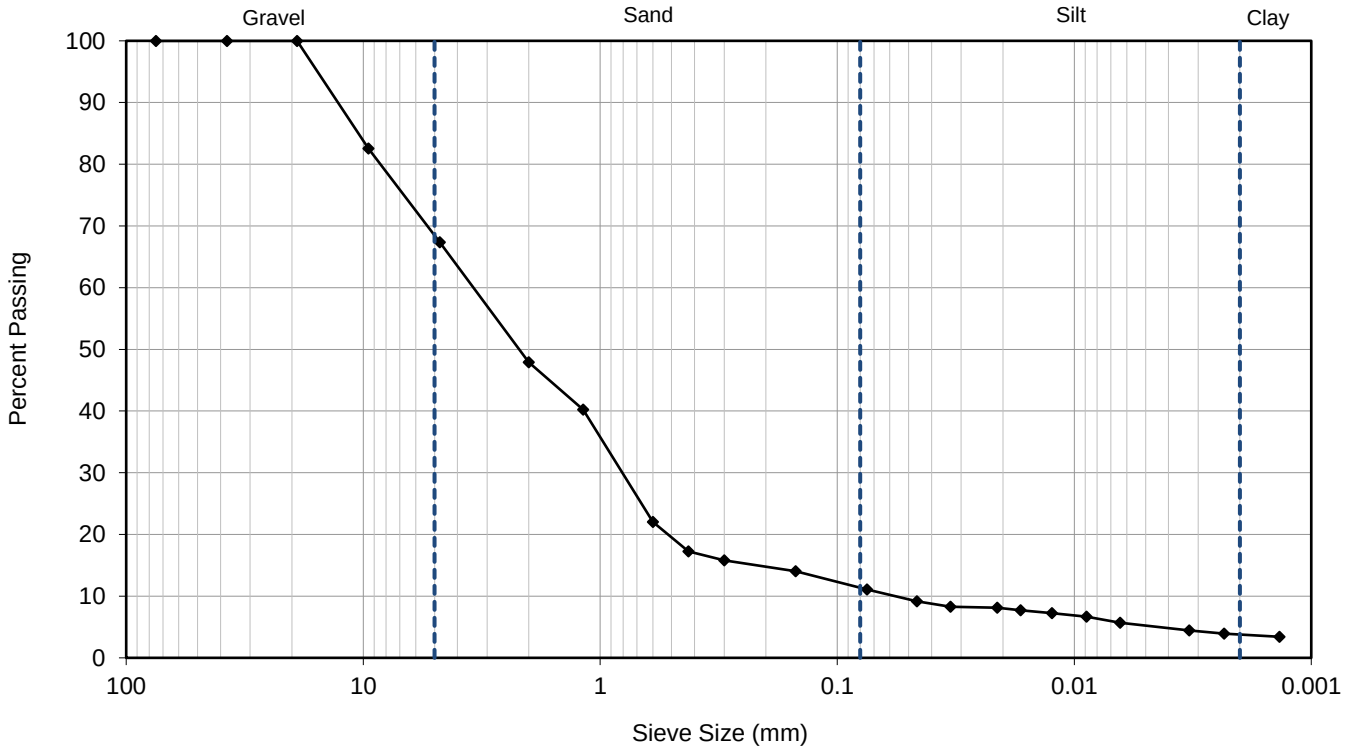
ASTM D7928

Sample Information

Sample No.	4	Date Received	-
Sample Date	Monday, April 17, 2023	Date Tested	Wednesday, April 19, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand gravelly trace silt trace clay		
Sample Location	BH-03 7.5m (24.5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
32.6 %	19	100.0
>5	9.5	82.5
	4.75	67.4
Sand	2	47.9
56.3 %	1.18	40.2
0.08 to 5	0.6	22.0
	0.425	17.2
Silt	0.3	15.8
7.4 %	0.15	14.1
0.002 to 0.08	0.075	11.1
	0.0462	9.2
Clay	0.0333	8.3
3.7 %	0.0211	8.1
<0.002	0.0168	7.7
	0.0124	7.3
	0.0089	6.7
	0.0064	5.7
Hydrometer	0.0033	4.5
Sample MC	0.0023	3.9
1.0 %	0.0014	3.4



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

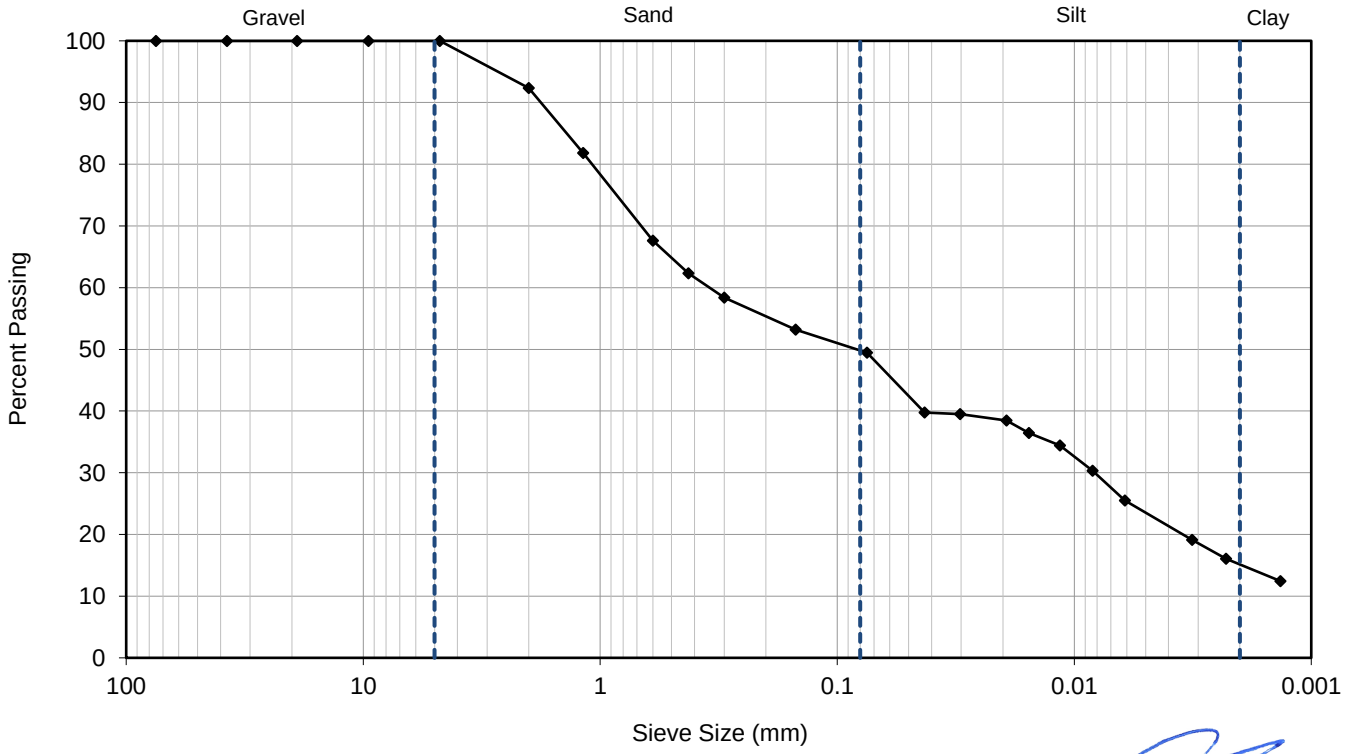
ASTM D7928

Sample Information

Sample No.	5	Date Received	-
Sample Date	Friday, March 17, 2023	Date Tested	Wednesday, April 19, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty some clay		
Sample Location	BH-03 9.7m (32')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
	19	100.0
>5	9.5	100.0
	4.75	100.0
Sand	2	92.3
50.6 %	1.18	81.8
0.08 to 5	0.6	67.6
	0.425	62.3
Silt	0.3	58.4
34.4 %	0.15	53.2
0.002 to 0.08	0.075	49.4
	0.0428	39.7
Clay	0.0303	39.5
15.0 %	0.0193	38.5
<0.002	0.0155	36.4
	0.0115	34.4
	0.0084	30.3
	0.0061	25.5
Hydrometer	0.0032	19.1
Sample MC	0.0023	16.1
0.9 %	0.0013	12.4



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

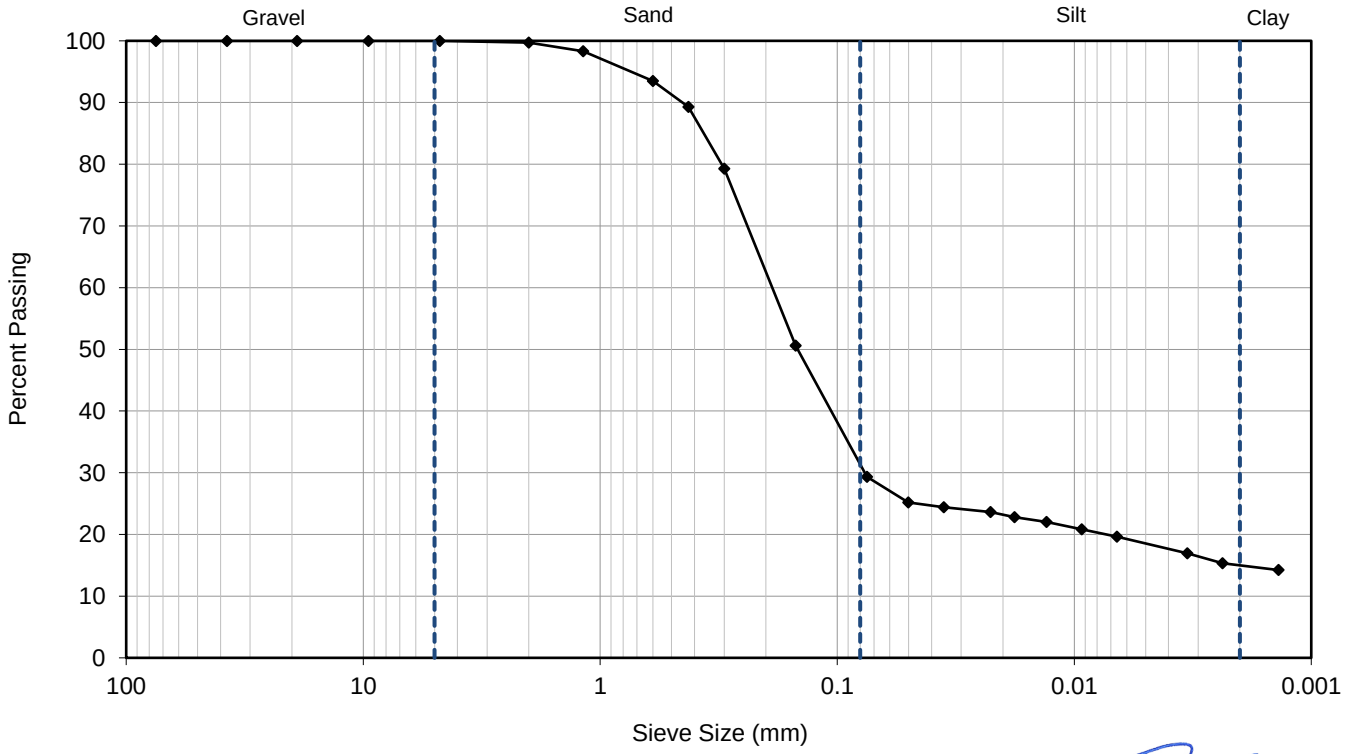
ASTM D7928

Sample Information

Sample No.	1	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand some clay some silt		
Sample Location	BH-04 0-1.5m (0'-5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
	19	100.0
>5	9.5	100.0
	4.75	100.0
Sand	2	99.7
70.7 %	1.18	98.3
0.08 to 5	0.6	93.5
	0.425	89.3
Silt	0.3	79.3
14.4 %	0.15	50.6
0.002 to 0.08	0.075	29.3
	0.0501	25.2
Clay	0.0355	24.4
14.9 %	0.0225	23.6
<0.002	0.0179	22.8
	0.0131	22.0
	0.0093	20.8
	0.0066	19.7
Hydrometer	0.0033	16.9
Sample MC	0.0024	15.3
0.5 %	0.0014	14.2



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Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

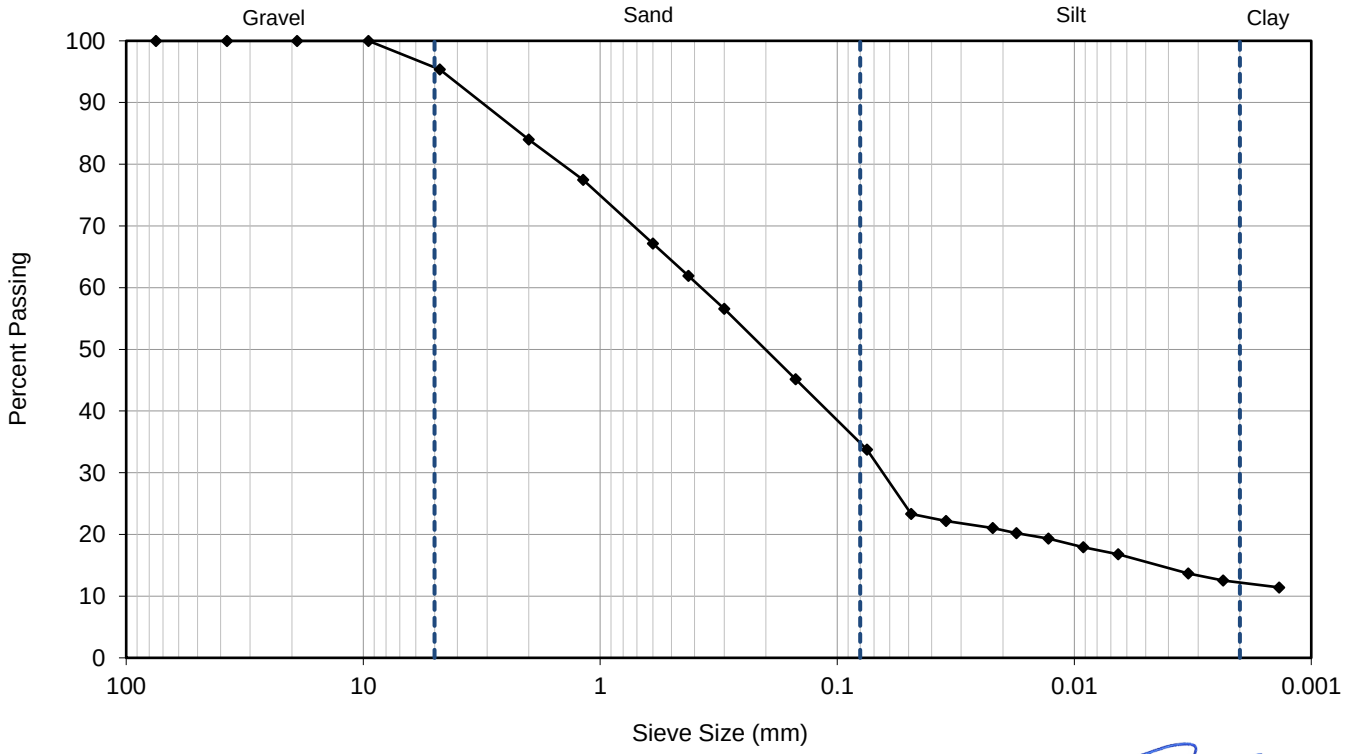
ASTM D7928

Sample Information

Sample No.	2	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Tuesday, April 25, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Sand silty some clay trace gravel		
Sample Location	BH-04 1.5-3m (5'-10')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
4.7 %	19	100.0
>5	9.5	100.0
	4.75	95.3
Sand	2	84.0
61.6 %	1.18	77.5
0.08 to 5	0.6	67.2
	0.425	61.9
Silt	0.3	56.6
21.6 %	0.15	45.2
0.002 to 0.08	0.075	33.8
	0.0488	23.3
Clay	0.0347	22.2
12.1 %	0.0221	21.1
<0.002	0.0175	20.2
	0.0129	19.3
	0.0092	17.9
	0.0065	16.8
Hydrometer	0.0033	13.7
Sample MC	0.0024	12.5
0.6 %	0.0014	11.4



Approved by

Clifton

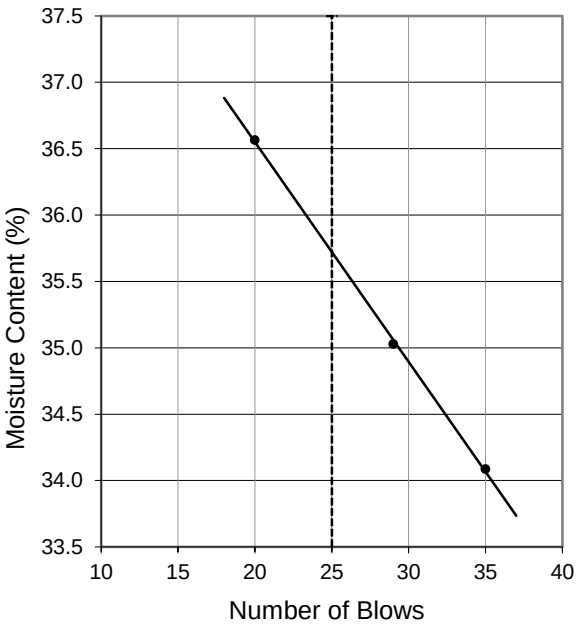
Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

ATTERBERG LIMITS PLASTICITY INDEX

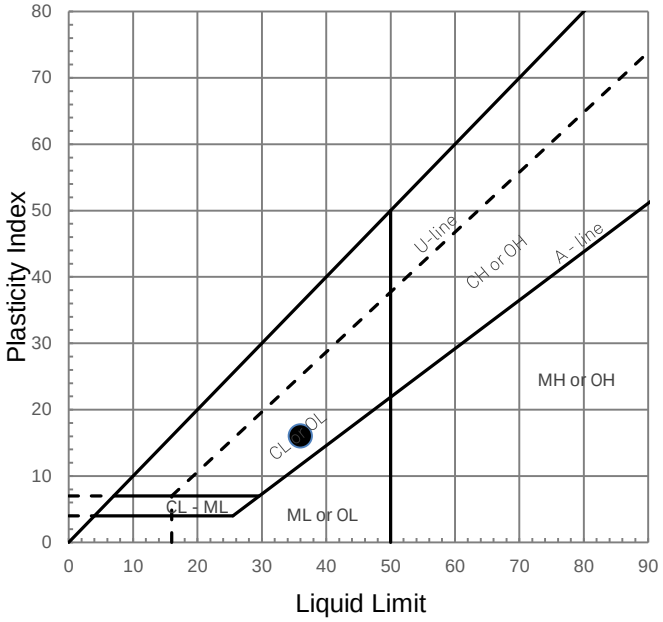
ASTM D4318 Method A

Sample Date	17-Mar-23	Liquid Limit	36		
Sample No	BH-04 S003 3-4.6m (10-15ft)	Plastic Limit	20	Soil type	Clay
Technician	IJ	Plasticity Index	16	Classification	CL

Liquid Limit



Plasticity Index



Approved by

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

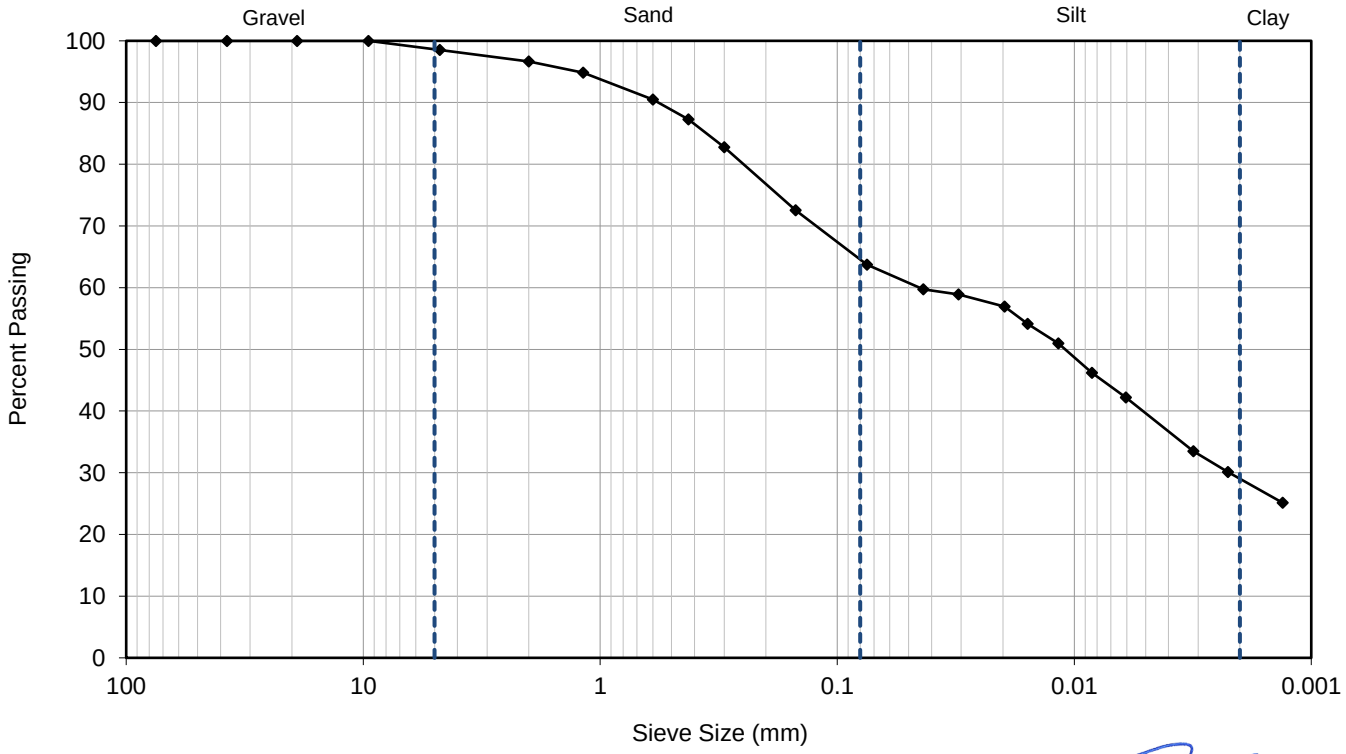
ASTM D7928

Sample Information

Sample No.	3	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Tuesday, May 2, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silty sandy clayey trace gravel		
Sample Location	BH-04 3-4.6m (10'-15')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
1.5 %	19	100.0
>5	9.5	100.0
	4.75	98.5
Sand	2	96.6
34.8 %	1.18	94.8
0.08 to 5	0.6	90.5
	0.425	87.3
Silt	0.3	82.8
34.9 %	0.15	72.5
0.002 to 0.08	0.075	63.7
	0.0434	59.7
Clay	0.0308	58.9
28.8 %	0.0197	56.9
<0.002	0.0157	54.1
	0.0117	51.0
	0.0084	46.2
	0.0061	42.2
Hydrometer	0.0031	33.5
Sample MC	0.0022	30.1
0.7 %	0.0013	25.1



Approved by

Clifton

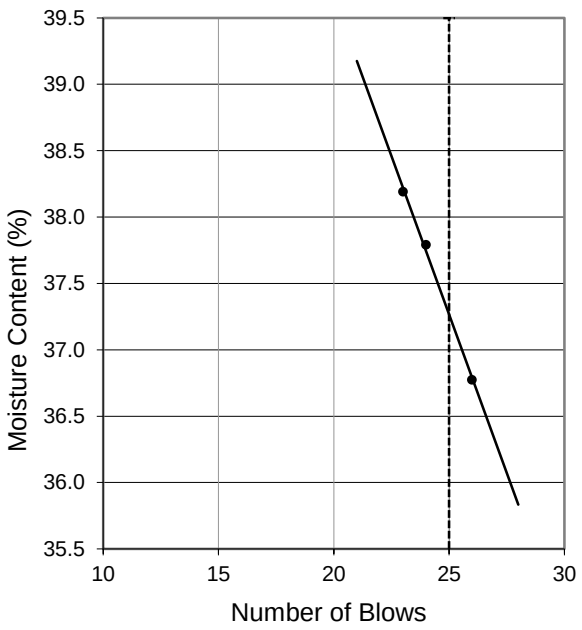
Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

ATTERBERG LIMITS PLASTICITY INDEX

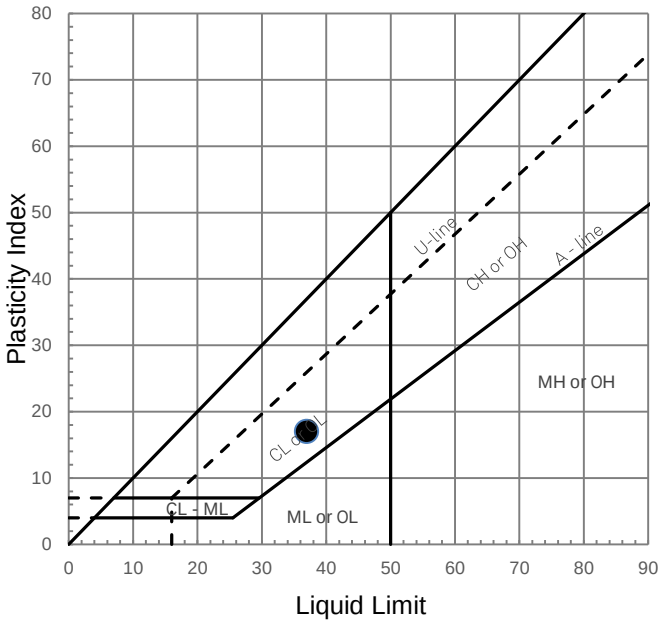
ASTM D4318 Method A

Sample Date	17-Mar-23	Liquid Limit	37		
Sample No	BH-04 S004 4.6-6.1m (15-20ft)	Plastic Limit	20	Soil type	Clay
Technician	SP	Plasticity Index	17	Classification	CL

Liquid Limit



Plasticity Index



Approved by

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

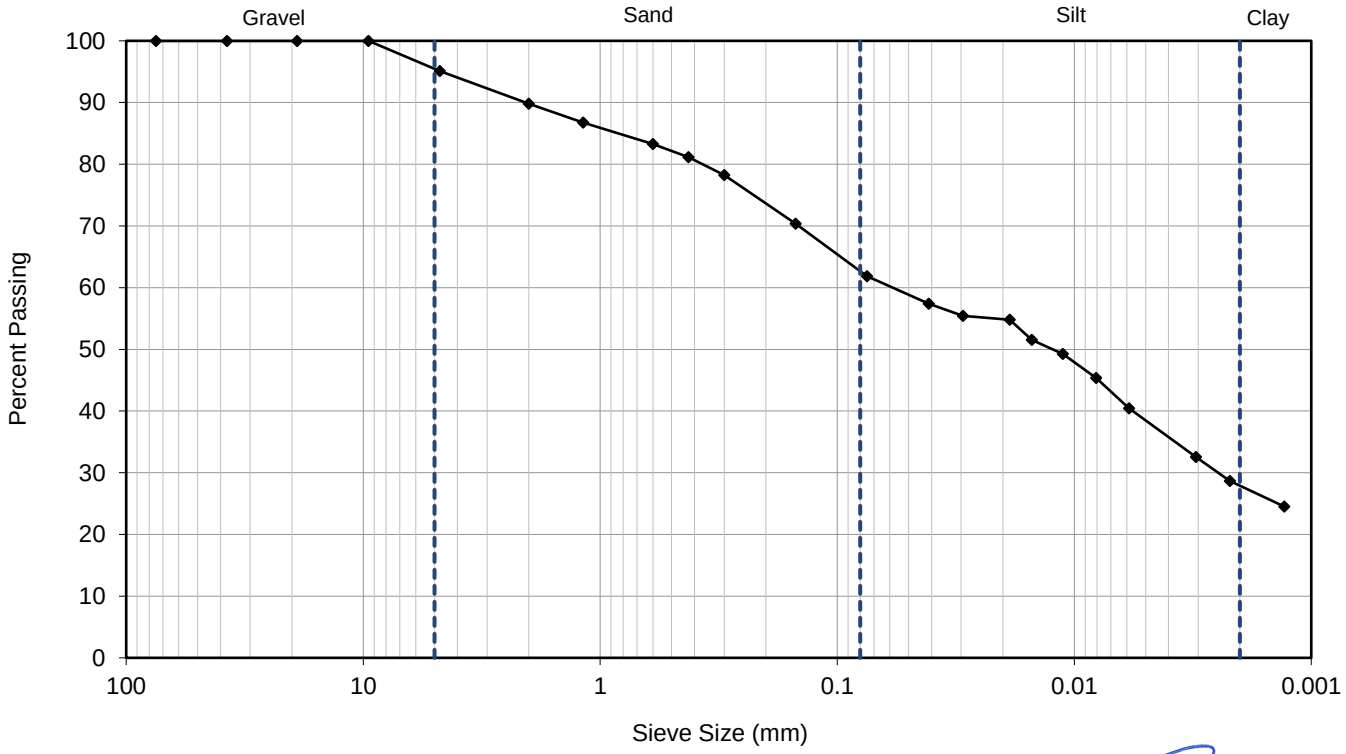
ASTM D7928

Sample Information

Sample No.	4	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Wednesday, May 3, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silty sandy clayey trace gravel		
Sample Location	BH-04 4.6-6.1m (15'-20')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
4.9 %	19	100.0
>5	9.5	100.0
	4.75	95.1
Sand	2	89.8
33.3 %	1.18	86.7
0.08 to 5	0.6	83.3
	0.425	81.1
Silt	0.3	78.2
34.1 %	0.15	70.4
0.002 to 0.08	0.075	61.8
	0.0411	57.4
Clay	0.0294	55.5
27.7 %	0.0187	54.8
<0.002	0.0151	51.5
	0.0112	49.3
	0.0081	45.3
	0.0059	40.4
Hydrometer	0.0031	32.6
Sample MC	0.0022	28.7
1.1 %	0.0013	24.5



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

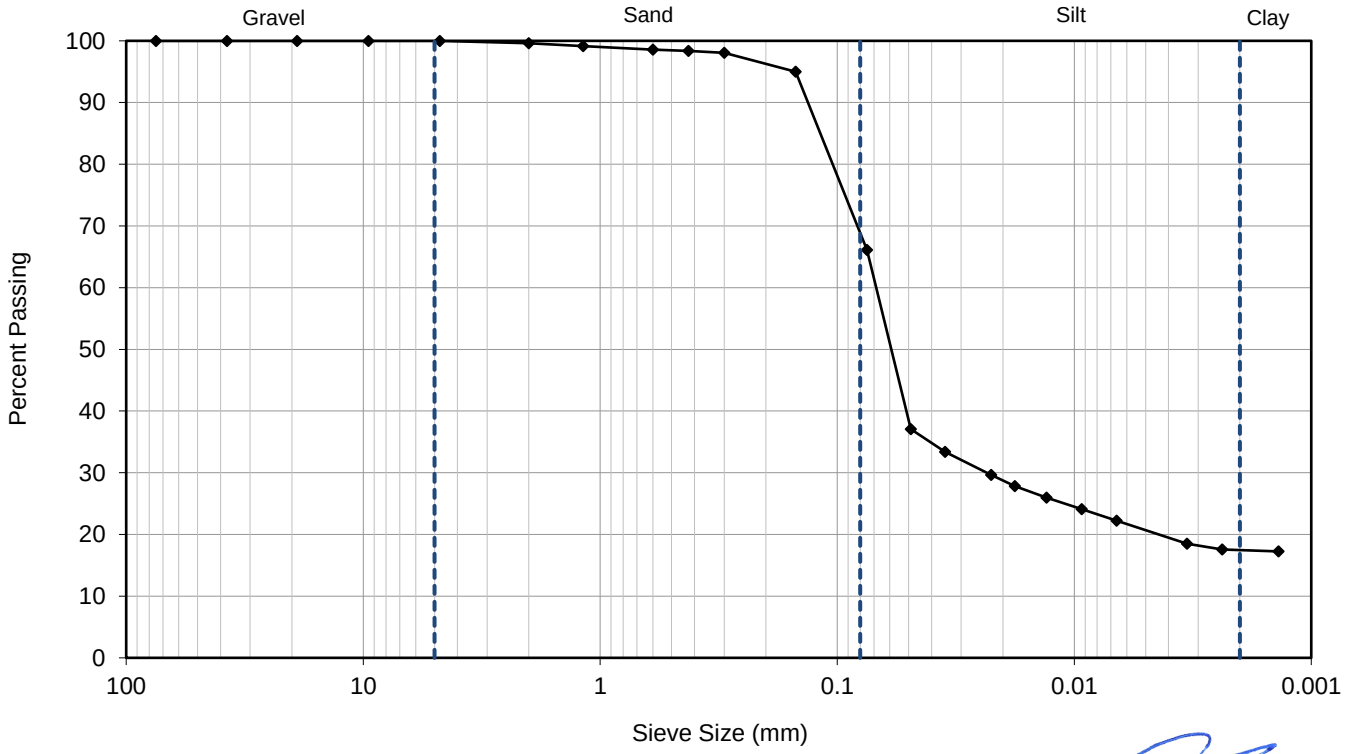
ASTM D7928

Sample Information

Sample No.	1	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Wednesday, May 3, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silt sandy some clay		
Sample Location	BH-05 0-1.5m (0'-5')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
	19	100.0
>5	9.5	100.0
	4.75	100.0
Sand	2	99.6
33.9 %	1.18	99.1
0.08 to 5	0.6	98.6
	0.425	98.4
Silt	0.3	98.1
48.7 %	0.15	95.0
0.002 to 0.08	0.075	66.1
	0.0489	37.1
Clay	0.0350	33.4
17.4 %	0.0224	29.7
<0.002	0.0178	27.8
	0.0131	26.0
	0.0093	24.1
	0.0066	22.2
Hydrometer	0.0033	18.5
Sample MC	0.0024	17.5
0.5 %	0.0014	17.3



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

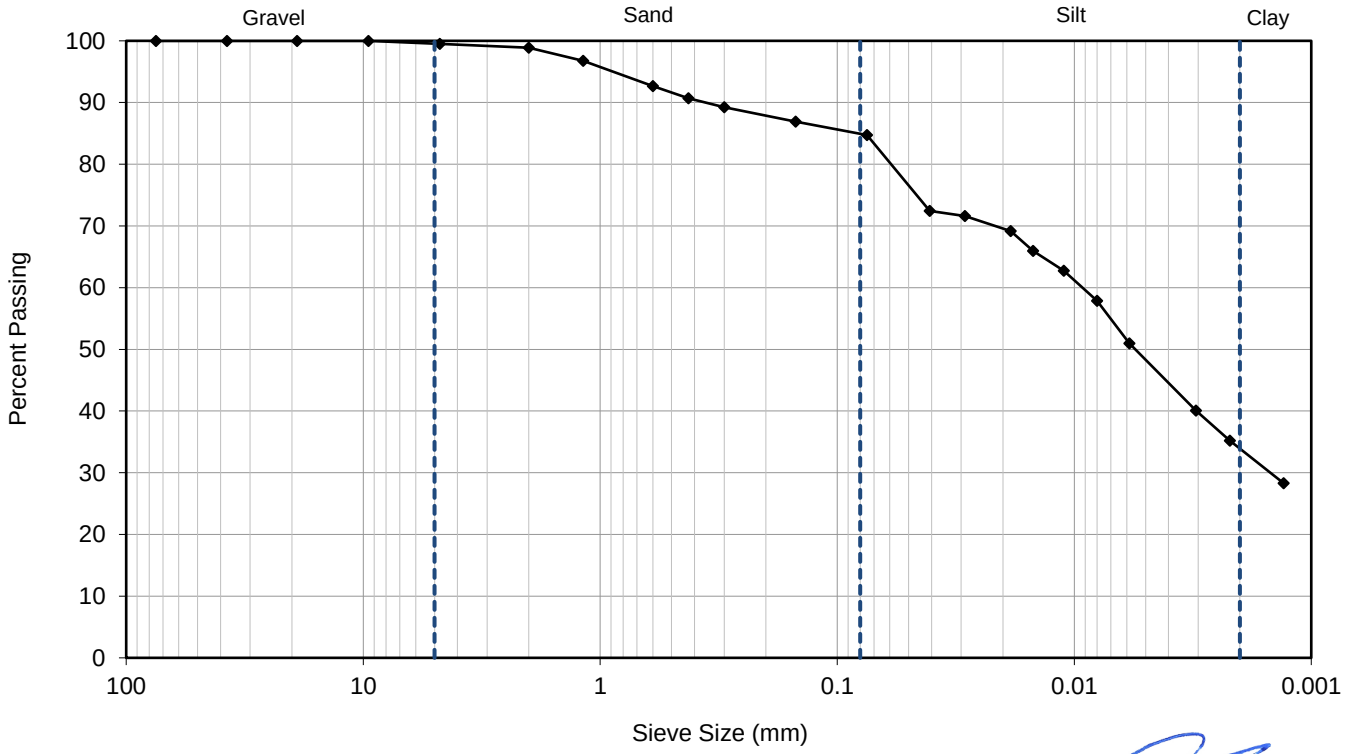
ASTM D7928

Sample Information

Sample No.	2	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Monday, May 8, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silt clayey some sand		
Sample Location	BH-05 3m (10')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
0.5 %	19	100.0
>5	9.5	100.0
	4.75	99.5
Sand	2	98.9
14.8 %	1.18	96.8
0.08 to 5	0.6	92.7
	0.425	90.7
Silt	0.3	89.2
51.1 %	0.15	86.9
0.002 to 0.08	0.075	84.7
	0.0408	72.4
Clay	0.0289	71.6
33.6 %	0.0185	69.2
<0.002	0.0149	66.0
	0.0111	62.7
	0.0080	57.9
	0.0058	51.0
Hydrometer	0.0031	40.1
Sample MC	0.0022	35.2
1.5 %	0.0013	28.3



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Hydrometer Particle Size Analysis

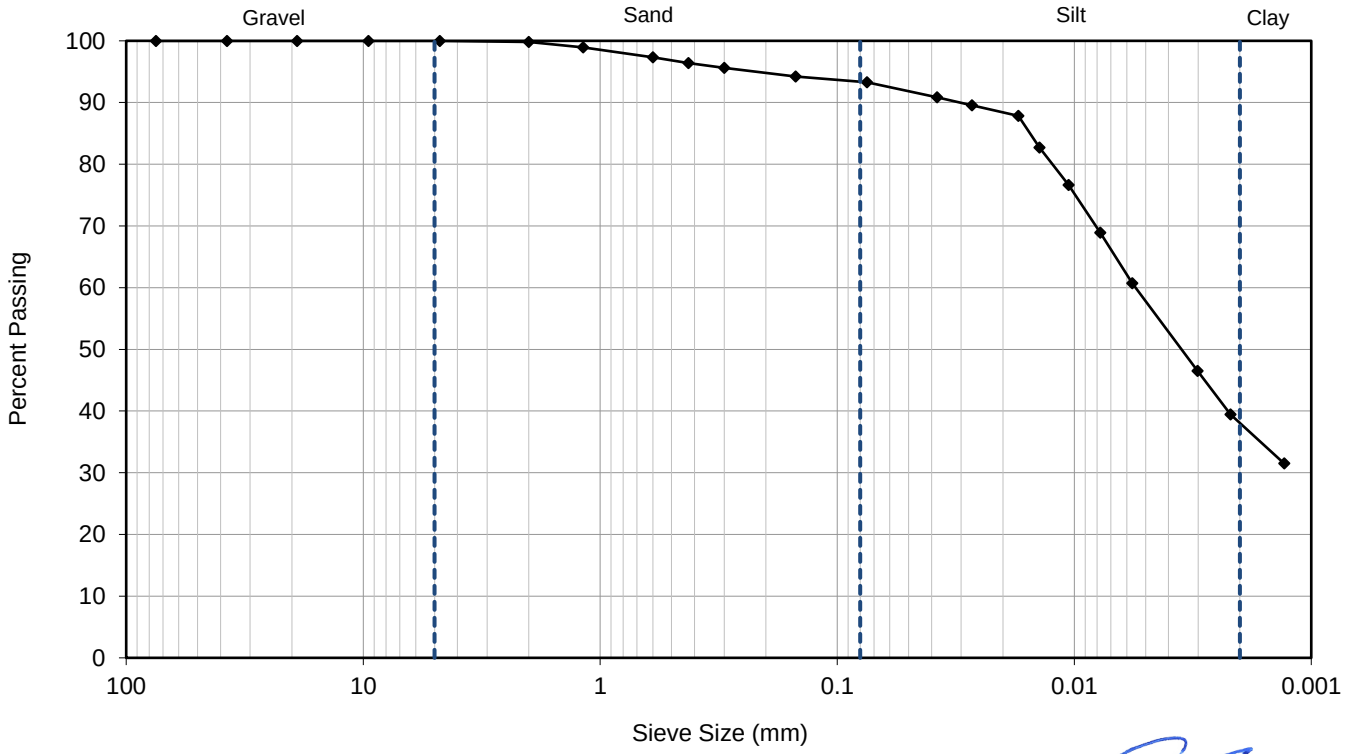
ASTM D7928

Sample Information

Sample No.	5	Date Received	-
Sample Date	Saturday, March 18, 2023	Date Tested	Tuesday, May 2, 2023
Time Sampled	-	Supplied by	-
Sampled by	Client	Tested by	IJ
Sample Description	Silt and clay trace sand		
Sample Location	BH-05 7.6m (25')		

Test Data

ASTM Particle Sizes (mm)	Sieve Size (mm)	Percent Passing
	75	100.0
Gravel	37.5	100.0
	19	100.0
>5	9.5	100.0
	4.75	100.0
Sand	2	99.8
6.7 %	1.18	98.9
0.08 to 5	0.6	97.3
	0.425	96.4
Silt	0.3	95.6
55.5 %	0.15	94.2
0.002 to 0.08	0.075	93.3
	0.0379	90.9
Clay	0.0270	89.6
37.8 %	0.0172	87.8
<0.002	0.0140	82.7
	0.0106	76.7
	0.0078	68.9
	0.0057	60.7
Hydrometer	0.0030	46.5
Sample MC	0.0022	39.5
1.0 %	0.0013	31.5



Approved by

Clifton

Project No	E589
Client	Maskwa Engineering
Project	2023 Geo. Lab Services
Location	Jean Marie River Bridge, NWT

Clifton

29 May 2023

Attention: Mr. Clell Crook clell@maskwaengineering.ca
Company: Maskwa Engineering Ltd.
Address: 925 Mackenzie Highway
Hay River, NWT T0H 2P0

Core Identification, Logging, and Laboratory Testing **File E589**
Maskwa Engineering
Hay River, NWT

Background

Clifton was retained by Maskwa Engineering (Maskwa, or the Client) to complete core logging and laboratory testing of soil and bedrock cores that were drilled near Jean Marie River Bridge Crossing, Northwest Territories. Based on correspondence with the Client, the boreholes were drilled on 17 to 18 March 2023, consisting of split spoon sampling for overburden to depths between 6.7 to 10 m below ground surface (bgs) and NQ coring (2.5" diameter) to approximately 12.4 m bgs. Two boxes of bedrock core was shipped by the Client to Clifton with the core being received by Clifton on 10 April 2023. Upon opening the core boxes, Clifton observed that the core was wrapped in newspaper but was not sealed/wrapped in plastic wrap as to prevent moisture loss. Clifton received authorization to proceed with the core logging and laboratory testing on 19 April 2023.

Core Identification and Logging

Borehole 2 (BH-02)

The BH-02 samples reviewed by Clifton were obtained from 6.7 to 12.3 m bgs. Stratigraphy at this borehole consisted of fine-grained, light brown to greyish-brown desiccated mud to friable mudstone bedrock, that was not lithified and highly weathered. The bedding planes of the core were measured between 87 to 90° to core axis (tca). Compacted mudstone (firm to hard) was observed from approximately 9.0 to 9.2 m bgs, which was hard but broken along bedding planes into approximately 0.05 to 0.1 m core chunks. By the time the core arrived at Clifton, the quality of the bedrock core had significantly deteriorated, and Clifton observed extensive mechanical fracturing likely resultant of the drilling process, transportation of the core, and age of the core samples. The majority of mechanical fracturing occurred along bedding planes in the core. Localized rubble was observed between 6.7 to 7.25 m and 8.2 to 8.8 m; the fracturing from 6.7 to 7.25 m appeared mechanically induced, and the fracturing from 8.2 to 8.8 m was associated with a vertical (0° tca) natural fracture. Localized cross cutting to sub-vertical fractures were observed in the drill core, commonly ranging between 0 to 60° tca; natural fractures exhibited planar, smooth and relatively fresh surfaces, with no visible infill observed along the fracture faces.

Based on the measurements of the drill core completed by Clifton, the Total Core Recovery (TCR) was measured as 4.1 m and the Rock Quality Designation (RQD) was measured as 0.38. Clifton measured the ISRM Strength Index to be between Firm Clay (S3) to Stiff Clay (S4); despite the core being relatively dry at the time of the field measurements, the core was subject to crumbling under light to moderate pressure. Due to the bedrock core being highly weathered, blocky to locally rubbly or decomposed with smooth fracture faces, the Geological Strength Index (GSI) is estimated to be approximately 10.

Point load testing was completed as a means to determine the approximate strength of the bedrock cores. Both axial and diametral point load data was collected for BH-02, the results are presented in Table 1.

Table 1 – Point Load Data for BH-02

Depth (m bgs)	Orientation	Measurement (mPa)	Length (m)	Width (m)	Failure Mode
7.64	Diametral	0.10	0.0762	0.0635	Valid
7.90	Axial	0.14	0.0508	0.0635	Valid
9.00	Axial	1.44	0.0889	0.0635	Valid
9.32	Diametral	0.18	0.0699	0.0635	Valid
11.00	Diametral	0.14	0.0635	0.0635	Valid
11.85	Axial	0.22	0.0508	0.0635	Valid

Do to the poor core quality, there were no samples that met the requirements to complete Unconfined Compressive Strength (UCS), or direct shear testing. Without the direct shear testing, the friction angle for the material could not be calculated. A borehole log for BH-02 is presented in Appendix A. Photographs of the drill core are presenting in Appendix B.

Borehole 3 (BH-03)

The BH-02 samples reviewed by Clifton were obtained from 10.0 to 12.7 m bgs. As with BH-02, the cores from BH-03 were also classified as fine-grained, light brown to greyish-brown desiccated mud to friable mudstone bedrock, that was not lithified and highly weathered from 10.0 to 12.4 m. Hard, competent mudstone bedrock was observed from approximately 10.6 to 10.8 m bgs. From 12.4 to 12.7 m, there was approximately 0.30 m of coarse-grained rounded to sub-rounded gravel.

The BH-03 mudstone bedrock exhibited extensive core deterioration as well as mechanically induced fracturing primarily along bedding planes. Two intervals of localized rubble were observed from 10.70 to 10.85 m and 11.10 to 11.5 m bgs. There were no natural fractures observed within the drill core.

The TCR was measured as 2.1 m and the Rock Quality Designation (RQD) was measured as 0.58. Similarly to BH-02 the ISRM Strength Index was estimated to be between Firm Clay (S3) to Stiff Clay (S4) as the core was subject to crumbling under light to moderate pressure. Due to the bedrock core being highly weathered, blocky to locally rubbly or decomposed with smooth fracture faces, the Geological Strength Index (GSI) is estimated to be approximately 10.

Due to core decomposition, there were no pieces of core that were adequate for point load testing. Additionally, there were no pieces of core that met the requirements for UCS and direct shear measurements. Without the direct shear testing, the friction angle could not be calculated. A borehole log for BH-03 is presented in Appendix A. Photographs of the drill core are presenting in Appendix B.

Closure

This report was prepared by Clifton Engineering Group Inc. for the use of Maskwa Engineering Ltd. for specific application to the Core Logging and Laboratory Sampling completed for drill cores sampled from near Jean Marie River Bridge Crossing, Northwest Territories.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Clifton Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report has been prepared in accordance with generally accepted standard engineering practice common to the local area. No other warranty, express or implied is made.

The drill core and all information regarding sampling intervals and sample types were provided to Clifton Engineering Group Inc. by Maskwa Engineering Ltd. Clifton Engineering Group Inc. accepts no responsibility for any deficiencies or inaccuracies in the information provided in this report that are the direct result of intentional or unintentional misrepresentations, errors or omissions of the information reviewed.

The sampling and associated laboratory testing indicate conditions only at the specific locations and times investigated, only to the depth penetrated, only for the properties tested and for the condition of the core as received. The core had severely deteriorated during shipping and as a result the properties measured may not be representative of the insitu conditions. The subsurface conditions may vary between the sampling locations and with time. The drill core interpretation provided is a professional opinion of conditions and not a certification of the site conditions. The nature and extent of bedrock variation may not become evident until further investigation has been completed. Although the bedrock conditions have been explored, our observations are limited to the drill cores that have been provided to Clifton Engineering Group Inc.

Should you have any concerns regarding to the scope of work stated above, please contact our office at (403) 263-2556.

Yours truly,

Clifton

2023-05-25

Bryn Gelowitz PGeo
Project Geoscientist

Reviewed by:
Allan Kelly MSc PEng PGeo PGeol
Senior Geotechnical Engineer/Geologist

Attachments
Appendix A – Borehole Logs
Appendix B – Core Photographs

Appendix A
Borehole Logs

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Symbols and Terms

Soil Descriptive Terms

A soil description for geotechnical, hydrogeological, or environmental applications includes the following properties:

- Soil Name (Origin)
- Texture
- Plasticity
- Colour
- Consistency or Compactness
- Moisture Condition
- Primary and Secondary Structure

Soil Name (Origin)

The soil name is the basic name of the predominant constituent such as gravel, sand, silt, or clay. The Unified Soil Classification System (USCS) from ASTM D2487 as modified in Chapter 3 of the Canadian Foundation Engineering Manual 4th Edition (CFEM) is used to determine the soil name. The basis of this system is presented in the chart on page 4 outlining the Soil Classification for Engineering Purposes.

(FILL) is used with the soil name to describe a soil that has been reworked.
(TILL) may be used with the soil name to describe a soil which has been deposited by glaciers and contains an unsorted, wide range of particle sizes.
TOPSOIL may be used to name surficial organic soil layers.

Texture

The soil texture refers to the size, size distribution and shape of the individual soil particles which comprise the soil. The following terms are commonly used to describe the soil texture.

Particle Size (ASTM D2487)	
Boulder	300 mm plus
Cobble	75 mm – 300 mm
Gravel:	4.75 mm – 75 mm
▪ Coarse	19 mm – 75 mm
▪ Fine	4.75 mm – 19 mm
Sand:	0.075 mm – 4.75 mm
▪ Coarse	2 mm – 4.75 mm
▪ Medium	0.425 mm – 2 mm
▪ Fine	0.075 mm – 0.425 mm
Silt and Clay	Smaller than 0.075 mm

Relative Proportions (CFEM)	
Gravel, Sand, Silt, Clay, etc.	35% and main fraction
And	>35%
Gravelly, sandy, silty, clayey, etc.	20% – 35%
Some	10% – 20%
Trace	1% – 10%

Gradation (ASTM D2487, CFEM)	
Well Graded	Having a wide range of grain sizes and substantial amount of all intermediate sizes
Uniform or Poorly Graded	Possessing particles of predominantly one size
Gap Graded	Possessing particles of two distinct sizes

Particle Shape (ASTM D2488)	
Angular	Sharp edges and relatively plane sides with unpolished face
Subangular	Similar to Angular but have rounded edges
Subrounded	Well-rounded corners and edges, nearly plane sides
Rounded	No edges, has smoothly curved sides
Flat	Width/Thickness >3
Elongated	Length/Width >3
Flat and Elongated	Meet criteria for both Flat and Elongated

Plasticity

Plasticity is used to describe a fine-grained soil as defined by the chart on page 4. The plasticity of a soil is based on the results of Atterberg Limits testing or through the application of approved field or laboratory tests for dilatancy, dry strength, or toughness. Plasticity is identified as non-plastic, low plastic, medium plastic, or high plastic. Medium plastic is only applicable to clay soils.

Colour and Oxidation

The soil colour at its natural moisture content is described by common colours and, quantitatively, in terms of the Munsell colour notation; (e.g., 5Y 3/1). The notation combines three variables, hue, value and chroma to describe the soil colour. The hue indicates its relation to red, yellow, green, blue, and purple. The value indicates its lightness. The chroma indicates its strength of departure from a neutral of the same lightness. Departure of the soil colour from a neutral colour indicates the soil has been oxidized. Oxidation of a soil occurs in an oxygen rich environment where most commonly metallic iron, oxidizes and turns a neutral coloured soil 'rusty' or reddish brown. Oxidized manganese gives a purplish tinge to the soil. Oxidation may occur throughout the entire soil mass or on fracture, joint, or fissure surfaces.

Consistency or Compactness

The consistency of a cohesive soil is a qualitative description of its resistance to deformation and can be correlated with the undrained shear strength of the soil. Approximate correlations with the Standard Penetration Test (SPT) N-Value can be used with caution. The compactness of a coarse-grained soil qualitatively describes the soil and can be correlated with the Standard Penetration resistance (ASTM D1586).

Consistency of Cohesive Soil (CFEM, ASTM D2488)

Consistency	**Undrained Shear Strength** (kPa)	**SPT N – Index** (blows/300 mm)
Very Soft	<12	< 2
Soft	12 – 25	2 – 4
Firm	25 – 50	4 – 8
Stiff	50 – 100	8 – 15
Very Stiff	100 – 200	15 – 30
Hard	>200	> 30

Compactness of Coarse-Grained Soil (CFEM)

Compactness	**SPT N – Index** (blows/300 mm)
Very Loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Over 50

Moisture Condition

Moisture condition is a qualitative description of the apparent degree of moisture in a soil. It is not a direct reflection of the soil's water content or saturation.

Moisture Condition (ASTM D2488-00)

Description	**Criteria**
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible, free water, usually soil is below water table

Structure

The soil structure is the manner in which the individual soil particles are assembled to form the soil mass. The primary soil structure (strata geometry) is the arrangement of soil particles as originally deposited. The secondary soil structure (fractures and cementation) refers to any rearrangement of the soil such as deformation and cracking which has taken place since deposition.

Strata Geometry	
Stratum	A single sedimentary ‘layer’, greater than 10 mm in thickness, visibly separable from other strata by a discrete change in lithology or sharp physical break
Stratified	Consisting of a sequence of layers which are generally of contrasting texture or colour
Laminated	Stratified with layer thickness between 2 – 10 mm
Thinly Laminated	Stratified with layer thickness less than 2 mm
Bedded	Stratified with layer thickness greater than 10 mm
Very Thinly-bedded (Flaggy)	Stratified with layer thickness between 10 – 50 mm
Thinly-bedded (Slabby)	Stratified with layer thickness between 50 – 600 mm
Thickly-bedded (Blocky)	Stratified with layer thickness between 600 – 1200 mm
Thick-bedded (Massive)	Stratified with layer thickness greater than 1200 mm
Lensed	Inclusions of small pockets of different soil, such as small lenses of sand material throughout a mass of clay

Fracture Structures	
Fracture	A break or discontinuity in the soil or rock mass caused by stress exceeding the materials strength
Joint	A fracture along which no displacement has occurred
Fissure	A gapped fracture, which may open and close seasonally. Usually an extensive network of closely spaced fractures, giving the soil a ‘nuggetty’ structure
Slickensides	Fractures in clay that are slick and glossy in appearance, caused by shear movements
Brecciated	Contains randomly orientated angular fragments of a finer mass, usually associated with shear displacement in soils
Fault	A fracture or fracture zone along with displacement has occurred
Blocky	A cohesive soil that can be broken down into small angular lumps which resist further break down
Cementation	Chemically precipitated material, commonly calcite ($CaCO_3$), binds the grains of soil, usually sandstone. Described as weak, moderate, or strong (ASTM D2488-00)

Inclusions

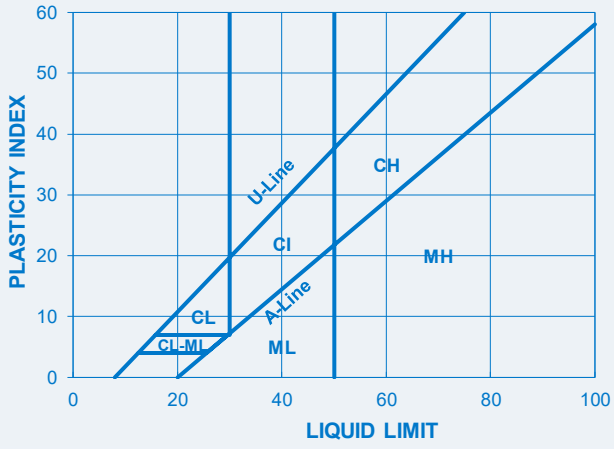
Inclusions are parts that comprise less than 1% of the soil mass. Descriptors for inclusions should consist of frequent or occasional. Inclusions may be accretionary structures (nodules, concretions), veinlets, colour banding, salt crystals, pebbles, or coal particles. Non-mineral inclusions such as organic material (e.g., roots, rootlets) can also be included in the soil description for strata that are not identified as an organic soil.

Staining

Staining is generally applicable to environmental investigations but can also be included if observed during geotechnical or hydrogeological investigations. Staining descriptions should be limited to generalized descriptions only unless confirmed through additional testing (e.g., hydrocarbon staining).

Classification of Soils for Engineering Purposes

ASTM D 2487 and CFEM

Major Divisions			Group Symbol	Typical Names	Classification Criteria		
Coarse-grained soils > 50% retained on No. 200 sieve (>0.075 mm)	Gravels More than 50% of coarse fraction retained on No. 4 sieve (4.75 mm)	Clean gravels <5% fines	GW	Well-graded gravel	Classification on basis of percentage of fines: > 5% pass No. 200 sieve - GW, GP, SW, SP > 12% pass No. 200 sieve - GM, GC, SM, SC 5% to 12% pass No. 200 sieve - Borderline classification, use dual symbols	$C_U = \frac{D_{60}}{D_{10}} \geq 4$	$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 1 to 3
			GP	Poorly graded gravel		Not meeting either Cu or Cc criteria for GW	
		Gravels with >12% fines	GM	Silty gravel		Atterberg Limits below A-line or PI < 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravel		Atterberg Limits on or above A-line and PI >7	
	Sands 50% or more of coarse fraction passes No. 4 sieve (<4.75 mm)	Clean sands <5% fines	SW	Well-graded sand		$C_U = \frac{D_{60}}{D_{10}} \geq 6$	$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 1 to 3
			SP	Poorly graded sand		Not meeting either Cu or C criteria for SW	
		Sands with >12% fines	SM	Silty sand		Atterberg Limits below A-line or PI less than 4	Atterberg Limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sand		Atterberg Limits on or above A-line and PI >7	
Fine-grained soils 50% or more passes No. 200 sieve (<0.075 mm)	Silts Below A-Line Negligible organic content	W_L < 50%	ML	Silt			
		W_L > 50%	MH	Elastic silt			
	Clays Above A-Line Negligible organic content	W_L < 30%	CL	Low Plastic Clay			
		30% <W_L < 50%	CI	Medium Plastic Clay			
		W_L > 50%	CH	High Plastic Clay			
	Organic Silts and Clays	W_L < 50%	OL	Organic clay or silt (Clay plots above A-Line)			
		W_L > 50%	OH				
Highly Organic Soils			PT	Peat, muck, and other highly organic soils			

Symbols Used on Borehole Logs

Lithology Type


Clay


Silt


Sand


Gravel


Cobbles


Till – oxidized


Till – unoxidized


Peat


Fill (undifferentiated)


Coal


Topsoil or Organic Soil


Concrete


Asphalt


Clay Shale


Sandstone


Mudstone


Bedrock (undifferentiated)

Borehole Completion and Backfill Materials


Bentonite


Concrete


Cover


Cuttings


Grout


Sand


Slough


Solid Pipe


Slotted Pipe

Soil Sample Type


Thin Walled Tube


Split Spoon


Disturbed


Core (any type)


No Recovery

Groundwater Symbols

▼ Piezometric elevation as determined by a piezometer installation.

▽ Water levels measured in borings at time and under the conditions noted.

Geotech BH m Elev CAL v13.idf

BOREHOLE LOG

Borehole: BH-02

Page: 1 of 1

Client:	Maskwa Engineering Ltd.	Northing:	0	Date Drilled:	17-18 March 2023
Project:	NWT Core Logging	Easting:	0	Drill:	N/A
Location:	Jean Marie River Bridge, NWT	Ground Elev.:	0	Drilling Method:	NQ Coring
Project No.:	E589	Top Casing Elev.:	N/A	Logged by:	BG

Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800 – 2200); Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100 – 200 – 300 – 400)	Piezometer Construction Detail
6										
7		Mudstone: Fine-grained mudstone to desiccated mud, non-lithified, light brown to greyish-brown, dry, blocky and rubbly to locally decomposed, bedding planes at 87-90° to core axis. Rubbly core from 6.7-7.25m (mechanical).		BH2-7: Soluble Sulphate						
				*BH2-4: Corrosion						
				BH2-2: Unit Weight						
8		At 7.64m, Diametral Point Load Test (0.10 mPa)								
		At 7.75m, 20° tca fracture, smooth surface, no infill		*BH2-5: Corrosion						
		At 7.9m, Axial Point Load Test (0.14 mPa)		BH2-1: Moisture Content						
		From 8.2-8.8m, rubbly core associated with subvertical fractures (0-3° tca)								
9		At 9.0m, Axial Point Load Test (1.44 mPa)								
		At 9.2m, bedding at 89° tca and 30° tca fracture, smooth surface, no infill								
		At 9.32m, Diametral Point Load Test (0.18 mPa)								
10		At 9.45m, 65° tca fracture, smooth surface, no infill								
		At 9.53m, bedding at 87° tca								
11		At 11.0m, Diametral Point Load Test (0.14 mPa)								
		At 11.47m, 3° tca fracture, smooth surface, no infill		BH2-3: Unit Weight						
		At 11.53m, bedding at 90° tca		*BH2-6: Corrosion						
		At 11.85m, Axial Point Load Test (0.22 mPa)								
12		At 12.15m, bedding at 90° tca and 0° tca fracture, smooth surface, no infill								
		At 12.3m, end of hole (EOH)								
		Samples BH2-1, BH2-2, BH2-3 and BH2-7 analysed by Clifton Engineering Group Inc.								
13		*Samples BH2-4, BH2-5, and BH2-6 analysed by BV Laboratory								
		TCR = 4.1m								
		RQD = 0.38m								
14										

Geotech BH m Elev CAL v13.idf

BOREHOLE LOG

Borehole: BH-03
Page: 1 of 1

Client:	Maskwa Engineering Ltd.	Northing:	0	Date Drilled:	17-18 March 2023
Project:	NWT Core Logging	Easting:	0	Drill:	N/A
Location:	Jean Marie River Bridge, NWT	Ground Elev.:	0	Drilling Method:	NQ Coring
Project No.:	E589	Top Casing Elev.:	N/A	Logged by:	BG

Depth (m)	Symbol	Soil Description	Sample Type	Sample No.	SPT 'N'	USC	% Sulphate	Moisture Content (percent): Plastic Limit ▲ / Natural Moisture ● / Liquid Limit ◆ (0 – 50 – 100)	Dry Density - kg/m3 (1800, 2200) / Shear Strength - kPa: Unconf. ■ / Pocket Pen. ● / Lab Vane ◆ (100, 200, 300, 400)	Piezometer Construction Detail
9										
10		Mudstone: Fine-grained mudstone to desiccated mud, non-lithified, light brown to greyish-brown, dry, blocky and rubbly to locally decomposed, bedding planes at 83-88° to core axis.		*BH3-4: Corrosion						
				BH3-3: Hydrometer						
		At 10.12m, 80° tca fracture, slickenside surface, no infill								
		From 10.70-10.85m, rubbly to decomposed core		BH3-2: Unit Weight						
11		From 10.60-10.80m, hard and competent bedrock. At 10.67m, bedding at 83° tca								
		At 10.90m, bedding at 87° tca								
		From 11.10-11.5m, rubbly to decomposed core		BH3-1: Moisture Content						
		At 11.6m, bedding at 88° tca		*BH3-5: Corrosion						
12		GRAVEL: Coarse-grained, round to sub-rounded gravel								
		At 12.7m, end of hole (EOH)								
13		Samples BH3-1, BH3-2, and BH3-3 analysed by Clifton Engineering Group Inc.								
		*Samples BH3-4 and BH3-5 analysed by BV Laboratory								
		TCR = 2.1m								
		RQD = 0.58								
14										

Appendix B
Core Photographs

Clifton

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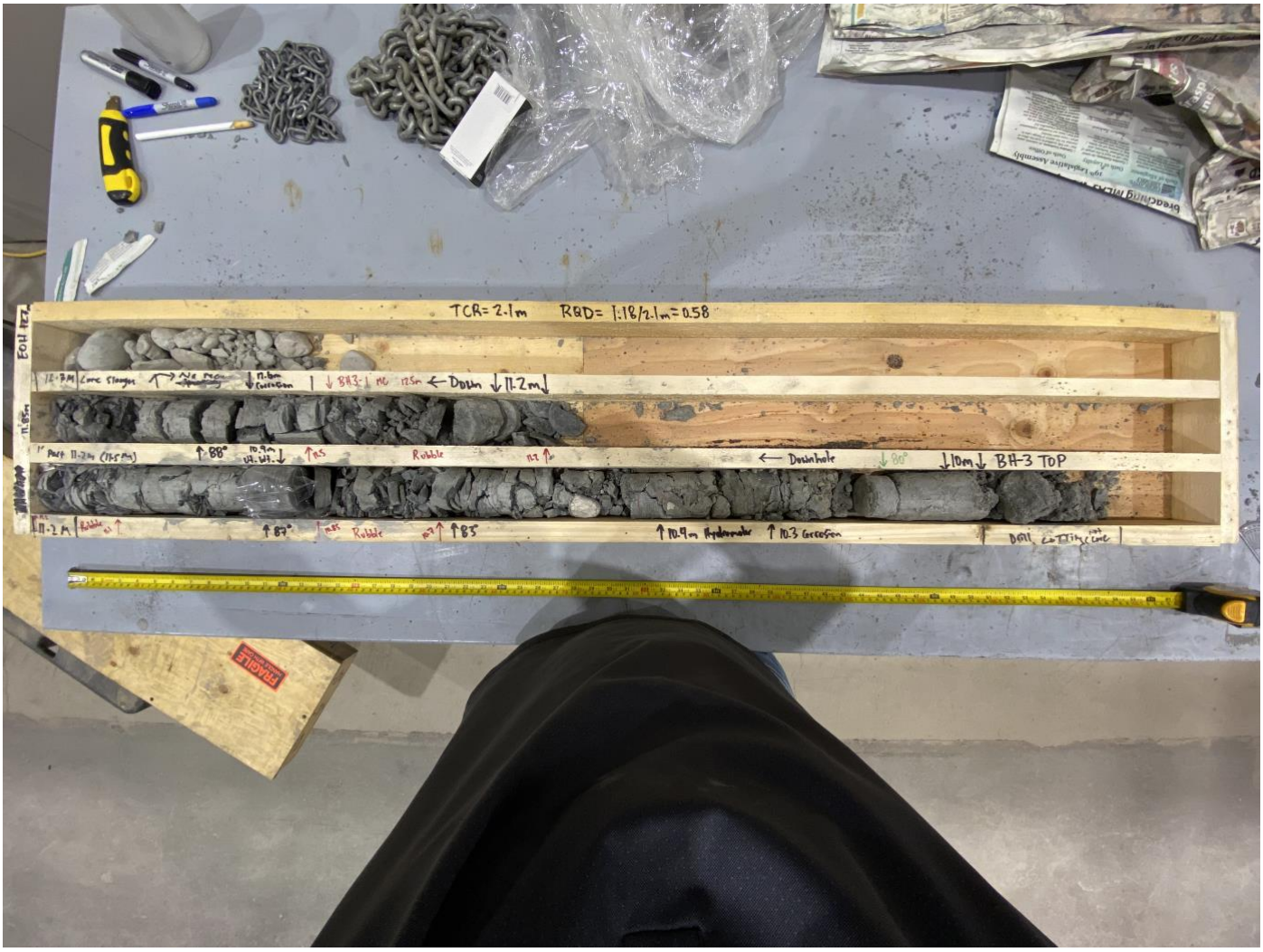
Maskwa Engineering Ltd. – Borehole 2 (BH-02)

Photograph 1: BH-02

Maskwa Engineering Ltd. – Borehole 3 (BH-03)



Photograph 2: BH-03

Unit Weights

ASTM D7263

Moisture Determination					
Borehole Number	BH-02	BH-02	BH-03		
Sample Number	2	3	2		
Depth	25.4ft	37.7ft	35.8ft		
Tare Weight, g	7.55	7.95	7.72		
Weight of Tare and Wet Sample, g	96.01	66.73	72.72		
Weight of Tare and Dry Sample, g	93.96	64.79	69.97		
Moisture Content, %	2.4	3.4	4.4		

Density Determination					
Borehole Number	BH-02	BH-02	BH-03		
Sample Number	2	3	2		
Depth	25.4ft	37.7ft	35.8ft		
Weight of Sample, g	459.92	384.70	335.67		
Weight of Sample and Wax, g	462.77	387.00	337.93		
Wt. of Sample and Wax in Water, g	268.90	229.90	268.90		
Volume of Sample and Wax, cm^3	193.87	157.10	69.03		
Weight of Wax, g	2.85	2.30	2.26		
Density of Wax, g/cm^3	0.86	0.86	0.86		
Volume of Wax, cm^3	3.30	2.66	2.61		
Volume of Sample, cm^3	190.57	154.44	66.42		
Wet Density, kg/m^3	2413	2491	5054		
Dry Density, kg/m^3	2357	2409	4840		

Remarks

Reviewed By: Kyle Zobell

Clifton

Project No.	E589
Client	Maskwa Engineering
Project	2023 Geo Lab Services
Location	Jean Marie, NWT

Your Project #: E589
Your C.O.C. #: BV0954

Attention: Bryn Gelowitz

Clifton Engineering Group Inc.
10509 46 STREET SE
CALGARY, AB
CANADA T2C 5C2

Report Date: 2023/04/27
Report #: R3328359
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C328352
Received: 2023/04/24, 14:24

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Soluble Ions	1	2023/04/26	2023/04/26	AB SOP-00033 / AB SOP-00042	EPA 6010d R5 m
Soluble Paste	1	2023/04/26	2023/04/26	AB SOP-00033	Carter 2nd ed 15.2 m
Soluble Ions Calculation	1	N/A	2023/04/26		Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Bureau Veritas Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

Your Project #: E589
Your C.O.C. #: BV0954

Attention: Bryn Gelowitz

Clifton Engineering Group Inc.
10509 46 STREET SE
CALGARY, AB
CANADA T2C 5C2

Report Date: 2023/04/27
Report #: R3328359
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C328352
Received: 2023/04/24, 14:24

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Melissa McIntosh, Customer Solutions Representative
Email: Melissa.McIntosh@bureauveritas.com
Phone# (403) 291-3077

==========

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RESULTS OF CHEMICAL ANALYSES OF SOIL

Bureau Veritas ID		BPH241			
Sampling Date		2023/04/20			
COC Number		BV0954			
	UNITS	BH-02 SAMPLE 1	RDL	MDL	QC Batch
Calculated Parameters					
Calculated Sulphate (SO4)	mg/kg	130	2.7	N/A	A942498
Soluble Parameters					
Saturation %	%	55	N/A	N/A	A944498
Soluble Sulphate (SO4)	mg/L	240	5.0	N/A	A945017

RDL = Reportable Detection Limit
N/A = Not Applicable

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	18.3°C

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
A944498	ABQ	QC Standard	Saturation %	2023/04/26		105	%	75 - 125
A944498	ABQ	RPD	Saturation %	2023/04/26	2.4		%	12
A945017	VSC	QC Standard	Soluble Sulphate (SO4)	2023/04/26		85	%	75 - 125
A945017	VSC	Method Blank	Soluble Sulphate (SO4)	2023/04/26	<5.0		mg/L	
A945017	VSC	RPD	Soluble Sulphate (SO4)	2023/04/26	14		%	30

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

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NOTIFICATION LOG

No Reportable Regulation Exceedances Noted.

Bureau Veritas Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Harry (Peng) Liang, Senior Analyst, B.Sc., QP

Bureau Veritas Proprietary Software
Logiciel Propriétaire de Bureau Veritas

Automated Statchk

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by {0}, {1} responsible for {2} {3} laboratory operations.

Bureau Veritas Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

7684/1

Calgary: 4000 19th St. NE, T2E 6P8. Toll Free (800) 386-7247
Edmonton: 9331-48 St. T6B 2R4. Toll Free (800) 386-7247
bvna.com

CHAIN OF CUSTODY RECORD

BV 0954

Report Information		Comments	Analysis Requested																												Same as CoC
Company: Clifton			# of containers	BTEX F1 ☐ VOC ☐	BTEX F1-F2	BTEX F1-F4	Routine Water	Regulated Metals Tot ☐ Diss ☐	Mercury Total ☐ Dissolved ☐	Salinity 4	Sieve (75 micron)	Texture (% Sand, Silt, Clay)	Basic Class II Landfill	X Sal phate														HOLD - DO NOT ANALYZE	
Contact: Bryn Gelowitz																															Project/LSD
Phone: 403-354-3379																															E58a
Email: bryn_gelowitz@clifton.ca																															Special Instructions
Sampled by:																															
Sample Identification	Depth (Unit)	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix																											
11 BH-02 Sample 7	22ft	23/4/20																													
12																															
13																															
14																															
15																															
16																															
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Please indicate Filtered, Preserved or Both (F, P, F/P)																															

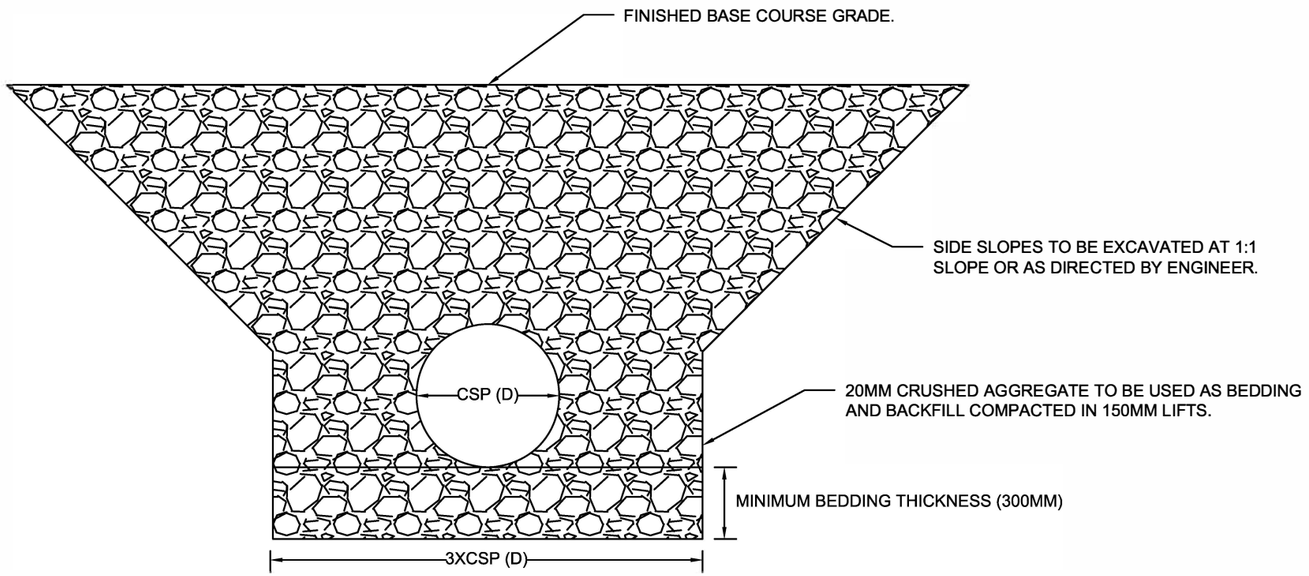
Relinquished by: (Signature/ Print)	DATE (YYYY/MM/DD)	Time (HH:MM)	Received by: (Signature/ Print)	DATE (YYYY/MM/DD)	Time (HH:MM)
Ian Feenstra	23/4/24	12:00	ATRAVERCILL	2023/04/24	14:24

24-Apr-23 14:24
Melissa McIntosh
C328352

Seal-N Ice-N
AKV INS-0001
18/18/19

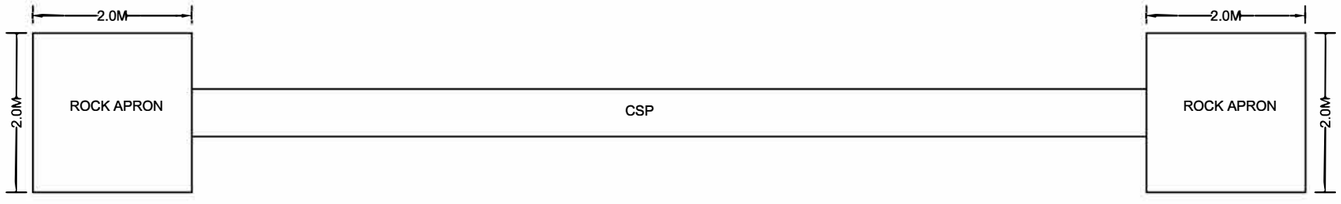
AB FCD-00331/10

Appendix D



NOTE:

- CSP (D) = CORRUGATED STEEL PIPE DIAMETER.
- AN ENGINEER MUST INSPECT THE THE EXCAVATION PRIOR TO BACKFILL.
- A WOVEN GEOTEXTILE SHALL BE USED AT THE BASE OF THE EXCAVATION.
- CSP BEDDING TO BE AT 100% OF MAXIMUM DRY DENSITY ACCORDING TO ASTM D698 STANDARD PROCTOR VALUE PRIOR TO INSTALLATION.
- FILL MUST BE BROUGHT UP SIMULTANEOUSLY ON EITHER SIDE OF THE CSP IN MAXIMUM LIFTS OF 150MM COMPACTED TO 100% OF THE STANDARD PROCTOR VALUE.
- 300MM THICK ROCK APRON TO BE PLACED ON NON WOVEN GEOTEXTILE FILTER FABRIC ON EITHER END OF CSP AS EROSION CONTROL.
- ROCK APRON TO FOLLOW ROCK RIPRAP CLASS 1.
- THIS DRAWING IS INTENDED TO DEATIL THE FILL REQUIRMENTS FOR THE ACCESS ROAD CULVERT REPLACEMENTS.



ROCK RIPRAP CLASS 1:

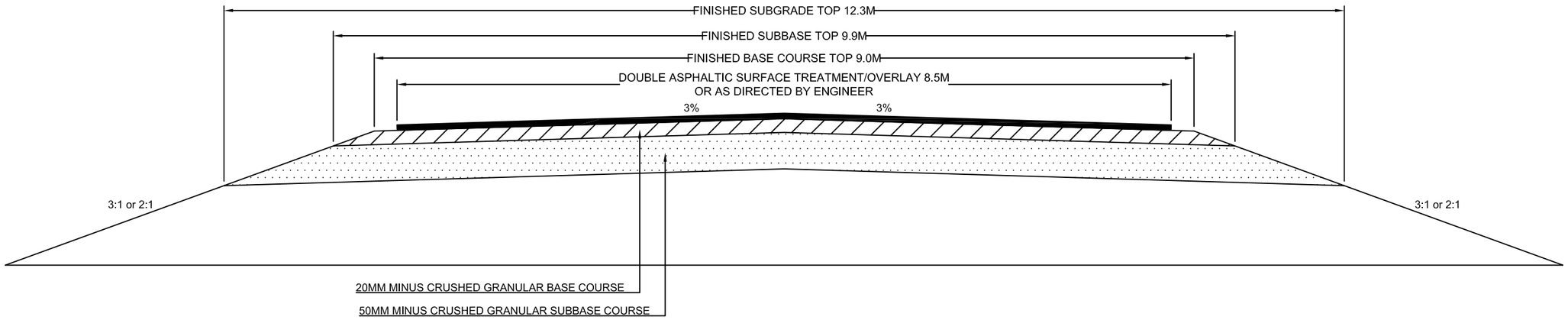
NOMINAL MASS: 40KG
NOMINAL DIAMETER: 300MM
NONE GREATER THAN: 130KG/450MM
20% TO 50%: 70KG/350MM
50% TO 80%: 40KG/300MM
100% GREATER THAN: 10KG/200MM

MASKWA ENGINEERING LTD

Project No.: 0000005729	DRAWING TITLE: CULVERT REPLACEMENT DETAIL	CLIENT: GNWT	SCALE: NTS
Dwg No.: 1			
Revision	PROJECT: JEAN MARIE RIVER BRIDGE REPLACEMENT ENGINEERING SERVICES	MASKWA JOB No.: 22-062	

No.	Date	Description	Chkd

DRAWN BY: CJC
CHECKED BY: BJ
DATE: JULY 2023



NOTE:

- WIDTH OF MATERIALS AND ROAD ARE LEFT TO THE DISCRETION OF THE PROJECT TRANSPORTATION ENGINEER AND MAY VARY FROM THIS DRAWING.

MASKWA ENGINEERING LTD

Project No.: 0000005729	DRAWING TITLE: EMBANKMENT RECONSTRUCTION DETAIL	CLIENT: GNWT	SCALE: NTS					DRAWN BY: CJC
Dwg No.: 2								CHECKED BY: BJ
Revision	PROJECT: JEAN MARIE RIVER BRIDGE REPLACEMENT ENGINEERING SERVICES	MASKWA JOB No.: 22–062						DATE: JULY 2023
				No.	Date	Description	Chkd	