Geotechnical Memorandum

To: **The Town of Radisson**
329 Main Street
PO Box 69
Radisson, SK S0K 3L0

Attention: **Norma Stumborg - Administrator**

Date: **25 September 2024**

Project: **3285-1 Town of Radisson – Wastewater Lagoon Upgrade**

Re: **Wastewater Treatment Lagoon Upgrade Geotechnical Memo, Radisson, SK**

1. INTRODUCTION & BACKGROUND

PINTER & Associates Ltd. (PINTER) is pleased to provide this technical memorandum to the Town of Radisson (the Client) based on the geotechnical investigation of the existing wastewater lagoon (Lagoon) and the Lagoon expansion area and study of the clay liner material to aid in the design for the expansion of the Lagoon in Radisson, SK. The Lagoon is located south of Radisson, at SW-21-40-10-3.

Based on the information provided to PINTER, the Client has encountered issues with the Lagoon due to the severe undersize of its current capacity, and potentially expanding population. The Client wishes to remediate this problem by expanding its wastewater treatment capacity and remediating any underlying issues with the existing Lagoon to allow future developments that will support its economic growth.

P. Machibroda Engineering Ltd. (PMEL) completed a geotechnical study for the proposed expansion area in 2009 and a total of six test holes were drilled (TH 09-1 to TH 09-6, shown in Figure 1). On 19 July 2024, PINTER performed a field investigation to confirm the soil condition listed inPMEL's report.

Hydraulic conductivity tests were also performed on selected soil samples to aid in designing the clay liner requirement and specifications for the proposed lagoon system.

2. SCOPE OF WORK

A preliminary investigation of the existing Lagoon was performed by PINTER on 29 April 2024. A total of three environmental test holes (BH 1 to BH3, shown in Figure 1) were drilled on the existing berm around the Lagoon. Two test holes were drilled to a depth of 6.0 m, and the remaining test hole was drilled to a depth of 7.5 m. Disturbed oil samples were collected during drilling for further lab testing. A separate clay sample was also collected by the Client and sent to the PINTER laboratory at a later date to determine the suitability of an alternative source of clay liner material for the proposed lagoon expansion. All laboratory test results are included in Appendix A.

PINTER also conducted an additional geotechnical investigation on 19 July 2024 to further understand the soil and groundwater conditions at the proposed lagoon expansion site. Due to limited site access, only one test hole (BH4, shown in Figure 1) was completed at the proposed lagoon expansion area during this site investigation. This test hole was drilled to a depth of 7.6 m.

Disturbed samples were obtained from auger cuttings at all test hole locations. Soil samples were carefully sealed in labelled plastic bags and transported to the soil laboratory for further examination, testing, and assessment. All samples were visually classified in the field, and the individual soil strata and interfaces between them were noted.

The fieldwork was supervised by PINTER field personnel, who was responsible for logging the test holes, carefully noting and describing the changes in soil strata, and noting the occurrence of water-bearing zones.

A Standpipe piezometer was installed in the test hole BH4 to assess the long-term groundwater level measurements. The piezometers were constructed of 25 mm diameter PVC pipe with a 3.0 m long, slotted screen at the tip. The annulus between the pipe and the test hole wall was backfilled with sand within the screened section and 0.3m above, and with back-spun drill cuttings and bentonite chips within the solid section. A handheld GPS was used to obtain approximate UTM coordinates of the test hole location.

3. SUBSURFACE CONDITIONS OF THE EXISTING LAGOON

Approximately 0.3 m to 1.2 m of topsoil was encountered at the surface of all the test holes at the existing lagoon berm.

The naturally deposited soil encountered below the topsoil consisted of silty clay extended to a depth of 6.9 m of test hole BH1 and the full depth of test hole BH2. Silt seams were encountered intermittently within the silty clay layer from 4.8 m to 5.1 m, 6.0 m to 6.9 m in BH1, and 3.3 m to 4.2 m in BH2. Clay till was encountered below the silty clay layer in BH1 and extended to the full depth of the test hole. In BH3, silt and sand were encountered beneath the topsoil and extended to a depth of approximately 4.0 m. Beneath this depth in BH3, silty clay was encountered and extended to the full depth investigated.

The silty clay encountered in the test holes was described as medium to high plastic clay with a moist condition. The moisture content of the clay varied between 23% and 40%. It was generally in a soft to stiff consistency. The test results in Table 1 confirmed the soil as medium Plastic clay (CI).

The silt encountered in the test holes was described as low to medium plastic silt with moist conditions. It was generally in firm condition. The moisture content of the sand varied between 23% and 36%.

The clay till was generally in damp condition and stiff consistency. It had medium plasticity with occasional gravel throughout. The moisture content of the clay till was 18.0%.

4. SUBSURFACE CONDITIONS OF THE LAGOON EXPANSION AREA

Approximately 50 mm of topsoil was encountered at the surface of the test hole within the lagoon expansion area. The stratigraphy of the naturally deposited soil profile encountered below the topsoil consisted of silty clay extending to a depth of 5.5 m. Beneath the clay, clay till was encountered and extended to the full depth of the test hole. This test hole was completed in the same area as the test hole TH 09-2 of PMEL's geotechnical investigation, which also confirmed a fairly identical soil profile at the site.

The silty clay encountered was generally moist with a soft to firm consistency. It was described as highly plastic. The moisture content of the clay varied between 28% and 36%. The test results in Table 1 confirmed the soil as High Plastic Clay (CH).

The clay till was generally moist with a soft to firm consistency. It was medium to high plastic with occasional fine gravel throughout. The moisture content of the clay till varied around 17%.

Groundwater seepage was noted during drilling in the test hole BH4. The groundwater was observed at 1.5 m below ground surface (mbgs) immediately after drilling, and there was no accumulation of sloughing material in the test hole. Approximately four weeks after drilling and on 15 August 2024, the groundwater level was measured at 1.3 mbgs in BH4.

5. LABORATORY STUDY OF SITE SOIL

Table 1 summarizes the Hydrometer (used to determine the grain-size distribution) and Atterberg Limits (used to determine the plasticity index) laboratory test results obtained for the selected soil samples at the site. These results were used to aid in classifying the site soil according to the Unified Soils Classification System (USCS). Based on the information obtained from the field investigation and lab test results, the silty clay within the proposed Lagoon expansion area, as well as both the existing clay berm material and the alternative clay borrowing source, appear to have a suitable soil composition for using as a compacted clay liner material.

- The soil from the lagoon expansion area was classified as high plastic silty clay (CH) with a PI of 47 % and a LL of 70 % with over 25% of clay content (70%).
- The soil from the existing berm was classified as medium plastic silty clay (CI) with a PI of 23 % and a LL of 39 % with over 25% of clay content (34%).
- The soil from the alternative borrowing source was classified as medium plastic silty clay (CI) with a PI of 26 % and a LL of 44 % with over 25% of clay content (43%). They were all within acceptable range for liner construction.

Table 1: Hydrometer and Atterberg Limits Test Results of Clay Liner Materials

Material Source	Depth (m)	Grain Size			Atterberg Limits			
		Silt (%)	Sand (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	USCS Classification
Existing Berm Area	2.0-3.0	31.4	34.6	34.0	38.8	15.5	23.3	CI
Alternative Borrow Area	1.8-2.1	31.5	25.4	43.1	44.0	17.6	26.4	CI
Lagoon Expansion Area	3.0-3.9	30.4	0.3	69.3	70.0	23.0	47.0	CH

CI: Intermediate Plasticity Clay
CH: High Plasticity Clay

The thickness required for a compacted clay liner is determined by establishing criteria for the seepage rate through the liner. The Water Security Agency's (WSA) Sewage Works Design

Standard Guidelines (EPB 503) specify that a maximum seepage rate of 0.15 m/year is acceptable for a wastewater facility, and the clay liner for the lagoon system shall be at least 600 mm in thickness. For in-situ materials or soil liners, an on-site permeability of at least ten (10) times the laboratory value shall be used to calculate the seepage.

The thickness of a clay liner in a lagoon system plays a significant role in determining the rate of seepage through the liner. The relationship between the thickness of the clay liner and the seepage rate can be understood through Darcy's Law and the concept of hydraulic conductivity.

Darcy's Law describes the flow of fluid through a porous medium and is given by:

$$Q = \frac{\mathrm{k} \cdot \mathrm{A} \cdot \Delta \mathrm{h}}{\mathrm{L}} \cdot \mathrm{T}$$

Since the seepage rate is in m/year as required in the WSA requirement, the cross-sectional factor was not considered. Therefore, the formula for the seepage rate is given by:

$$Q = \frac{\mathrm{k} \cdot \Delta \mathrm{h}}{\mathrm{L}} \cdot \mathrm{T}$$

Where:

- Q = Seepage rate (volume per time, e.g., m/year)
- K = Hydraulic conductivity of the clay (m/s)
- T = One year in seconds ($\frac{60s}{min} \cdot \frac{60\mathrm{min}}{\mathrm{h}} \cdot \frac{24h}{day} \cdot \frac{365days}{year} = 31536000s$)
- Δh = Hydraulic head difference across the liner (m)
- L = thickness of the clay liner (m)

The hydraulic conductivity results and seepage rate calculations for each material investigated are listed in Table 2, below. Based on the test results for hydraulic conductivity for materials from the proposed lagoon expansion area, the existing berm, and the alternative borrowing source, the yearly specific discharges (seepage rates) for all of them were lower than the regulated value from the WSA requirement. Therefore, a clay liner with a thickness of 0.6 m will be adequate for constructing the new cell with the on-site clay material for the lagoon expansion area.

Table 2: Clay Liner Calculations using Hydraulic Conductivity Test Results

	Alternative Borrowing Source	Existing Berm	Lagoon Expansion Area
Permeability Result (Lab Results)	3.3×10^{-11} m/s	9.0×10^{-11} m/s	1.1×10^{-10} m/s
Increased by a 10 Factor (WSA specified)	3.3×10^{-10} m/s	9.0×10^{-10} m/s	1.1×10^{-9} m/s
Water depth	2.10 m	2.10 m	2.10 m
Design Liner Thickness	0.60 m	0.60 m	0.60 m
Specific Discharge	1.1×10^{-9} m/s	3.1×10^{-9} m/s	3.8×10^{-9} m/s
Yearly Specific Discharge	0.04 m/year	0.10 m/year	0.12 m/year
Regulated Specific Discharge (Lagoons)	0.15 m/year	0.15 m/year	0.15 m/year
	4.8×10^{-9} m/s	4.8×10^{-9} m/s	4.8×10^{-9} m/s

6. CONSTRUCTION RECOMMENDATION AND QA/QC

The following general construction quality control must be adhered to:

- All topsoil must be stripped and stockpiled separately prior to constructing the cell. A minimum stripping depth of 150 mm is recommended. If deleterious soils/materials are encountered within the stripping depth, stripping depths may need to be increased on an as-required basis during construction.
- The native clay material at the site could be used for the clay liner.
- All liner and berm soils will be compacted to at least 98% of the maximum standard proctor dry density (MSPDD) as determined by moisture-density (ASTM D698) test or as specified in the design specifications or as directed by a qualified engineer. Water conditioning will be utilized so that the water content in situ is within the range of 1.0% below optimum to 3.0% above optimum, as determined by the moisture-density test (ASTM D698).
- Proof rolling of the subgrade will be conducted to verify that competent and uniform soil subgrade support conditions have been achieved. Proof rolling will not be performed during or shortly following precipitation events, and heavy equipment will not be allowed to travel on wet/soft subgrade soils until adequate drying has occurred. Proof rolling will be performed by two passes of a dual-wheel truck (or comparable

equipment) with a minimum of 80 kN single axle load. Soils which display rutting or appreciable deflections upon proof-rolling will be over-excavated to expose more competent soil and replaced with suitable engineered fill. All proof rolling and compaction efforts will include documentation detailing the findings, including photographs where possible. All finished subgrades will be protected from construction traffic and erosion as soon as possible.

- Construction of the liner will be done during non-freezing weather. It will be constructed in small sections or panels until the full thickness of the liner is completed so that the drying of the compacted clay does not occur before the complete thickness of the liner is placed. If the full thickness of the liner is not complete, the upper 150 mm of compacted soil will be scarified, moisture conditioned and recompacted at the start of the next construction period prior to the placement of the next soil lift.
- Construction quality control will be supervised by a qualified technologist or engineer under the direct supervision of a qualified geotechnical engineer. This will include subgrade preparation and placement and compaction of the liner material. This will provide guidance on acceptable soils incorporated into the liner and appropriate compaction density and moisture conditions required to achieve a liner with acceptable permeability.
- The berms and liner will be constructed using moisture conditioned and compacted clay soils placed in lifts not exceeding 150 mm to be able to attain the design thickness. Any pockets of excessively sandy or silty soils will either be discarded or incorporated into the clay soils through blending and mixing, as directed by the engineer.
- Continuous supervision of the construction will be conducted, with density and moisture content checked at least once every 500 m^2 per lift using a nuclear densometer. If a failure occurs, additional compaction and moisture conditioning will take place and be retested before the next lift is placed.
- The ground surface will be maintained during construction to ensure ready run-off of surface water and avoid pooling.
- Saturated lifts will be removed, reconditioned, replaced, and recompacted.

7. EXCAVATION

OH&S SOIL CLASSIFICATION

The soil in which excavations and trenching will occur is defined under the Occupational Health and Safety Regulations (2020) as “type 3 soil”. Where a worker is required to enter an

excavation or trench more than 1.2 m deep, either the walls must be cut back from the bottom of the excavation at a slope no steeper than 1H:1V, and/or a temporary protective structure designed by a professional engineer must be installed. Equipment, spoil piles, stockpiles and construction materials must be kept at least 1 m from the edge of the excavation.

Before excavating begins, the employer or contractor will ensure that where the stability of a structure may be compromised, it is supported by a temporary protective structure designed by a professional engineer.

DEWATERING

Water, whether due to groundwater seepage or rain, will not be allowed to remain in the excavation for extended periods as it will negatively affect the bearing capacity of the in-situ soil. If a worker is required to enter an excavation, it must first be free from any accumulation of water. The best practice is to time construction so that there is minimal delay between excavation and construction/backfill of material. If, during excavation, water enters the trench, a small sump will be placed in the base to allow for a 'trash' pump to dewater the excavation.

As described in the previous sections, the soils at the site are predominantly clayey, with some silty and sandy layers present. The relatively low hydraulic conductivity of the clay indicates that the soil is largely impermeable, meaning any groundwater present will seep into excavations slowly. However, the silt or sand layers will allow water to seep more quickly. The excavations for the proposed cell are expected to extend below the groundwater levels at the site, so a trench will be constructed along the side leading to a temporary sump. From the sump, the water will be pumped into a drainage ditch or off-site. Once the water flow diminishes, the liner will be placed according to the design specifications.

GENERAL RECOMMENDATION

The following general recommendations are made for excavations.

- A competent supervisor must be on-site at all times when a worker is in an excavation or excavation work is being done.
- Machinery and heavy equipment will not be allowed closer to the excavation than one half of the depth of the excavation, unless precautions are implemented to ensure that the workers in the excavation are safe. Spoil material will not be piled closer than 1 m from the edge of the excavation and with side slopes no steeper than 1:1. The sides of

spoil piles must be maintained to ensure that loose material does not roll into the excavation.

- Infiltration of water into the soil around the excavation can result in loss of strength and collapse of the excavation walls. It is recommended that workers will not be in the excavation during rainfall and that excavation walls will be carefully inspected for cracking and potential failures after rainfall before work continues in the excavation.
- The condition of the soil around the excavation will be carefully observed to ensure that slope failures or sloughing does not occur along any fractures, fissures or joints in the till. All loose material on the sides of the excavation will be trimmed. The excavation will be left open for the minimum amount of time required for construction.

8. CONSTRUCTION AND INSPECTION

The design recommendations provided within this report are based on the assumption that a sufficient level of inspection will be provided during construction and that qualified and experienced contractors will carry out construction.

PINTER or a qualified engineering firm will be retained for design review and engaged for inspection (and materials testing as required).

PINTER requests the opportunity to review drawings and specifications related to any earthworks or other designs based on the recommendations provided in this report.

9. DECOMMISSIONING OF MONITORING WELLS

Monitoring wells located within the construction limits should be decommissioned prior to lagoon construction activities to eliminate the potential for lagoon seepage along these pathways. Decommissioning should consist of drilling out the PVC pipes and pipe backfill and replacing these materials with hydrated bentonite. Monitoring wells falling outside the construction limits should be retained for long-term monitoring.

10. ENVIRONMENTAL MONITORING

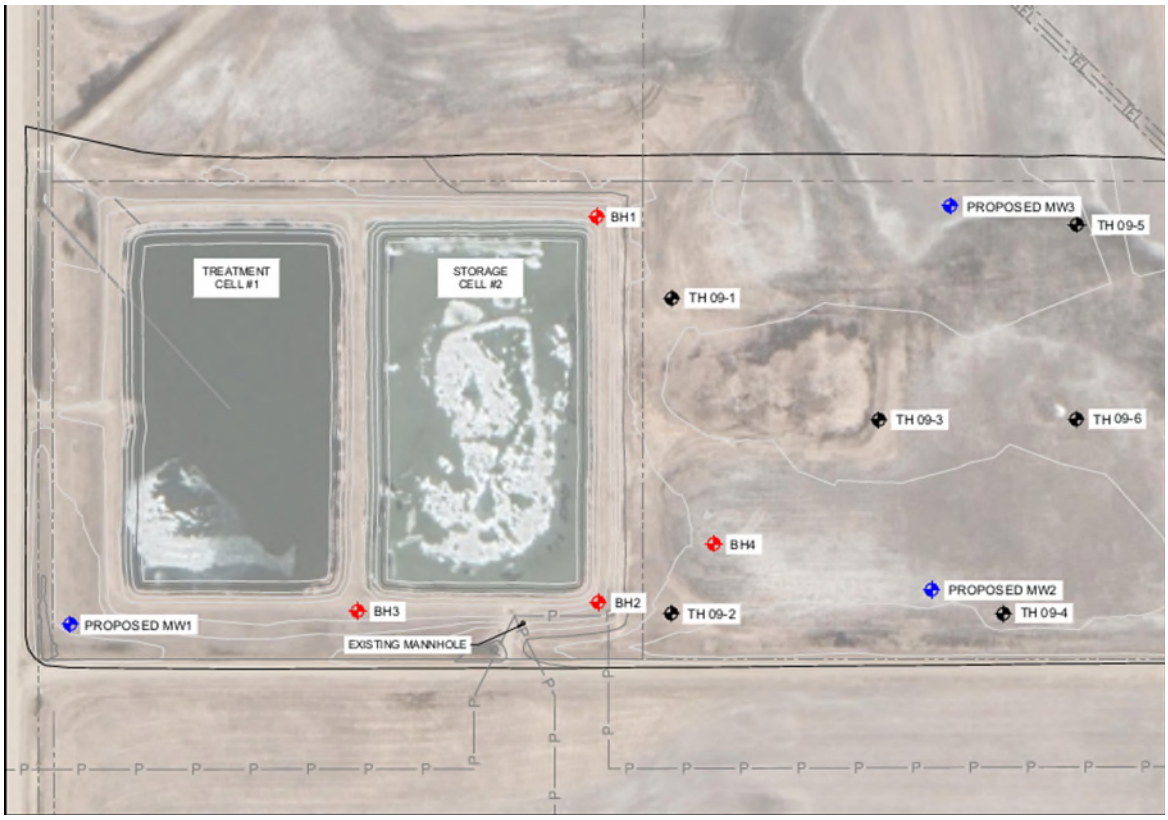
Piezometer development and sampling should be performed in accordance with “Guidelines for Groundwater Monitor Wells at Wastewater Disposal Sites” (November 1987) and “Protocols for the Installation and Sampling of Monitor Wells” (April 1989) published by Water Quality Branch, Saskatchewan Environment. Monitoring and maintenance should be undertaken to help verify that the Lagoon is functioning properly. It is recommended that the

piezometers be encased in lockable protective steel casings for optimization of long-term performance.

Monitoring wells should be strategically placed around the sewage lagoon to monitor the groundwater flow direction and detect any potential seepage or contamination. Typically, wells are installed both upgradient (background water quality) and downgradient (where contamination might occur) of the Lagoon.

Based on the groundwater level measured immediately after PINTER's field drilling program and the groundwater levels measured during PMEL's geotechnical investigation in 2009, the groundwater tends to flow from the southwest to the northeast. Therefore, one monitoring well (MW 1) to a maximum depth of 7.6 m is recommended to be installed on the southwest corner of the existing lagoon area (outside of the berm), and two other monitoring wells (MW 2 and MW 3) to a maximum depth of 7.6 m are recommended to be installed on the east side of the proposed lagoon expansion area as shown on Figure 1.

Figure 1. The Location of Proposed Monitoring Wells (Blue)



Standpipe piezometers will be installed to obtain long-term groundwater level measurements and groundwater samples. The piezometers will be constructed of 50 mm diameter PVC pipe with a 3 m long, machine-slotted screen at the tip. The screening portion and 0.3 m above will be filled with filter sand, and the solid portion above the screening will be sealed with either bentonite or cement grout to prevent surface water or contaminants from entering the well. The seal should be extended from the top of the filter sand to the ground surface.

After the installation of the monitoring wells, a monitoring schedule will be established to regularly sample groundwater and assess the impact of the sewage lagoon on groundwater quality. At the same time, monitoring wells will be inspected to ensure they are functioning correctly and are not blocked or damaged.

11.STATEMENT OF LIMITATIONS

This memorandum has been prepared for the exclusive use of **The Town of Radisson.** Any use of this report by a third party or any reliance on or decisions to be made based on it is the responsibility of such third parties. PINTER & Associates Ltd. accepts no responsibility for damages, if any, suffered by any third parties as a result of decisions made or actions taken based on this memorandum.

Sincerely,

PINTER & Associates Ltd.

Per:

Kai He, E.I.T.
Junior Geotechnical Engineer

Reviewed by:

Nalinda Dissanayake, P.Eng.
Geotechnical/Hydrogeology Lead

Date: 25 September 2024

Appendices

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LOG OF BORING
BH1

3285-1
Raddison Lagoon Expansion
Raddison, SK

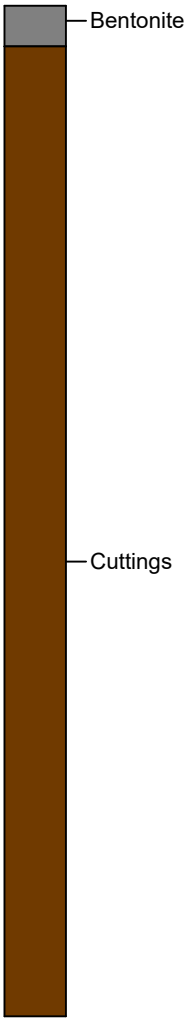
Drilling Method	: Solid Stem Auger	Depth to Slough (m)	: None observed
Date Finished	: 29 April 2024	Depth to Water (m)	: None observed
Surface Elev. (m)	: 100(reference)	Comp. Depth (m)	: 7.5
Logged By	: DP	Northing	: 5813877
Checked By	: KH	Easting	: 337438

Sample Legend
- Split Spoon Sample
- Grab Sample

Atterbergs & Moisture (%) 0 10 20 30 40 50 60 70 80 90 100
Pocket Pen (kPa) 0 100 200 300 400 500
SPT (N) 0 10 20 30 40 50 60 70 80 90 100

Depth (m)	Elevation	GRAPHIC	DESCRIPTION	Sample	Blow Count	Comments
0	100		TOP SOIL (0.3 m)			
			CLAY, silty, trace sand, moist, soft to firm, medium to high plasticity, dark brown			
1	99					
			- Black organics from 1.9m to 2.2m			
2	98					
3	97					
4	96					
			- Silt layer from 4.8m to 5.1m			- 8.1% of sand, 29.0% of silt, and 62.9% of clay
5	95					
6	94		- Increased silt content below 6.0m			
7	93		CLAY TILL, silty, some fine to coarse sand, trace fine gravel, moist, stiff, medium plasticity, dark olive brown			
			End of test hole at 7.5m. No accumulation of sloughing material and no groundwater at immediately after drilling.			
8	92					
9	91					
10						

Backfill Details: BH1



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LOG OF BORING
BH2

3285-1
Raddison Lagoon Expansion
Raddison, SK

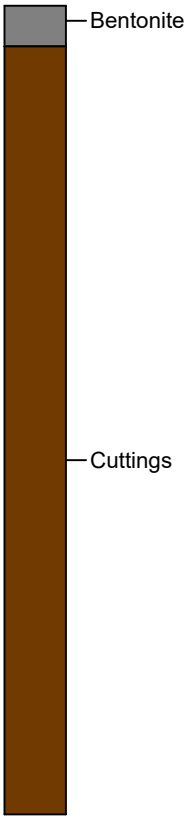
Drilling Method	: Solid Stem Auger	Depth to Slough (m)	: None observed
Date Finished	: 29 April 2024	Depth to Water (m)	: None observed
Surface Elev. (m)	: 100(reference)	Comp. Depth (m)	: 6.0
Logged By	: DP	Northing	: 5813734
Checked By	: KH	Easting	: 337432

Sample Legend
- Split Spoon Sample
- Grab Sample

Atterbergs & Moisture (%): 0 10 20 30 40 50 60 70 80 90 100
Pocket Pen (kPa): 0 100 200 300 400 500
SPT (N): 0 10 20 30 40 50 60 70 80 90 100

Depth (m)	Elevation	DESCRIPTION	Comments
0	100	TOP SOIL (1.2 m)	
1	99	CLAY, some silt, trace sand, moist, soft to firm, low to medium plasticity, dark brown	
2	98	- Black organics from 2.7m to 3.0m	
3	97	- Incresed sand content at 3.0m - Incresed silt content below 3.0m	- 34.6% of sand, 31.4% of silt, and 34.0% of clay
4	96		
5	95		
6	94	End of test hole at 6.0m. No accumulation of sloughing material and no groundwater at immediately after drilling.	
7	93		
8	92		
9	91		
10			

Backfill Details: BH2



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LOG OF BORING
BH3

3285-1
Raddison Lagoon Expansion
Raddison, SK

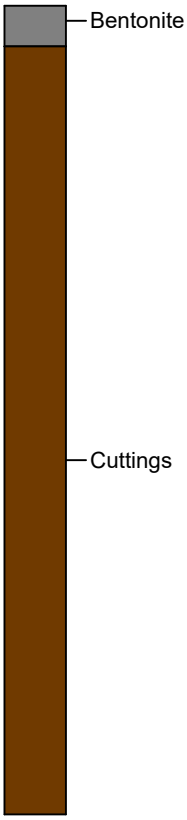
Drilling Method	: Solid Stem Auger	Depth to Slough (m)	: None observed
Date Finished	: 29 April 2024	Depth to Water (m)	: None observed
Surface Elev. (m)	: 100(reference)	Comp. Depth (m)	: 6.0
Logged By	: DP	Northing	: 5813735
Checked By	: KH	Easting	: 337341

Sample Legend
- Split Spoon Sample
- Grab Sample

Atterbergs & Moisture (%): 0 10 20 30 40 50 60 70 80 90 100
Pocket Pen (kPa): 0 100 200 300 400 500
SPT (N): 0 10 20 30 40 50 60 70 80 90 100

Depth (m)	Elevation	DESCRIPTION	Comments
0	100	TOP SOIL (0.6 m)	
1	99	SANDY SILT, some clay, moist, soft to firm, low to medium plasticity, brown	
2	98		
3	97		
4	96	CLAY, silty, some fine sand, moist, firm, medium to high plasticity, dark brown	
5	95	- Black streaks from 5.6m to 5.7m	- 25.4% of sand, 31.5% of silt, and 43.1% of clay
6	94	End of test hole at 6.0m. No accumulation of sloughing material and no groundwater at immediately after drilling.	
7	93		
8	92		
9	91		
10			

Backfill Details: BH3



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LOG OF BORING
BH4

3285-1
Raddison Lagoon Expansion
Raddison, SK

Drilling Method	: Solid Stem Auger	Depth to Slough (m)	: None observed
Date Finished	: 19 July 2024	Depth to Water (m)	: 1.5
Surface Elev. (m)	: 100(reference)	Comp. Depth (m)	: 7.6
Logged By	: KH	Northing	: 5813754
Checked By	: ND	Easting	: 337476

Sample Legend
- Split Spoon Sample
- Grab Sample

Atterbergs & Moisture (%) 0 10 20 30 40 50 60 70 80 90 100
Pocket Pen (kPa) 0 100 200 300 400 500
SPT (N) 0 10 20 30 40 50 60 70 80 90 100

Depth (m)	Elevation	DESCRIPTION	Comments
0	100	TOP SOIL (50 mm)	
		CLAY, silty, moist, soft to firm, medium to high plasticity, olive brown	
1	99		
2	98		
3	97		- 0.3% of sand, 30.4% of silt, and 69.3% of clay
4	96		
5	95		
6	94	CLAY TILL, silty, trace fine gravel, moist, soft to firm, medium to high plasticity, dark olive brown	
7	93		
8	92	End of test hole at 7.6m. No accumulation of sloughing material and groundwater at 1.5m immediately after drilling.	
9	91		
10			

Backfill Details: BH4
- 0.90m Stickup
- Bentonite
- Cuttings
- Solid 1.0"PVC Sched 40
- Bentonite
- Sand
- Slotted 1.0"PVC Sched 40

STANDARD PROCTOR REPORT

(Test Reference: ASTM D 698)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

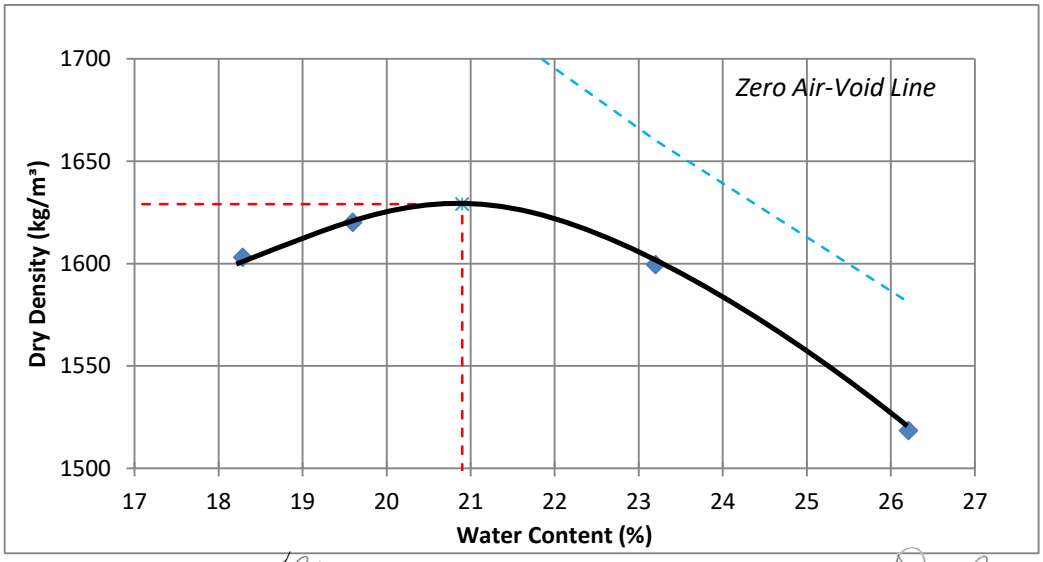
Sample: **Composite minus top layers**

Sample Information	
Date Sampled:	-
Date Received:	5/10/2024
Date Tested:	5/16/2024
Sample Desc.:	Clay Till
Supplied By:	Client
Sampled By:	Client
Tested By:	AN
Sample Location:	BH1, 2, and 3
Site Location:	-

Proctor Result Points	
Compacted Moisture	Compacted Density
18.3	1603
19.6	1620
23.2	1599
26.2	1518

Proctor Information		
Maximum Dry Density:	1629	kg/m^3
Optimum Moisture Content:	20.9	%
Oversize Corrected Density:	1629	kg/m^3
Oversize Corrected Moisture:	20.9	%
Moisture as Received:	N/A	%
Oversize Details:	0.0	%>9.5mm
Specific Gravity:	2.70	Assumed
Method Used / Mould Size:	B	101 mm
Preparation Method:	Moist	
Type of Hammer Used:	Manual	

Additional Info	
Plastic Limit:	-
Liquid Limit:	-
PI:	-
USC:	-
% Gravel:	-
% Sand:	-
% Silt size particles	-
% Clay size particles	-



Checker: Anna Nahosha **Reviewer:** Don Hazelwanter

Client: PINTER & Associates Ltd.
Project: 3285-1
Project #: 700560
Date: 05/16/2024

Materials Engineering

ATTERBERG LIMITS TEST REPORT

AtkinsRéalis

CERTIFIED BY CCIL

(Test Reference: ASTM D 4318)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: BH-1 5 and 6 (comp) (air-dried)

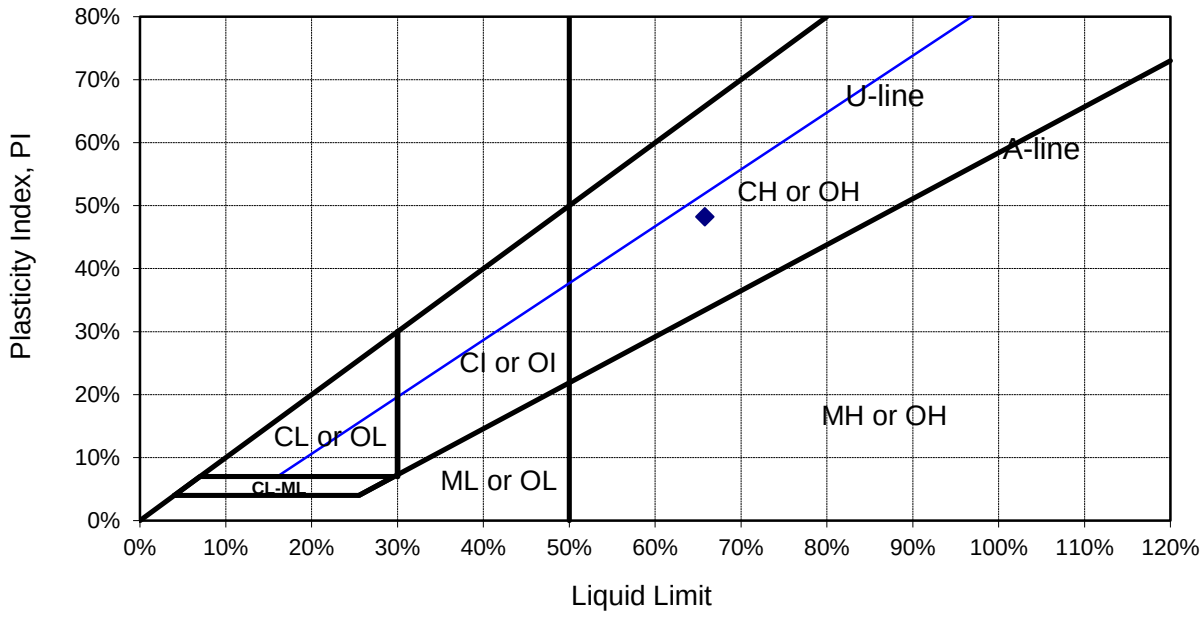
PLASTIC LIMIT	
Tare Wt, g	13.88
Wet + Tare, g	23.39
Dry + Tare, g	21.97
Water content	17.6%

LIQUID LIMIT (METHOD B)			
# of Blows	26	28	
Tare Wt, g	14.03	14.21	
Wet + tare, g	25.40	25.18	
Dry + tare, g	20.91	20.86	
Water content	65.3%	65.0%	AVERAGE
Adjusted W/C	65.6%	66.0%	65.8%

SUMMARY	
Plastic Limit:	**17.6%**
Liquid Limit:	**65.8%**
Plasticity Index:	**48.2%**
Classification:	**CH**
Natural Water Content:	**N/A**

COMMENTS

-



Checker: Mariglyn Corado

Reviewer: Don Hazelwanter

Client: **PINTER & Associates Ltd.**
Project: **700560**
Project #: **3285-1**
Date: **05/17/2024**

Materials Engineering

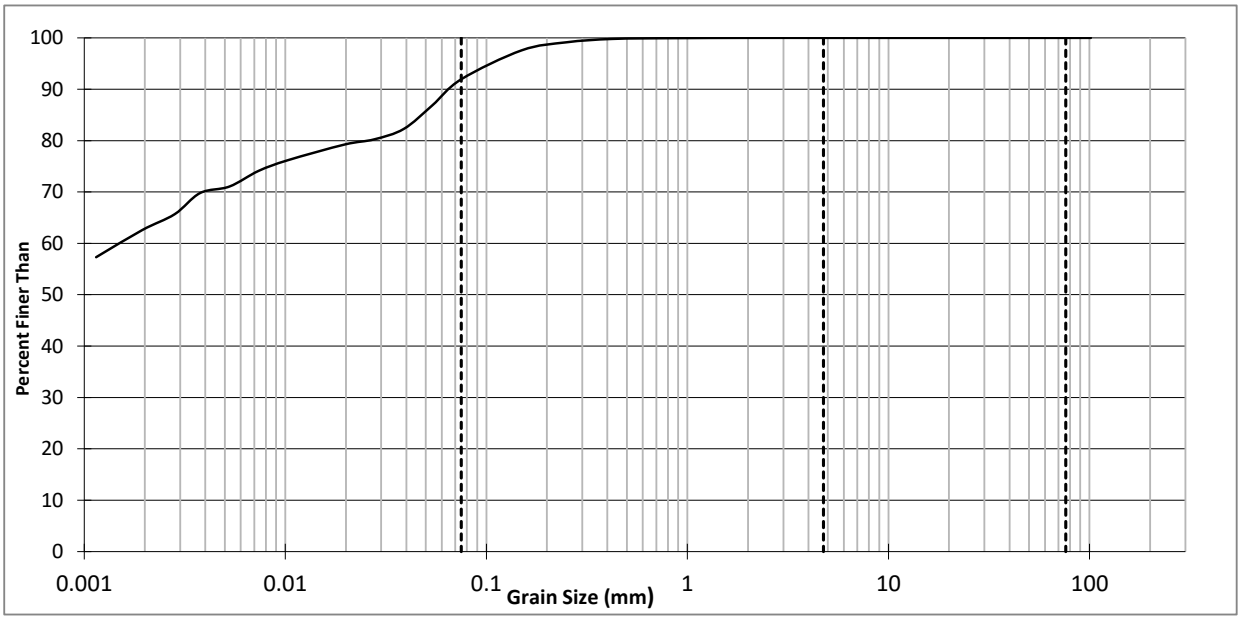
HYDROMETER TEST REPORT

(Test Reference: ASTM D7928/AASHTO T88)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: Composite 5 & 6 BH-1

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100	0.0538	86.9	% Cobble	0.0
3"	76.2	100	0.0389	82.3	% Gravel	0.0
2"	50.8	100	0.0277	80.3	% Sand	8.1
1"	25.4	100	0.0197	79.2	% Silt Size (<75µ>2µ)	29.0
3/4"	19.1	100	0.0103	76.2	% Clay Size (<2µ)	62.9
3/8"	9.50	100	0.0074	74.1		
#4	4.75	100	0.0053	71.1	Dispersing Agent used:	
#10	2.00	100	0.0038	69.8	*Sodium Hexametaphosphate*	
#20	0.850	100	0.0028	65.7		
#40	0.425	100	0.0019	62.6		
#60	0.250	99	0.0011	57.3	Comments:	
#100	0.150	98			-	
#200	0.075	92			-	



FINES (silt, clay) 91.9 %	SAND 8.1 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: Ayobami Busari **Reviewer:** Don Hazelwanter

Client: **Pinter & Associates Ltd.**
Project: **3285-1**
Project #: **700560**
Date: **05/23/2024**

Materials Engineering

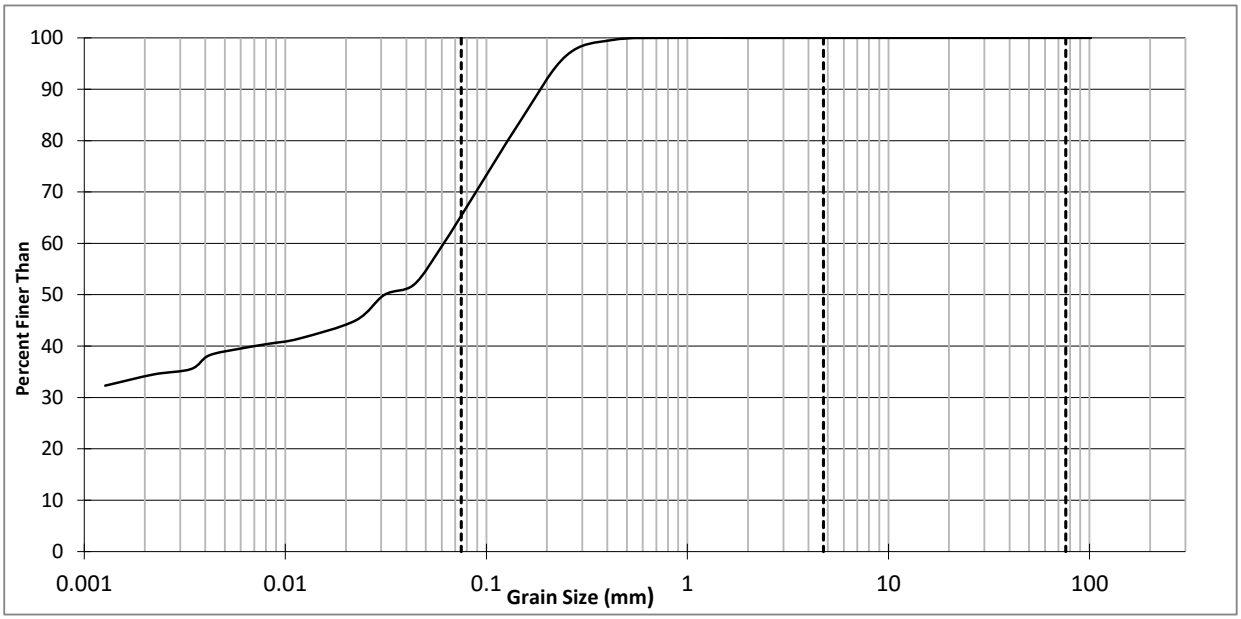
HYDROMETER TEST REPORT

(Test Reference: ASTM D7928/AASHTO T88)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: Composite 3 & 4 BH-2

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100	0.0600	59.4	% Cobble	0.0
3"	76.2	100	0.0437	52.0	% Gravel	0.0
2"	50.8	100	0.0311	50.0	% Sand	34.6
1"	25.4	100	0.0224	45.0	% Silt Size (<75µ>2µ)	31.4
3/4"	19.1	100	0.0117	41.5	% Clay Size (<2µ)	34.0
3/8"	9.50	100	0.0083	40.5		
#4	4.75	100	0.0059	39.5	Dispersing Agent used:	
#10	2.00	100	0.0042	38.2	*Sodium Hexametaphosphate*	
#20	0.850	100	0.0034	35.5		
#40	0.425	100	0.0022	34.5		
#60	0.250	97	0.0013	32.3	Comments:	
#100	0.150	84			-	
#200	0.075	65			-	



FINES (silt, clay) 65.4 %	SAND 34.6 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: Ayobami Busari **Reviewer:** Don Hazelwanter

Client: **Pinter & Associates Ltd.**
Project: **3285-1**
Project #: **700560**
Date: **05/15/2024**

Materials Engineering

ATTERBERG LIMITS TEST REPORT

AtkinsRéalis

CERTIFIED BY CCIL

(Test Reference: ASTM D 4318)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: BH-2 3 and 4 (comp) (air-dried)

PLASTIC LIMIT	
Tare Wt, g	13.79
Wet + Tare, g	23.02
Dry + Tare, g	21.78
Water content	15.5%

LIQUID LIMIT (METHOD B)			
# of Blows	23	25	
Tare Wt, g	14.46	13.82	
Wet + tare, g	26.49	26.60	
Dry + tare, g	23.11	23.02	
Water content	39.1%	38.9%	AVERAGE
Adjusted W/C	38.7%	38.9%	38.8%

SUMMARY	
Plastic Limit:	**15.5%**
Liquid Limit:	**38.8%**
Plasticity Index:	**23.3%**
Classification:	**CI**
Natural Water Content:	**N/A**

COMMENTS

-

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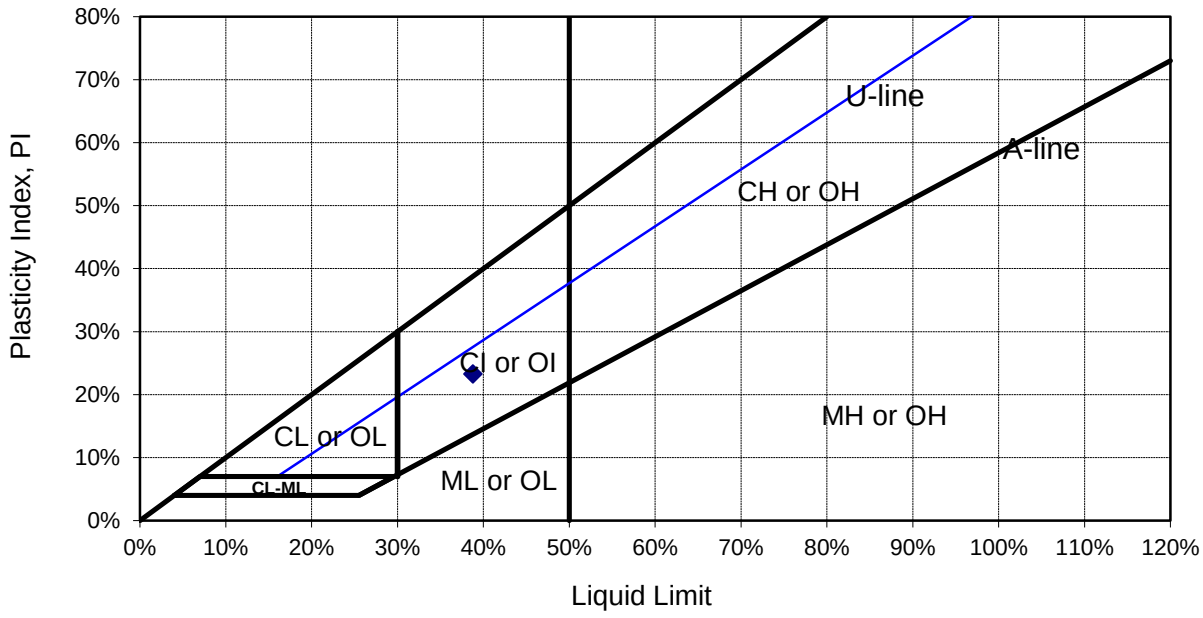


Checker: Mariglyn Corado

Reviewer: Don Hazelwanter

Client: **PINTER & Associates Ltd.**
Project: **700560**
Project #: **3285-1**
Date: **06/04/2024**

Materials Engineering

HYDRAULIC CONDUCTIVITY TEST REPORT

(Test Reference: ASTM D5084)

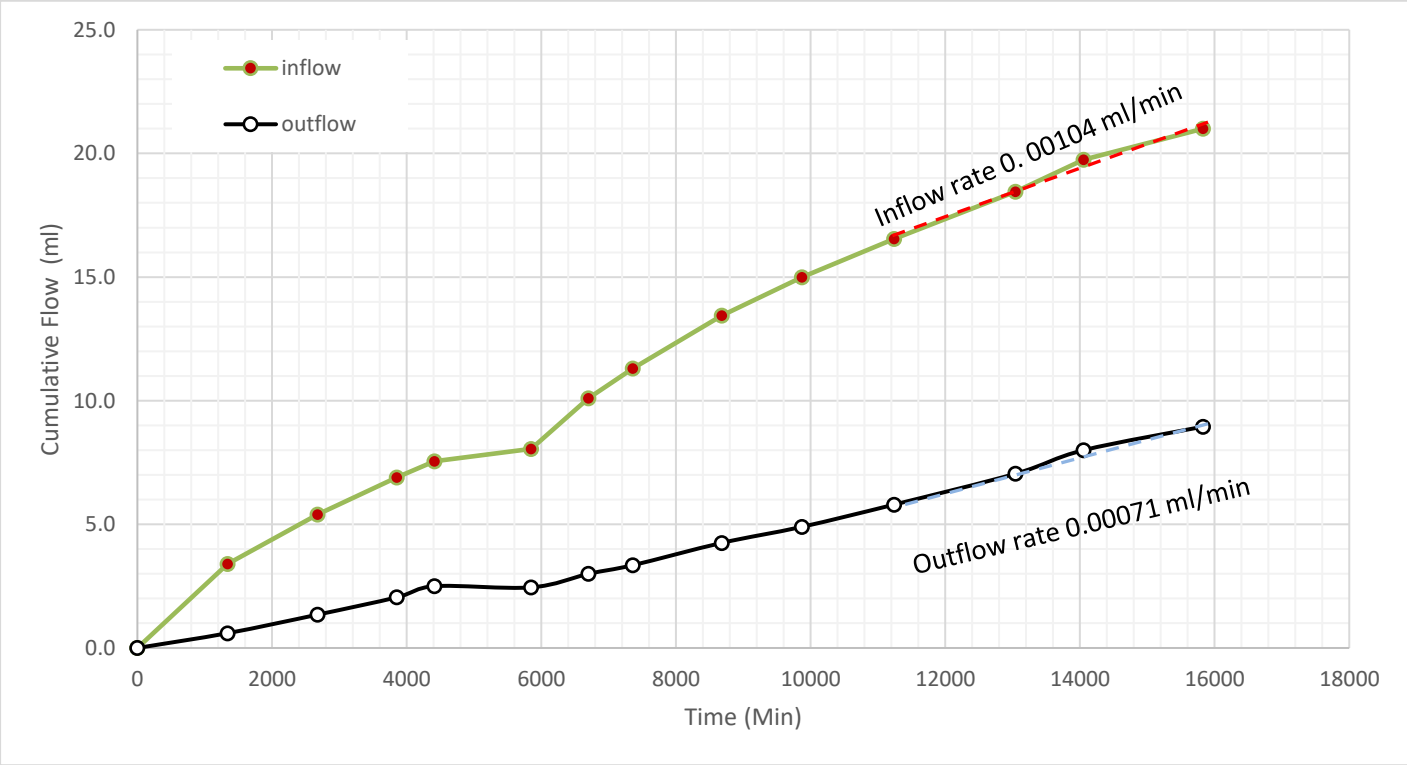
AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: Composite 3&4 BH2

Test Type: Remoulded, Standard Proctor

Cell pressure =	230	kPa	Final water content =	27.9%	
Average back pressure =	200	kPa	Final dry density =	1558	kg/m^3
Head across specimen =	74	cm	Final deg. of saturation =	100%	
Hydraulic gradient =	21.0				
Initial sample diameter =	99.36	mm	Inflow rate =	0.00104	ml/min
Initial sample height =	35.07	mm	Outflow rate =	0.00071	ml/min
Initial water content =	28.3%		Average flow rate =	0.00088	ml/min
Initial dry density =	1465	kg/m^3			
Initial deg. of saturation =	93%		**Hydraulic Conductivity (based on average flow rate):**		
Specific gravity =	2.65	(assumed)	**k= 8.96E-09 cm/s**		

Permeant: de-aired distilled water



Comments:

Checker: Don Hazelwanter **Reviewer:** Mariglyn Corado

Project #: 700560
Client: Pinter and Associates Ltd.
Project: 3285-1
Date: 06/05/2024

Materials Engineering

STANDARD PROCTOR REPORT

(Test Reference: ASTM D 698)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

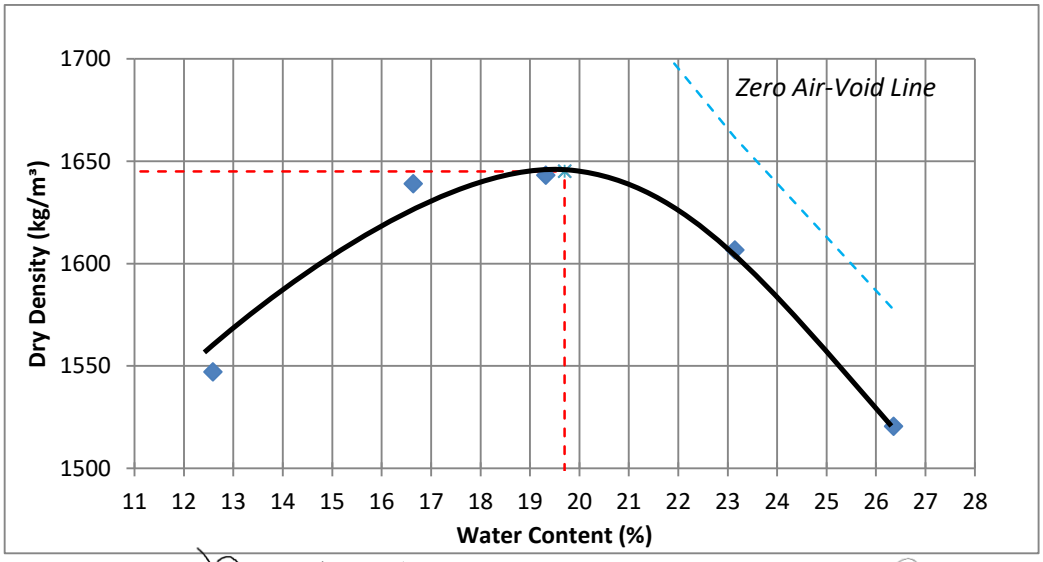
Sample: **Composite (6&7) at 6-7ft**

Sample Information	
Date Sampled:	-
Date Received:	-
Date Tested:	6/11/2024
Sample Desc.:	Clay Till
Supplied By:	Client
Sampled By:	Client
Tested By:	RB
Sample Location:	-
Site Location:	-

Proctor Result Points	
Compacted Moisture	Compacted Density
12.6	1547
16.6	1639
19.3	1643
23.1	1607
26.4	1521

Proctor Information		
Maximum Dry Density:	1645	kg/m^3
Optimum Moisture Content:	19.7	%
Oversize Corrected Density:	1645	kg/m^3
Oversize Corrected Moisture:	19.7	%
Moisture as Received:	N/A	%
Oversize Details:	0.0	%>9.5mm
Specific Gravity:	2.70	Assumed
Method Used / Mould Size:	B	101 mm
Preparation Method:	Moist	
Type of Hammer Used:	Mechanical	

Additional Info	
Plastic Limit:	-
Liquid Limit:	-
PI:	-
USC:	-
% Gravel:	-
% Sand:	-
% Silt size particles	-
% Clay size particles	-



Checker: Reid Bridges

Reviewer: Don Hazelwanter

Client: PINTER & Associates Ltd.
Project: 3285-1
Project #: 700560
Date: 06/11/2024

Materials Engineering

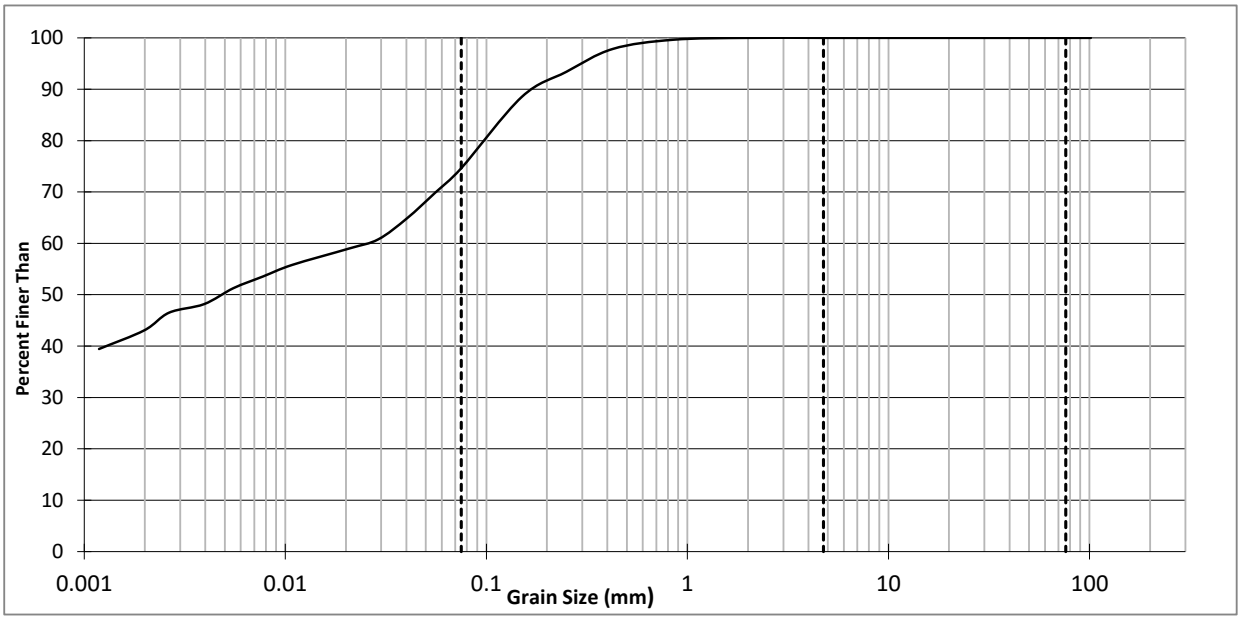
HYDROMETER TEST REPORT

(Test Reference: ASTM D7928/AASHTO T88)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: 6 and 7 composite

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100	0.0556	69.8	% Cobble	0.0
3"	76.2	100	0.0403	64.9	% Gravel	0.0
2"	50.8	100	0.0290	60.8	% Sand	25.4
1"	25.4	100	0.0207	59.0	% Silt Size (<75µ>2µ)	31.5
3/4"	19.1	100	0.0108	55.8	% Clay Size (<2µ)	43.1
3/8"	9.50	100	0.0077	53.5		
#4	4.75	100	0.0055	51.3	Dispersing Agent used:	
#10	2.00	100	0.0039	48.2	*Sodium Hexametaphosphate*	
#20	0.850	100	0.0026	46.5		
#40	0.425	98	0.0020	43.1		
#60	0.250	93	0.0012	39.4	Comments:	
#100	0.150	89			-	
#200	0.075	75			-	



FINES (silt, clay) 74.6 %	SAND 25.4 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: Ayobami Busari **Reviewer:** Don Hazelwanter

Client: **PINTER & Associates**
Project: **3285-1**
Project #: **700560**
Date: **06/17/2024**

Materials Engineering

ATTERBERG LIMITS TEST REPORT

AtkinsRéalis

CERTIFIED BY CCIL

(Test Reference: ASTM D 4318)

AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: Composite 6 and 7 (air-dried)

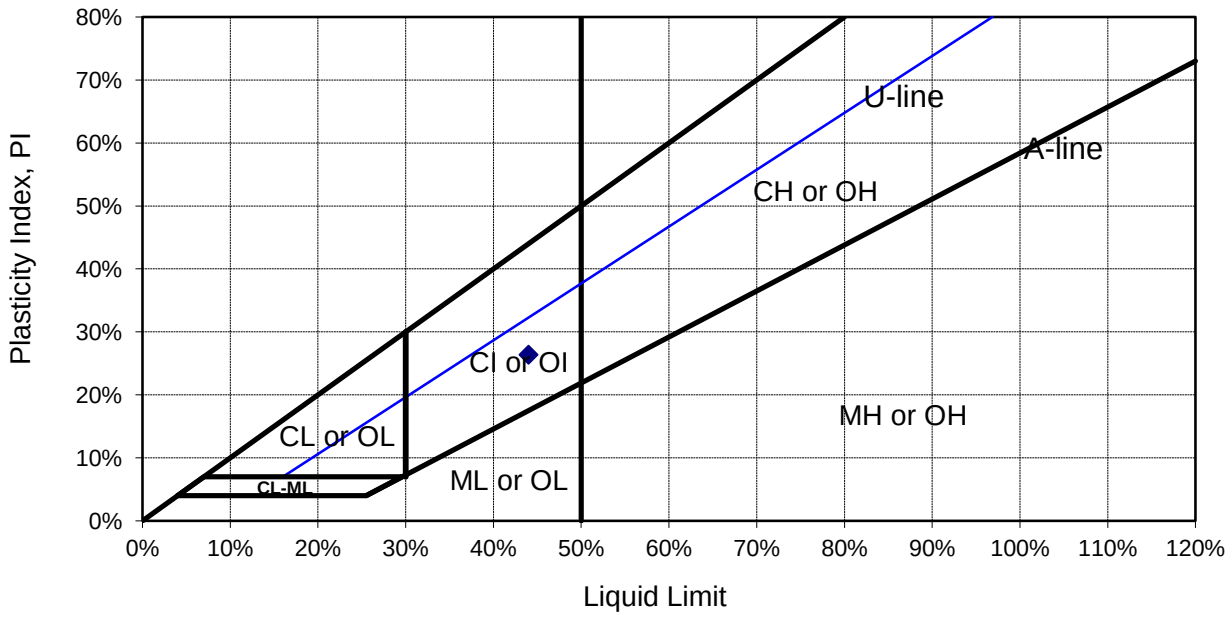
PLASTIC LIMIT	
Tare Wt, g	14.38
Wet + Tare, g	26.79
Dry + Tare, g	24.93
Water content	17.6%

LIQUID LIMIT (METHOD B)			
# of Blows	24	22	
Tare Wt, g	13.80	14.46	
Wet + tare, g	40.19	45.21	
Dry + tare, g	32.02	35.80	
Water content	44.8%	44.1%	AVERAGE
Adjusted W/C	44.6%	43.4%	44.0%

SUMMARY	
Plastic Limit:	**17.6%**
Liquid Limit:	**44.0%**
Plasticity Index:	**26.4%**
Classification:	**CI**
Natural Water Content:	**NA**

COMMENTS

-



Checker: Mariglyn Corado **Reviewer:** Don Hazelwanter

Client: **PINTER & Associates Ltd.**
Project: **700560**
Project #: **3285-1**
Date: **06/13/2024**

Materials Engineering

HYDRAULIC CONDUCTIVITY TEST REPORT

(Test Reference: ASTM D5084)

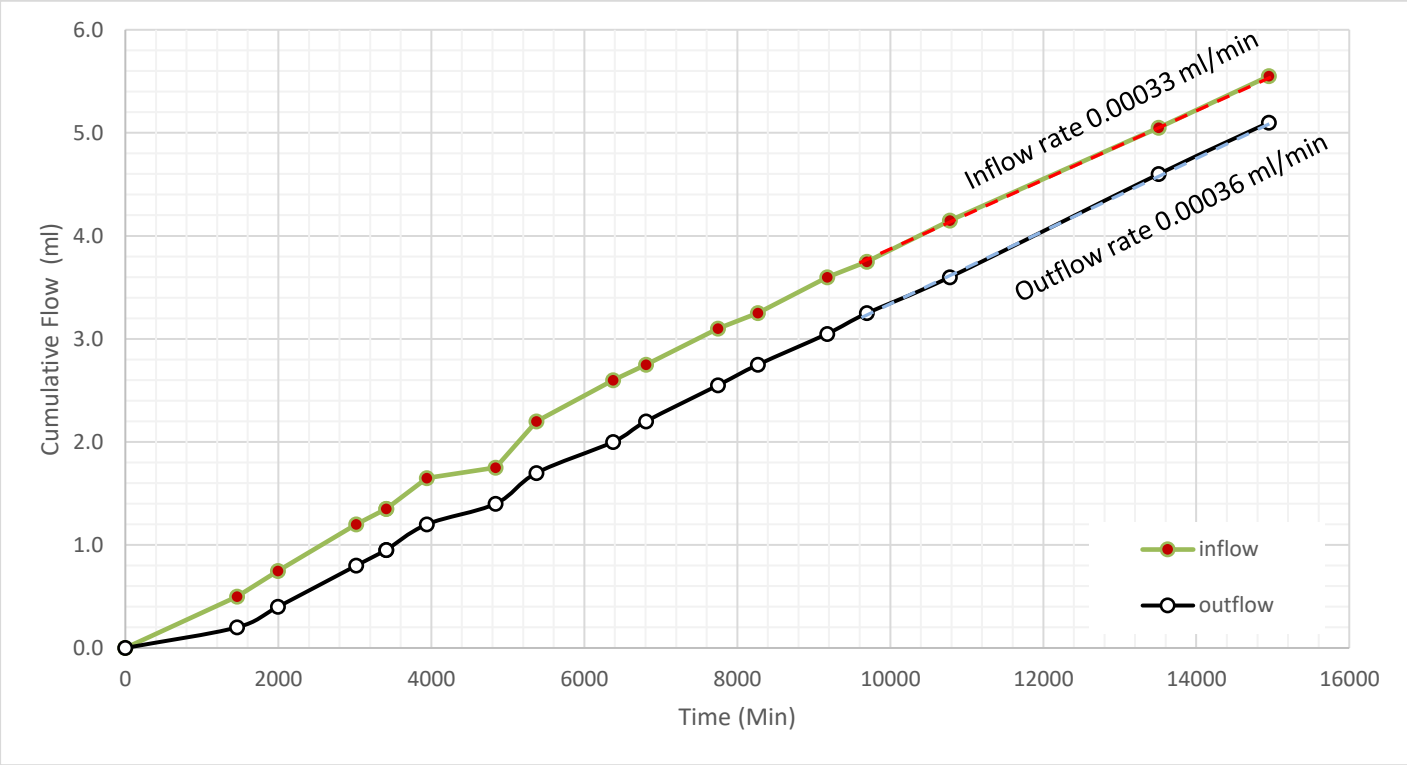
AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: 6/7 Composite

Test Type: Remoulded, Standard Proctor

Cell pressure =	230	kPa	Final water content =	25.7%	
Average back pressure =	200	kPa	Final dry density =	1619	kg/m^3
Head across specimen =	73	cm	Final deg. of saturation =	100%	
Hydraulic gradient =	21.7				
Initial sample diameter =	101.27	mm	Inflow rate =	0.00033	ml/min
Initial sample height =	33.62	mm	Outflow rate =	0.00036	ml/min
Initial water content =	22.3%		Average flow rate =	0.00034	ml/min
Initial dry density =	1626	kg/m^3			
Initial deg. of saturation =	94%		**Hydraulic Conductivity (based on average flow rate):**		
Specific gravity =	2.65	(assumed)	**k= 3.28E-09 cm/s**		

Permeant: de-aired distilled water



Comments:

Checker: Don Hazelwanter **Reviewer:** Mariglyn Corado

Project #: 700560
Client: Pinter and Associates
Project: 3285-1
Date: 07/26/2024

Materials Engineering

HYDRAULIC CONDUCTIVITY TEST REPORT

(Test Reference: ASTM D5084)

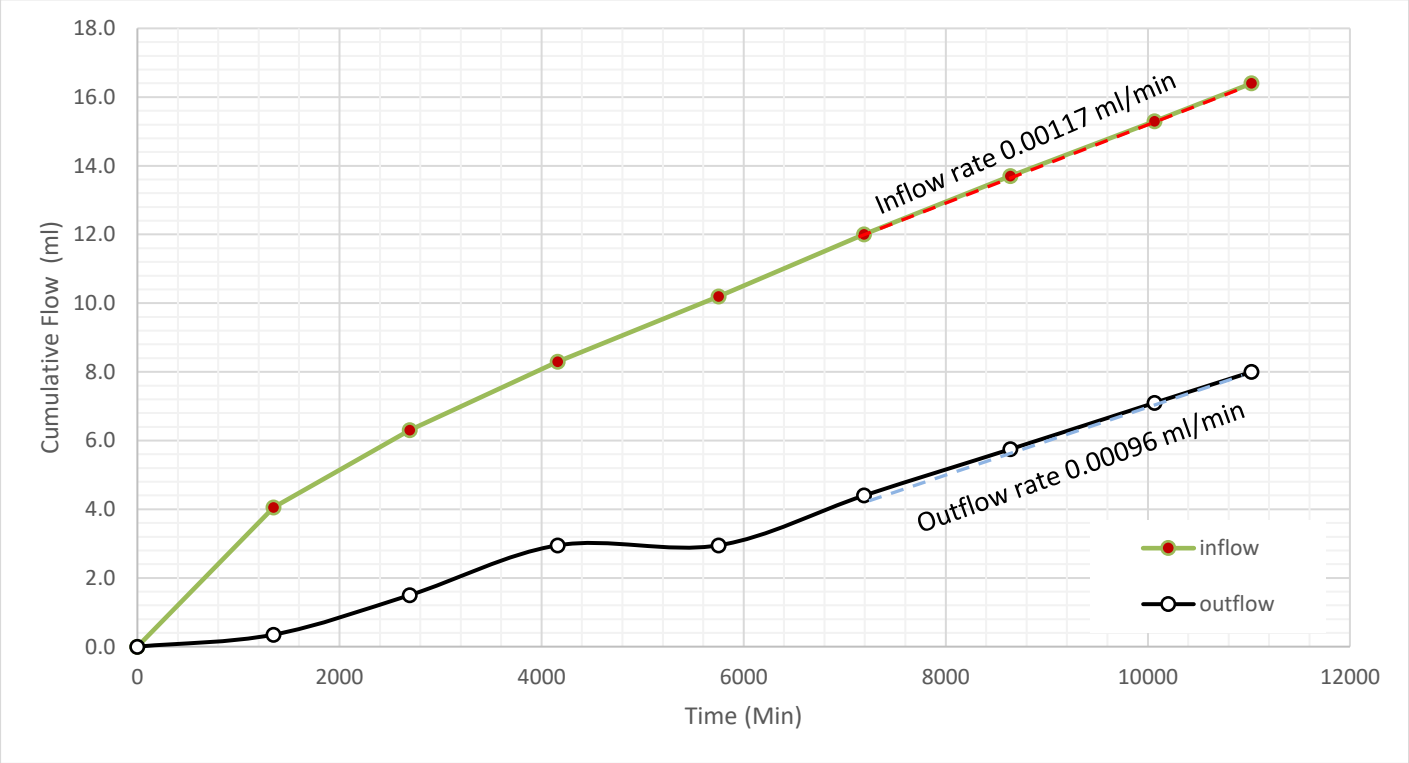
AtkinsRéalis Canada Inc.
406 Jessop Ave.
Saskatoon, SK S7N 2S5
306-668-6800

Sample: 5A-101

Test Type: Remoulded, Standard Proctor

Cell pressure =	230	kPa	Final water content =	26.0%	
Average back pressure =	200	kPa	Final dry density =	1566	kg/m^3
Head across specimen =	70	cm	Final deg. of saturation =	100%	
Hydraulic gradient =	20.4				
Initial sample diameter =	100.72	mm	Inflow rate =	0.00117	ml/min
Initial sample height =	34.37	mm	Outflow rate =	0.00096	ml/min
Initial water content =	22.6%		Average flow rate =	0.00106	ml/min
Initial dry density =	1571	kg/m^3			
Initial deg. of saturation =	87%		**Hydraulic Conductivity (based on average flow rate):**		
Specific gravity =	2.65	(assumed)	**k= 1.09E-08 cm/s**		

Permeant: de-aired distilled water



Comments: Set up at 97.9% of optimum density

Checker: Don Hazelwanter **Reviewer:** Mariglyn Corado

Project #: 700560
Client: Pinter and Associates
Project: 3285-1
Date: 08/16/2024

Materials Engineering

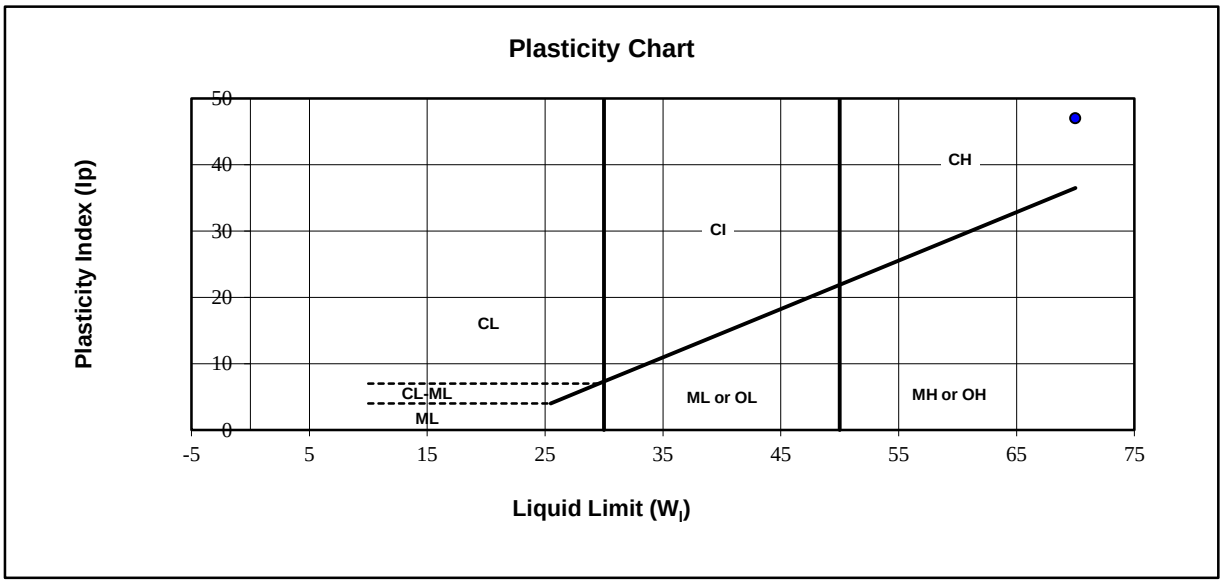
PINTER
& ASSOCIATES LTD
832B 47th Street East Saskatoon
SK S7K 0X4

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Wastewater Lagoon Upgrade	**Sample Number:**	4
		Borehole:	101
Project No:	3285-1	**Depth:**	10FT
Client:	Town of Radisson	**Sampled By:**	KH **Tested By:** JA
Attention:		**Date Sampled:**	19-Jul-2024
Email:		**Date Tested:**	31-Jul-2024

Sample Description: Clay



Liquid Limit ($W_{1)}$:	70	**Natural Moisture (%)**	36.4
Plastic Limit :	23	**Soil Plasticity:**	High
Plasticity Index (Ip) :	**47**	**Mod.USCS Symbol:**	CH

Remarks:

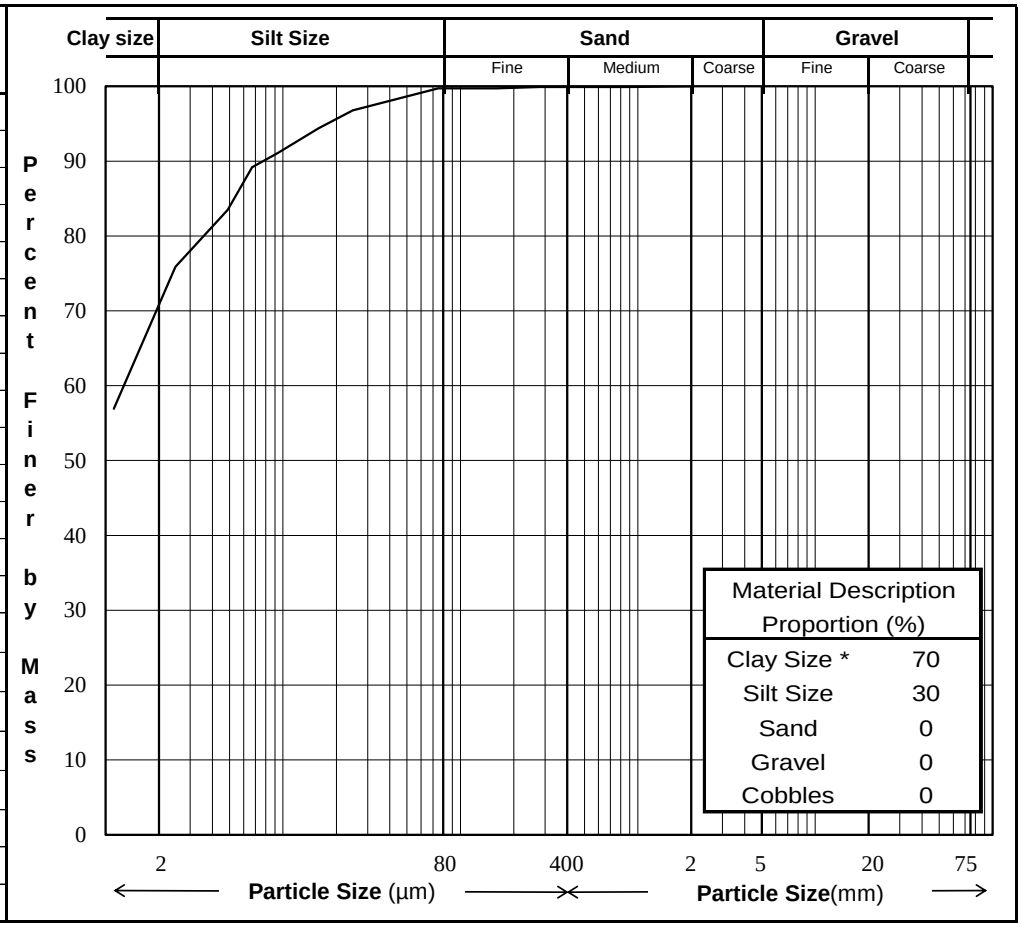
Reviewed By: P.Eng.

PINTER
& ASSOCIATES LTD
832B 47th Street East Saskatoon
SK S&K 0X4

PARTICLE SIZE ANALYSIS
(Hydrometer) TEST REPORT
AASHTO T88 †

Project:	Wastewater Lagoon Upgrade	Sample No.:	4
Client:	Town of Radisson	BH Location:	101
Project No.:	3285-1	Depth:	10FT
Location:	Radisson, SK	Date Tested	July 26, 2024
Description:	Clay	Tested By:	JA

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
37.5 mm	
25 mm	
19 mm	
12.5 mm	
9.5 mm	
4.75 mm	
2.0 mm	100
900 µm	100
400 µm	100
280 µm	100
160 µm	100
75 µm	100
25 µm	97
16 µm	94
9 µm	91
7 µm	89
5 µm	83
2 µm	76
1 µm	57



Remarks: † Unless expressly stated, this test was performed by the Air Dry Method
* The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

Reviewed By: _____ P.Eng.