LUD of Richer
Wastewater Servicing Study

PRESENTED TO

Rural Municipality of Ste. Anne

MAY 7, 2024
ISSUED FOR USE
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Revision History

REV. NO	ISSUE DATE	PREPARED BY	REVIEWED BY	APPROVED BY	DESCRIPTION OF REVISION
1	2024-03-14	Matt Litke Minh Hoang	Lin Watt Tyler Evans	Lin Watt	Issued for Review
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EXECUTIVE SUMMARY

The Rural Municipality of Ste Anne (RM) and the Manitoba Water Services Board (MWSB) have retained Tetra Tech to perform a servicing study for the LUD of Richer (Richer). This included reviewing previous records and documentation, performing a geotechnical investigation, assessing population projections over a 20-year design period, developing a conceptual collection system for Richer, providing potential lagoon-based wastewater treatment options, and outlining recommendations with Class D opinions of capital costs.

Background

The Rural Municipality of Ste. Anne is located southeast of Winnipeg and has an area of 47,776 hectares. Approximately a tenth of the RM's 5,584 residents reside in the LUD (Local Urban District) of Richer, based on the 2021 Canada Census. Richer has been experiencing an average growth rate of approximately 2% annually over the last 10 years.

All properties in Richer are currently serviced by individual on site septic tanks and fields or holding tanks. Septic tank and holding tank waste is currently trucked to the RM's truck haul lagoon located near the Town of Ste. Anne about 20 km west. The RM council is planning for new sustainable, safe, and eco-friendly wastewater management and treatment options to facilitate further growth in Richer. A sewer system would allow for increased economic development, infill development, and eliminate the need for septic trucks to travel on and damage streets and roads in Richer.

The RM has recently received new subdivision development applications all with minimum lot sizes of two acres. This is due to the lack of sewer system and the provincial requirement that residences with basic on-site septic systems must have minimum lot sizes of 2 acres. The RM has concerns about drinking water security - Richer residents obtain their drinking water via private groundwater wells, which could be at risk given the density of on-site sewer systems and their increased risk of failure or leakage into the aquifer compared to a piped service.

The findings of this study are based on the development of a second treatment facility. This facility would service the rural areas on the east side of the RM, as well as a sewer system in the collection service area in Richer.

Summary of Study and Recommendations

Tetra Tech reviewed available census data to project future design year 20 populations for the sizing of the systems. A medium growth rate was selected based on feedback from the RM and MWSB, based on the previous trends seen within Richer. A design start year of 2025 was selected, as implementation of the findings of this study are not anticipated to occur immediately. The population projections included in Section 2.1.1 are representative of the wastewater collection service area, bounded by the immediate area of Richer. This area will be serviced by the wastewater collection system. A larger extended service area, described in Section 2.1.4, will be serviced by truck haul, and directed to the new wastewater treatment facility. The 20-year design residential population for the wastewater treatment system is **1,276** people, as outlined in Section 2.2.1.

Tetra Tech completed a geotechnical investigation of the two sites proposed by the RM including a desktop study, test pitting, and laboratory analysis. Site 1 was selected for its geotechnical merits, as well as other siting benefits, as indicated in Section 3.1.3.

For the wastewater treatment facility, the options considered were a facultative lagoon, or an aerated lagoon with Submerged Attached Growth Reactor (SAGR) cell for nutrient removal. High level sizing, analysis, and probable opinions of capital cost were completed to compare the suitability of each option. Tetra Tech's recommendation for the treatment facility is a two-cell facultative lagoon system. The facultative system was selected based on its lower capital cost, simple operation and low maintenance requirements, and wide use in many municipalities throughout Manitoba.

For the wastewater collection system, high level analysis, layout, and sizing of both a gravity and pressure sewer system was completed to compare the suitability and capital cost of the systems to service the community. Both systems were deemed feasible for the community. A Pressure Sewer system with individual grinder pumps is recommended for Richer based on the lower capital cost and other scope saving advantages.

Tetra Tech's recommended conceptual design consists of a **two-cell synthetic-lined facultative lagoon**, built at the proposed Site 1 (located southwest of Richer) and serviced by a 16.5 km long **pressure sewer system** connecting directly to the lagoon and branching out to service the homes within the community with grinder-style pumps at each residence or commercial property. A conceptual figure of the proposed design is included in Appendix B.

Our opinion of probable construction cost for the conceptual servicing system described in the study is **$19,920,000.00**, outlined in detail in Section 5.0. Tetra Tech's recommendations for project phasing and key next steps are included in Section 6.2 and 6.3, respectively.

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Manitoba Water Services Board, the Rural Municipality of Ste. Anne their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than The Rural Municipality of Ste. Anne or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

The Rural Municipality of Ste Anne (RM) and the Manitoba Water Services Board (MWSB) have retained Tetra Tech to perform a servicing study for the LUD of Richer (Richer). This study included a geotechnical field investigation and accompanying report, assessing population projections over a 20-year design period, developing a conceptual collection system for Richer, providing potential lagoon-based wastewater treatment options, and outlining recommendations with Class D opinions of capital costs.

1.1 Background

The LUD of Richer is a community located within the Rural Municipality of Ste Anne, southeast of Winnipeg. As of the 2021 census, 607 of the RM's 5,584 inhabitants reside in Richer. Over the last ten years, Richer has experienced an average growth rate of approximately 2% annually. According to RM staff, the municipality currently averages 2.8 people per dwelling, which equates to approximately 217 private dwellings in Richer.

Richer currently does not have facilities for wastewater treatment or wastewater collection. All properties in Richer are serviced by individual on site systems or holding tanks. Septic tank and holding tank waste is trucked to the RM's truck haul lagoon, located near the Town of Ste. Anne about 20 km west of Richer. The RM wastewater treatment facility was recently expanded to include a new facultative primary cell and wetland for phosphorus removal, as well as a new dual truck dump station to receive hauled waste from the entire RM. The RM council is planning for new sustainable, safe, and eco-friendly wastewater management and treatment options to facilitate further growth in the RM generally and Richer specifically.

The RM has recently received new subdivision development applications, all with minimum lot sizes of two acres. Should a sewer system be installed, smaller lot sizes would be possible as the Province of Manitoba requires residences with basic on-site septic systems to meet a minimum lot size of 2 acres. The RM also has concerns about drinking water security as Richer residents obtain their drinking water via private groundwater wells. On-site septic systems have an increased risk of failure or leakage into the aquifer compared to a newly installed piped wastewater collection service.

A wastewater collection system and local treatment facility would allow for increased economic development, denser infill development, and reduced maintenance on streets and roads impacted by septic truck travel.

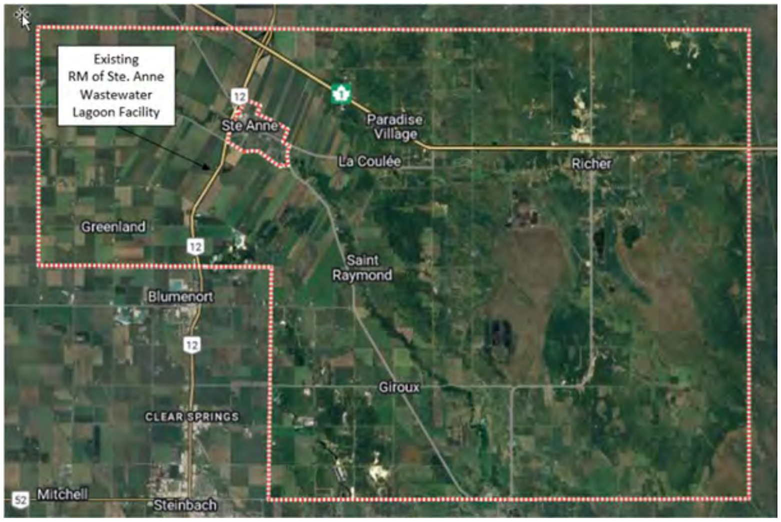

Figure 1-1: RM of Ste. Anne Municipal Boundaries

2.0 DESIGN PARAMETERS

The following design parameters were used for the options analysis and sizing of the wastewater collection and wastewater treatment infrastructure. Both systems will be sized based on the 20-year design horizon.

2.1 Population Projection

2.1.1 Residential Population

Available census data from 2006 to 2021 was used to project population growth for Richer. Three growth scenarios (low, medium, high) are presented in **Figure 2-1** and **Table 2-1** below. The low and high population growth scenarios represent the minimum and maximum positive growth rates recorded from 2006 to 2021 applied forward. The medium growth scenario is the average annual growth rate of the available data. These options were presented to the RM and MWSB and the project team selected the medium growth rate for the purposes of the servicing study, based on observed current trends within Richer as well as the RM overall.

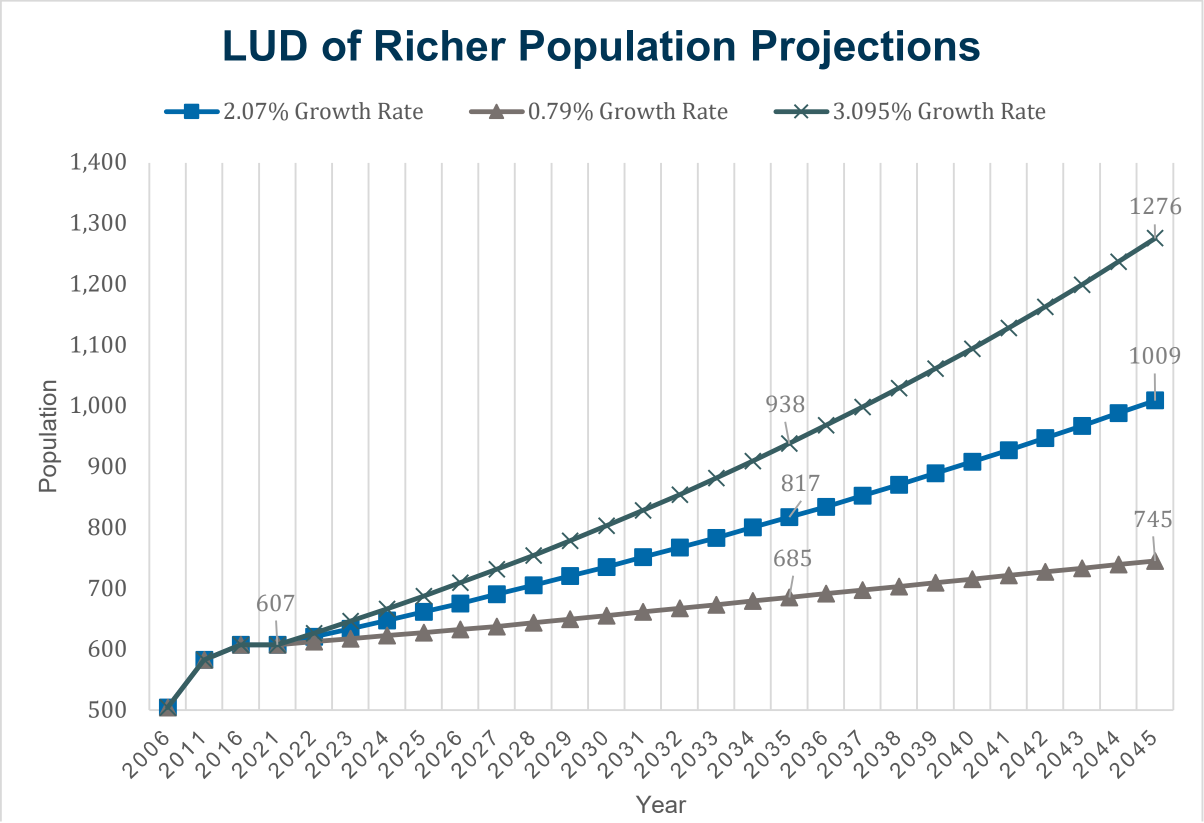

Figure 2-1: LUD of Richer Population Projections

Table 2-1: LUD of Richer Population Projections

Year	Low Growth 0.785%	Medium Growth 2.074%	High Growth 3.095%
2021 (Last Census)	607	607	607
2023 (Current Year)	617	633	646
2025 (Design Year 0)	627	661	687
2035 (Design Year 10)	685	817	9.8
2045 (Design Year 20)	745	**1,009**	1,276

A design start year of 2025 was selected, as implementation of the findings of this study are not anticipated to occur immediately. As indicated in Table 1 above, the 20-year design residential population for the wastewater treatment system is 1,009 people.

The population estimates and projections are assumed to be representative of the wastewater collection service area. The service area to be covered by the wastewater collection system is bounded by Therrien Drive and Godard St to the north, Richer Perimeter Road to the east and west, and Municipal Road 44N and Saindon Drive to the south. Based on RM feedback, the service area was also extended in the northwest edge to include approximately seven additional properties down Dawson Road to the east. The updated wastewater collection service area is defined in **Figure 2-2** below.

Figure 2-2: Richer Wastewater Collection Service Area

2.1.2 Industrial & Commercial Sources

The RM currently does not have any industrial wastewater sources. The following commercial sources of wastewater were identified within the Richer service area:

- Richer Inn Motor Hotel
- Esso Gas Station
- HUSKY Gas Station
- Derica's Restaurant
- Dawson Trail Museum
- Burnells Food Plus
- Johnson Fruit Stand (seasonal contribution)

The RM would like the wastewater system in Richer to allow for future industrial and commercial growth. The RM has requested the system be sized to accommodate an equivalent of an additional 150 persons at design year 20. The additional 150 persons allowance is expected to cover the contributions associated with any new industrial developments as well as changes or expansions to existing businesses.

2.1.3 Institutional Sources

The LUD includes a school with approximately 208 attendees (comprised of 180 students and 28 staff). Much of the school's attendees travel each day from outside of Richer and could be considered as adding to the serviced population. However, according to the RM, an equal or greater number of Richer residents commute away from the LUD during the day for work or other reasons, so the contribution of the school is not considered as additional population to be serviced by the treatment facility. Due to the concentration of flows that would occur at the school during daytime usage, consideration for the school's population will be given in the wastewater collection system design.

2.1.4 Extended Service Area

All truck-hauled wastewater in the RM, including Richer, is currently directed to the RM of Ste Anne lagoon located south of the Town of Ste Anne on the west side of the RM. The RM has expressed interest in sizing the potential Richer wastewater treatment lagoon facility so that hauled waste from the Extended Service Area around Richer could be directed to the new Richer lagoon rather than being hauled the longer distance to the RM lagoon.

This extended area would not have a wastewater collection system but would continue to be serviced by truck hauling. The surrounding area outside of the extended service area would still need to be hauled to the larger RM of Ste Anne lagoon. **Figure 2-3** below shows the approximate extents of the Extended Service Area (approximately a 2–3-mile distance outside of Richer).

Population data is not available for the extended service area. The estimated contribution of the Extended Service Area was calculated based on the number of lots within the boundary that will not be connected to the wastewater collection system. Based on the boundary drawn by the RM and information from Manitoba Assessment Municipal Boundaries, there are 233 existing lots in the Extended Service Area.

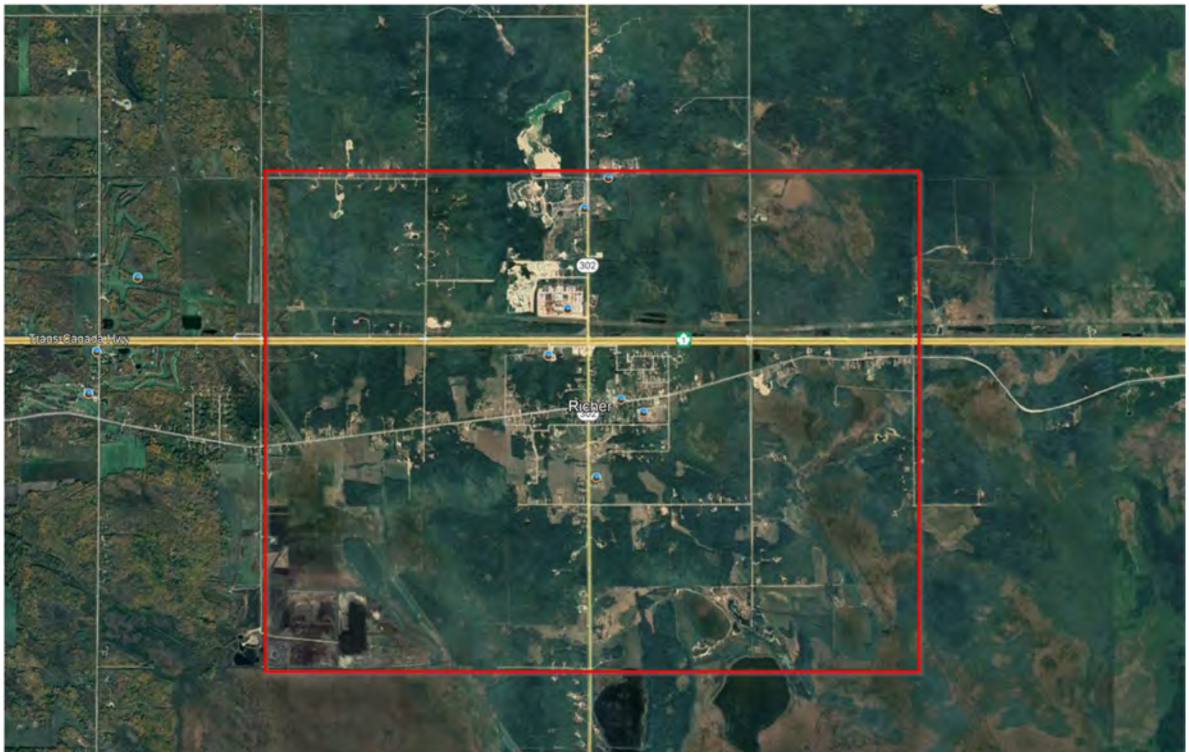

Figure 2-3: Richer Wastewater Treatment Extended Service Area

All lots in the Extended Service Area are assumed to be serviced by either septic tanks or holding tanks. For the purpose of this study, Tetra Tech has assumed that all lots smaller than 2 acres are serviced by holding tanks, and lots greater than 2 acres will have septic tanks and fields. Based on this assumption, there are currently an estimated 216 dwellings serviced by septic tanks and 17 dwellings serviced by holding tanks.

The RM has indicated that future development is expected to occur on the west boundary of the Extended Service Area. There is potential for lot creation that has been identified to extend the settlement center zone. 117 additional lots have been estimated by the RM, bringing the total future number of serviced lots to 350 at the 20-year design horizon. The future development is expected to be a mix of lot sizes and was assumed to include 50% septic tanks and 50% holding tanks for the purpose of this study.

Table 2-2: Extended Service Area

Parameter	Quantity (Current)	Quantity (20-year Design)
Number of Lots	233	350
Estimated Number of Septic Tanks	216	275
Estimated Number of Holding Tanks	17	75

Tetra Tech reviewed hauling logs for septic and holding tanks provided by the RM. The frequency and volume of hauling service to individual civic addresses varied greatly. Five complete years of data from 2018-2022 were analyzed to calculate maximum, minimum, and average annual values for the holding tank daily contribution, septic tank daily contribution, and septic tank blended concentration, according to the methodology outlined below. The calculated values are as follows:

Table 2-3: Key Historic Truck Haul Parameters (2018-2022)

Parameter	Units	Minimum	Average	Maximum (Design Value)
Holding Tank Contribution	L/property/day	162.27	189.00	**224.85**
Septic Tank Contribution	L/property/day	9.95	11.70	**13.91**
Holding Tank Concentration	kg-BOD/m^3	0.20	-	**0.38**
Septic Tank Blended Concentration	kg-BOD/m^3	0.576	0616	**0.653**

The average daily contributions per tank were calculated by adding the total annual volume hauled for each type of tank divided by the number of unique civic addresses with each type of tank. Since septic tanks are generally not full of sludge when they are emptied, a blended concentration was estimated for the septic tank contributions assuming that sludge was generated at the rate cited in Manitoba's Onsite Wastewater Management Guide (60 L/capita/year). This translates to a volume of 150 L/property/year of sludge at the textbook strength of 7.0 kg BOD/m^3. The rest of the hauled septic tank volume was assumed to be of similar strength to the hauled holding tank wastewater. MWSB requested a range of 0.20-0.38 kg BOD/m^3 for hauled holding tank wastewater based on their references and experience. Tetra Tech has used the upper end of this range (0.38 kg BOD/m^3) in this study, noting it is lower than the typical textbook value of 0.8 kg BOD/m^3 for mixed municipal wastewater.

2.2 Serviced Population

2.2.1 Wastewater Treatment System

The wastewater treatment system will be sized on a population basis, including both the serviced population and the equivalent population for industrial and commercial loading. The serviced population includes both the residences that will connect to the collection system as well as the extended service area (hauled) population. The hauled contribution will be estimated based on the approximate number of septic and holding tanks. The 20-year design equivalent population to be serviced by the wastewater treatment facility is approximately 1,276 as summarized in **Table 2-4** below.

Table 2-4: Service Populations

Category	Population Contribution (Design Year 20)
Residential Population (Collected)	1,009
Industrial Equivalent (Collected)	150
School Population (Collected)	0*
Extended Service Area Equivalent (Hauled)	117**
Total Serviced Population	**1,276**

*Actual school attendance is approximately 208 persons but is assumed to be offset by residents from the service area who commute away from Richer during the school day.

**Wastewater generation for the Extended Service Area was calculated based on the number of septic and holding tanks, and back calculated to an equivalent connected population based on the total load contribution and the per capita strength of the collection population. The population figure is representative only. The actual population in the Extended Service Area would be approximately 980 persons based on the RM reported household size of 2.8 persons/dwelling, assuming one dwelling per legal lot.

2.2.2 Wastewater Collection System

Analysis for the linear assets (sewers and lift stations if applicable) was completed on a Residential Equivalent Unit (REU) basis where one REU is equal to one single-family home. With this system, commercial, Industrial, and institutional buildings will be assigned REUs based on typical textbook values. This is because each section of the linear asset will serve part of the community and it is often clearer to locate and classify buildings and REUs.

The following will be used for the residential parameters:

Average household size	2.8 persons / dwelling

According to recent information from MWSB and the RM, the municipality currently averages 2.8 persons per dwelling. This is higher than the 2021 census value of 2.5 persons per dwelling assumed in the draft version of this report.

The wastewater collection system will connect only the Service Area outlined in **Figure 2-2** above. The Extended Service Area in **Figure 2-3** will be serviced by truck haul. For simplicity it was assumed that future population growth would all occur as single-family residential growth. There are no current detailed plans for developments in the community. The total of 264 residential equivalent units (as summarized in **Table 2-5** below) is representative of the service connections required at Design Year 0. The collection system was laid out based on existing lot locations and is sized for the immediate demand.

Table 2-5: Residential Equivalent Unit Summary

Category	REU Contribution (Design Year 20)
Residential Dwellings	250
Industrial/Commercial	14
Total	264

2.3 Wastewater Treatment and Collection Parameters

2.3.1 Wastewater Treatment Facility (Lagoon)

The wastewater treatment facility proposed for Richer and surrounding area is a facultative lagoon-based system. Wastewater treatment lagoons are a relatively simple, cost-effective, and proven wastewater treatment process, particularly when compared to mechanical treatment alternatives.

2.3.1.1 Influent Parameters:

No sampling data is available to indicate wastewater strength for the current populations in the RM of Ste. Anne or the LUD of Richer. Since no existing piped networks are present, textbook values will be used to estimate the contributions of the Service Area connected to the collection system. The wastewater generation rate for serviced connections was taken to be the average flowrate from Metcalf and Eddy for a 2.8-person household (292 L/c/d), at the textbook wastewater strength (0.076 kg-BOD/c/d).

Partial annual truck hauling logs are available and were reviewed to determine wastewater generation rates for properties with holding tanks and septic tanks, according to the methodology outlined in Section 2.1.4. The wastewater generation based on historic hauling records for properties with septic tanks was 13.9 L/property/day as shown in **Table 2-3**. However, most wastewater facility permits only allow septic tank waste to be accepted during the 135-day period between June 1 and October 15 each year. As a result, the design daily flow from septic tanks used in the organic loading calculations has been prorated for this shortened period, resulting in an adjusted flow of 39.0 L/property/day.

Based on the assumptions and calculations above, the following design influent parameters will be used:

- **Service Area (Collection System):**

Wastewater Generation	292 L/capita/day
Wastewater Strength	0.076 kg BOD/capita/day

- **Extended Service Area (Hauled):**

Wastewater Generation (Septic tanks)	13.9 L/property/day (annual average) 39.0 L/property/day (hauling window average)
Sludge Strength - Blended (Septic tanks)	0.65 kg BOD/m^3
Wastewater Generation (Holding tanks)	224.9 L/property/day
Sewage Strength (Holding tanks)	0.20-0.38 kg BOD/m^3

2.3.1.2 Lagoon Design Parameters:

Total organic and hydraulic loading to the wastewater treatment facility for the 20-year design was calculated by Tetra Tech according to the influent parameters described in Section 2.3.1.1 and are shown in **Table 2-6** and **Table 2-7** below.

The total hydraulic loading rate was calculated based on the design population of the service area multiplied by the per capita wastewater generation rate, plus the per-property volume generated from septic tanks multiplied by the number of septic tanks, plus the per-property volume generated from holding tanks multiplied by the number of holding tanks.

Table 2-6: Lagoon Hydraulic Loading

Source	Population (persons)	Per Capita Flow (L/cap/day)	# of Properties	Per Property Flow (L/day)	Total Flow (m^3/day)
Serviced Area Residential Population	1,009	292	Not used for calculation		295
Serviced Area Industrial Equivalent	150	292	Not used for calculation		44
Extended Service Area Septic Tanks	Not used for calculation		275	13.9*	4
Extended Service Area Holding Tanks	Not used for calculation		75	224.9	17
Total					**360**

*Conservative assumption as septic tanks should not be emptied during the lagoon winter storage period.

The total organic loading rate was calculated based on the design population of the service area multiplied by the per capita wastewater strength, plus the volume generated from septic tanks multiplied by the blended septic tank sludge strength, plus the volume generated from holding tanks multiplied by the maximum sewage strength.

Table 2-7: Lagoon Organic Loading

Source	Population (persons)	Per Capita Load (kg-BOD_5/cap/day)	# of Properties	Per Property Flow (L/day)	Strength (kg-BOD_5 /m^3)	Total Load (kg-BOD_5 /day)
Serviced Area Residential Population	1,009	0.076	Not used for calculation			77
Serviced Area Industrial Equivalent	150	0.076	Not used for calculation			11
Extended Service Area Septic Tanks	Not used for calculation		275	39.0*	0.65	7
Extended Service Area Holding Tanks	Not used for calculation		75	224.9	0.38	6
Total						**101**

*Prorated daily flow based on 135-day receiving period.

The Manitoba Design Objectives for Wastewater Treatment Lagoons allow the required lagoon size to be calculated based on the surface organic loading rate and required hydraulic storage volume. Key lagoon design parameters are shown below in **Table 2-8**.

Table 2-8: Key Lagoon Design Parameters

Parameter	Unit	Design Value (Design Year 20)
Total Organic Loading Rate	kg-BOD_5/day	101
Total Hydraulic Loading Rate	m^3/day	360
Maximum Organic Surface Loading Rate*	kg-BOD_5/ha/day	56
Required Primary Cell Surface Area	m^2	18,200
Required Storage Volume**	m^3	81,700

*Primary cell loading rate should not be exceeded (based on odor generation).

**Provision shall be made for winter storage based on holding liquid from at least November 1 to June 15 of the following year (227 days). Storage capacity is based on the operating volume of secondary cells that is available above the invert of the discharge pipe. Primary cell capacity contributing to hydraulic storage is limited to one-half (1/2) the actual operating volume.

The required primary cell surface area was calculated to ensure the specified maximum organic surface loading rate as stipulated by Manitoba Conservation and Water Stewardship guidelines (requiring at least one hectare of liquid surface area per 56-kg BOD_5 of daily organic loading) would not be exceeded.

2.3.1.3 Effluent Quality Objectives:

The wastewater treatment facility will be required to meet the following effluent quality objectives, which are based off both the Manitoba Water Quality Standards, Objectives and Guidelines (2011) and the Federal WSER guidelines:

- 25 mg $CBOD_5$/L

- 25 mg/L TSS (unless caused by algae)
- 200 MPN/100mL fecal coliforms or Escherichia coli (E. Coli) content
- 1.25 mg/L unionized ammonia as nitrogen (N) at 15°C ±1°C
- 1 mg/L phosphorus (P)

Table 2-9: Effluent Quality Requirements

Parameter	Units	WSER Requirements	Provincial Requirement
Un-ionized Ammonia as Nitrogen (N) at 15°C ±1°C	mg/L	≤ 1.25	-
$cBOD_5$	mg/L	≤ 25	≤ 25
Average Total Suspended Solids	mg/L	≤ 25	≤ 25
Total Residual Chlorine	mg/L	≤ 0.02	-
Acute Lethality	-	Pass	-
Fecal Coliforms/E. coli	CFU per 100 mL	-	200
Total Phosphorous	mg/L	N/A	1 mg/L*

*Population-dependent

The above table is applicable for a batch discharge (controlled or seasonal discharge) lagoon. Continuously discharging facilities may be expected to meet higher effluent quality standards based on the technology employed at the wastewater treatment facility and the sensitivity of the receiving body of water.

2.3.2 Wastewater Collection System

2.3.2.1 Design Flows

Design wastewater flow is comprised of dry weather flow from building services, extraneous inflow into manholes through covers, at pipe joints, through informal connections from ditches, and infiltration into mainline sewers and building services, manhole barrels through joints and cracks, or sump pump connections. Note that inflow and infiltration are negligible for a pressurized sewer system, due to being constructed with continuous fused pipe and having no manhole covers to allow inflow.

No sampling data is available for the current populations in the RM of Ste. Anne or the LUD of Richer. As a result, typical textbook values will be assumed for the purpose of the servicing study. Flow generation will be done on a REU basis with commercial, industrial, and institutional building being assigned a REU value based on typical textbook values.

Wastewater Generation	292 lpcpd
Infiltration (Gravity Sewer Only)	2,200 L / ha / day
Inflow (Gravity Sewer Only)	12 L / min / manhole
Maximum distance between manholes	130 m
Peaking Factor	Harmon

$$PF = 1 + \frac{14}{(4+\sqrt{P/1000})} \text{ where P is the population}$$

2.3.2.2 Gravity Sewers

Gravity sewers rely on an elevation drop in the form of pipe slope to create conditions for flow to occur. These sewers must be designed with minimum slope to avoid the deposition of solids, but not so steep that flow velocities cause erosion or abrasion of the pipe walls. The maximum allowable depth of flow in wastewater sewers is considered to be when the depth reaches 50% of the pipe diameter. This is done as at depths greater than 81% the flow can snap to full pipe or surcharged flow and can result in sewer service backup and basement flooding.

- No surcharge during peak flow conditions; Maximum depth of flow for sewer of 50% (half full)
- Pipes minimum slope to ensure a minimum full flow velocity of 0.6 m/s (2 ft/sec) is achieved, to prevent the settlement of solids within the pipe.
- Pipes laid at a maximum slope to ensure a maximum full flow velocity not greater than 3.0 m/s (10 ft/sec), to reduce abrasion damage to pipe walls and mitigate transient effects.
- Manning Roughness of n=0.013 for all smooth wall pipe materials (concrete, PVC, etc.)

In a gravity sewer system, manholes are placed at every 90-degree bend, every 120 meters, and at every branch connection. To calculate peak wet weather flows, the total number of manholes is used to determine inflow. Additionally, a 100-meter corridor along the pipe - which is a typical length from the back of one lot to the back of an adjacent property - is taken into account as the infiltration area.

2.3.2.3 Forcemains

Forcemains are pressure pipes with forced flow provided by pumping. Tetra Tech assumed one REU per property for preliminary sizing of the pressurized system options, since flow is intermittent, based on pump operation not wastewater generation.

- Minimum velocity of flow of 0.6 m/s, to resuspend and transport sediment within the forcemain.
- Maximum velocity of flow of 2.4 m/s, to reduce transient effects / water hammer.
- Maximum velocity within lift station piping of 3.0 m/s.
- Design Hazen and Williams Roughness C = 130 for thermoplastic forcemains (PVC, HDPE).

2.3.2.4 Lift Stations

Lift station size is governed by two design criteria; the frequency of pump starts and pump runtime. Every time a pump motor starts, the inrush of electrical current causes heat stress and wear on the motor. Once the motor is running, fluid surrounding and running through the pump provides motor cooling and it is desirable to run the pump long enough to adequately cool the motor between pump cycles. The number of pump starts per time interval and the pump runtime are a function of the inflow rate, the pump capacity and the wet well size.

- Maximum 6-10 pump starts an hour (per pump). Note that modern pumps claim to be capable of more frequent starts per hour without impacts on motor life, for the purposes of this study a conservative assumption of maximum pump starts has been used.
- Minimum pump run time of 1.5 to 2.0 minutes.

3.0 WASTEWATER TREATMENT OPTIONS

3.1 Site Investigation

The RM identified two possible locations for the proposed wastewater treatment facility. The first location (Site 1) is a plot consisting of three RM-owned lots (#83280, #83250, and #83200) located southwest of Richer. The second location (Site 2) is a plot of RM owned land (lot #69450) located northeast of Richer. Both sites were studied as part of the Geotechnical Investigation (completed November 8-9, 2023). The site locations relative to the Richer serviced area are shown in **Figure 3-1** below.

Figure 3-1: Proposed Lagoon Locations for Geotechnical Investigations – Site 1 & 2

Tetra Tech completed a desktop review of available geotechnical and geological information in the vicinity of the RM's two (2) proposed sites. As part of this review, the following data resources were relied upon:

- Surface Deposits Map (Department of Natural Resources, 1980)
- Surficial Geology of Winnipeg (Manitoba Geological Survey, 2004)
- GIN Basic Map Viewer

The desktop study indicated that Richer is located in an area with surficial soil deposits that vary between organic deposits, marginal glaciolacustrine sediments (sands and gravels), proximal glaciofluvial sediments (sands and gravels), and/or silt dominant glacial till.

Tetra Tech completed a field investigation consisting of five test pits and two driven point wells at Site 1, and six test pits and two driven point wells at Site 2. Test pitting was completed by Marc Vincent Excavation using a tracked excavator to maximum depths ranging from 2.1 m to 3.4 m below ground surface (bgs). Disturbed grab samples were retrieved from test pits at select intervals. Subsurface conditions observed during excavation were documented by Tetra Tech geotechnical staff according to the Unified Classification System for soils. Other pertinent information such as groundwater and sloughing conditions were also recorded. Test pits were backfilled with excavated material and compacted using the excavator bucket to original ground surface. Samples retrieved during the field investigation were tested in Trek Geotechnical's and ALS Environmental's materials testing laboratories, both located in Winnipeg, Manitoba. Laboratory testing was completed on select soil samples collected during the test pitting. The soil testing program included the determination of index properties such as moisture content, grain size distribution (sieve analysis/hydrometer method), plasticity (Atterberg Limits), and electrochemical properties (resistivity/conductivity, sulphate content, and pH). Detailed findings are included in the Geotechnical Report (Appendix C).

3.1.1 Site 1

Site 1 is located approximately 3.5 km southwest of Richer within Lots 83280, 83250, and 83200. The site is partially forested, and available surficial geology information indicates that it is generally characterized by near-surface gravelly sand and/or silt dominant glacial till deposits, as well as organic deposits in localized low-lying areas. The available subsurface information at this site generally indicates high permeability near-surface soils that would not be considered suitable for use as in-situ liner material for a wastewater lagoon.

The general soil profile found during the test pitting at Site 1 consisted of organics, sand, silt, and glacial till (in descending order from grade). Seepage and sloughing were not encountered during excavation of the test pits at Site 1.

Electrochemical test results showed that the glacial till and sand soils are classified less than moderate class of exposure to sulphate attack (for buried concrete structures) and moderately corrosive for buried metal.

3.1.2 Site 2

Site 2 is located approximately 3.0 km northeast of Richer within Lot 69450. Aerial photographs suggest that the site is heavily forested, and available surficial geology information indicates that it is generally characterized by sand and/or silt dominant glacial till deposits, as well as organic deposits in localized areas. The available subsurface information at this site generally indicates high permeability near-surface soils that would not be considered suitable for use as in-situ liner material for a wastewater lagoon.

The general soil profile found during the test pitting at Site 2 consisted of organics, sand, and gravel (in descending order from grade). Seepage was observed at depths varying from 1.5 m to 2.7 m bgs during excavation of five out of six test pits. Sloughing was encountered in all test pits at depths ranging from 1.2 m to 2.1 m bgs.

Electrochemical test results showed that the glacial till and sand soils are classified less than moderate class of exposure to sulphate attack (for buried concrete structures) and mildly to moderately corrosive for buried metal.

3.1.3 Geotechnical Recommendations

Based on the soil types encountered during the geotechnical investigation, a naturally-lined wastewater lagoon is not considered to be a feasible design option for Site 1 or Site 2. The hydraulic conductivity of the sands, gravels, silts, and glacial till soils that were observed are not anticipated to meet the Province of Manitoba's (the Province) hydraulic conductivity requirement of 1 x 10-7 cm/s (or less) for clay-lined lagoons. As a result, consideration will need to be given to either incorporating a synthetic liner (geomembrane or geosynthetic clay liner) or constructing the lagoon liner out of imported clay liner material that meets the Province's requirements.

Although soil conditions encountered at both Site 1 and Site 2 are not conducive to a clay-lined lagoon, they are anticipated to provide adequate foundation support for the proposed lagoon and associated infrastructure provided appropriate construction techniques are followed. It is worthwhile noting that Site 1 was generally characterized by a thinner layer of organics, less variability in soil types between test pits, and less frequent observations of seepage and sloughing during excavation of the test pits when compared to Site 2. Of the available options, Site 1 is the preferred geotechnical option for these reasons.

Additional recommendations for pre-design and detailed design are included in the attached geotechnical memorandum (Appendix C). Notably, Tetra Tech recommends installing piezometers on Site 1 at the RM's earliest opportunity so that seasonal groundwater levels can be monitored and recorded for use in the future lagoon design.

3.1.4 Site Comparison and Selection

While Site 1 is preferred from a geotechnical perspective, it also has other advantages including a larger available land area and a shorter and lower complexity conveyance route from Richer: Site 2 would require piped crossings of the Trans-Canada Highway and the Trans-Canada natural gas Main Line.

A key consideration is ownership and access of the land. The RM owns both prospective lagoon sites and completed tree clearing to allow access to Site 1 for the geotechnical investigation.

Another important consideration for site selection is the location of a nearby discharge location to accept flow by gravity from the lagoon. Neither Site 1 or Site 2 are located adjacent to an existing watercourse or wetland. Based on a desktop study of the available satellite imagery, no Provincial drains are located in the vicinity of Site 2, but surface watercourses and provincial drains are visible within a reasonable distance of Site 1. Site 1 is also located at a lower absolute elevation than Richer and Site 2, and the general elevation trend surrounding Site 1 is sloping away from Richer. Tetra Tech prefers Site 1 over Site 2 for discharge options.

Site 1 is also located at a greater distance from existing and proposed residences. There are existing residences on Municipal Road 41E, but they are outside of the minimum 300 m offset recommended by the Manitoba Design Objectives for Wastewater Treatment Lagoons and can be shielded from the proposed lagoon site by retaining the existing tree cover in the area. Although Site 2 can also meet the required minimum offsets, the RM has informed Tetra Tech that the adjacent lot to the north (lot 69400) has been sold and residential development is expected. Depending on where on the lot the potential new residence is constructed, the lagoon site plan may have to be altered for Site 2. The RM has noted that future development is expected on the west side of Richer, which is closer to Site 1. This will reduce costs for the collection system service for these developments.

Based on this comparative analysis between Site 1 and Site 2, Tetra Tech recommends Site 1 as the location of Richer's proposed wastewater treatment facility.

3.2 Comparison of Aerated and Facultative Lagoon

3.2.1 Treatment Process Alternatives

Wastewater treatment lagoons are a relatively simple and proven wastewater treatment process, particularly when compared to mechanical treatment alternatives. The two options for a lagoon-based system are a facultative or aerated system, both of which are described below.

3.2.1.1 Facultative Lagoon

Facultative lagoons are a favourable wastewater treatment alternative for small communities because of their simple operation and low maintenance requirements. They are a widely used treatment alternative in many municipalities throughout Manitoba. Facultative lagoons typically consist of two or more cells (primary, secondary, storage, etc.) and can be operated in series or parallel.

Facultative lagoons treat wastewater using sunlight and wind action: atmospheric aeration and aerobic organisms near the surface, anaerobic organisms near the bottom, and an anoxic (facultative) zone in between digest the wastewater. Typically, the primary cell accommodates sedimentation and provides most of the treatment, with the secondary and subsequent cells providing polishing and storage. Facultative lagoons are effective for removing BOD, TSS, fecal coliforms, pathogens, and ammonia during warm weather, however they may require additional process steps to meet phosphorus removal requirements.

The lowest capital cost option for phosphorus removal is to dose chemical coagulant (aluminum sulfate or ferric chloride) manually from the water surface via a boat. The coagulant is used to precipitate phosphates from the wastewater, and they settle out in the lagoon cells as sludge. A small chemical pump can be used to inject chemicals following the propwash of a boat to assist with even distribution throughout the cell. The frequency and quantity of dosing required would be determined based on calculations from sampling the influent TP levels. Chemical coagulants can also be dosed continuously or intermittently by implementing a mechanical system. An intercell mixing manhole can be used to dose chemical, or a slipstream system can be implemented that draws a side stream of wastewater from the cell, mixes it with chemical coagulant in the building, and returns it to the cell for settling. Both systems allow for optimizing the chemical dosing rate with regular sampling. Implementing a permanent mechanical dosing system carries higher capital and operational costs, particularly as power is required to be brought to site, but greatly improves safety and convenience for the operators.

Other options for phosphorus removal include Constructed Wetlands or Trickling Discharge. Constructed wetlands are consist of an engineered shallow pond or channel which has been planted with aquatic plants. Phosphorus removal in a constructed wetland is limited to the seasonal uptake of the plants and harvesting of the plants is required. Trickling discharge requires reconfiguring the lagoon to discharge effluent over a longer period of time through a natural ditch. Although it is technically simple, trickle discharge requires higher operational requirements for compliance with regulations and may not be able to consistently meet TP limits. These other options typically require additional land area, higher capital costs, and more intensive operating and maintenance processes. For the purpose of this study, manual dosing of coagulant from the water surface has been assumed.

The main benefit of a facultative lagoon is the reduced operational cost and complexity. Facultative lagoons are typically considered a Class 1 wastewater treatment facility, requiring less operator training and experience to run. This allows existing RM staff to be utilized for the facility's operation. The daily time required for operating a facultative lagoon is significantly lower as there are no mechanical or aeration systems to check and maintain. The seasonal discharge window also requires less effort and cost for ongoing sampling.

The key downside to facultative lagoons is that they require substantial land area. The land requirement is large to accommodate storage for the winter months when treatment rates generally slow down compared to warmer periods. The requirement for a facultative controlled discharge lagoon is a 230-day storage period and discharge will only be permitted between June 16 – October 31 of each year. The proposed Site 1 for the new facility has sufficient land area to accommodate a facultative lagoon.

3.2.1.2 Aerated Lagoon and SAGR® System

The alternative to a facultative lagoon is an aerated lagoon that may also be followed by a submerged attached growth reactor (SAGR®) system. Aerated lagoons provide increased treatment in a smaller footprint by using mechanical aeration blowers and diffusers installed in the cells to improve mixing and oxygen content. Aerated lagoons are effective in removing BOD, TSS, fecal coliforms, and pathogens. Continuous discharge aerated lagoons typically require additional treatment (such as a SAGR® system) for polishing and nutrient removal (including ammonia removal). A SAGR® is a clean stone bed, where wastewater can flow through horizontally or vertically. SAGR® systems can provide nitrification for ammonia removal and further polishing of TSS, BOD, fecal coliforms, and pathogens.

As with facultative lagoons, phosphorous removal may also be a concern but can be achieved by dosing a coagulant, either by batch or continuous slipstream dosing. With an aerated system, it is more typical to implement a continuous or intermittent mechanical dosing system. This system can be located in an intercell structure or receiving manhole to dose chemical into the influent, allow mixing with the wastewater and settling out in the lagoon cells. Alternatively, a building housing chemical storage and pumps can be constructed at the lagoon site or integrated with the blower building. An intercell mixing manhole can be used to dose chemical, with a heat-traced feedline from a chemical storage building. Or a slipstream system can be implemented that draws a side stream of wastewater from the cell, mixes it with chemical coagulant in the building, and returns it to the downstream cell(s) for settling. Both systems allow for optimizing the chemical dosing rate with regular sampling. Implementing a permanent mechanical dosing system carries higher capital and operational costs, but greatly improves safety and convenience for the operators. Other options for phosphorus removal include Constructed Wetlands or Trickling Discharge. Although manual dosing is also an option, it can be harder to achieve consistent phosphorus removal with this method, due to the smaller volume of the aerated cells and continuous discharge.

Continuous discharge aerated lagoon system requires less land area than a facultative controlled discharge system. However, for continuous discharge to be considered, there must be a suitable receiving waterbody (continuously flowing even during the winter months). Power is also required at the site. Overall, when compared to a facultative lagoon, aerated lagoons are typically able to produce a higher quality effluent but have more mechanical components, leading to a more complex system with higher operations and maintenance costs.

The main disadvantages of an aerated system are increased maintenance complexity and operational costs. Systems with aerated lagoons, SAGRs, and chemical dosing systems are often classified as a Class 2 wastewater treatment facility, which require more experienced trained operators. The blower equipment, aeration diffusers, SAGR step feed valves, and other components of the system require daily inspections and more other preventative maintenance tasks including oil changes, part replacements, and repairs. Continuous discharge also requires more frequent wastewater sampling and analysis.

3.2.2 Discharge Route Alternatives

For the purpose of this study, it is assumed that the conceptual lagoon facility at Site 1 will discharge treated effluent by gravity flow into an open ditch to the nearby unnamed tributary (which flows northwest and is located approximately 600 m south from the lagoon site) to Lake Riviera, which eventually meets the Seine River, as shown below in **Figure 3-2**.

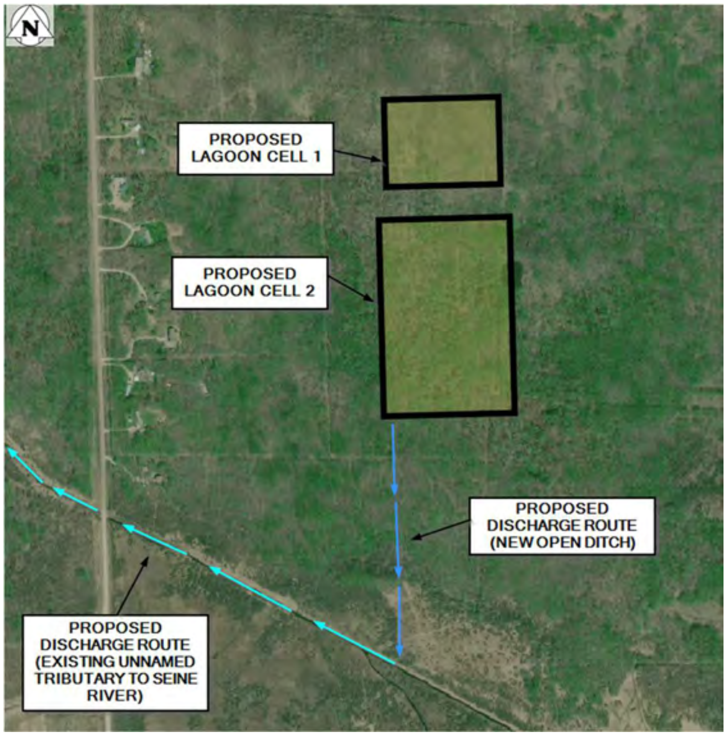

Figure 3-2: Proposed Discharge Route

A drainage and waterways investigation is recommended at the preliminary design stage to confirm the discharge route for the new lagoon facility, including verifying elevations through topographic survey to confirm that gravity discharge is possible. As local landowners may be required to sign off on discharge permits, Tetra Tech also recommends engaging landowners along the discharge route at the preliminary design stage.

3.2.3 Facility Evaluation and Selection

Tetra Tech's recommendation for the treatment facility is a two-cell facultative lagoon system. The proposed lagoon Site 1 has sufficient area to accommodate the larger facultative pond sizes for the treatment and storage cells. The deciding advantage of the facultative lagoon option is its simple operation and low maintenance requirements, and wide use in many municipalities throughout Manitoba. A seasonal controlled discharge facultative lagoon also can utilize the discharge route identified in **Figure 3-2**. The site is not suitable for year-round discharge, as it would create freezing and flooding issues. The facultative lagoon is also the lower capital cost option based on Tetra Tech's Class D estimate.

A Class D opinion of probable capital costs of both systems is show in **Table 3-1**.

Table 3-1: Wastewater Treatment Class D Opinion of Probable Costs Summary

	Facultative Lagoon	Aerated Lagoon & SAGR
Construction Cost	$ 4,280,000	$ 6,650,000
Indirect Costs (40%)	$ 1,600,000	$ 2,650,000
Total Construction Cost	**$ 5,610,000**	**$ 9,300,000**

The class D opinion of probable cost indicates a facultative lagoon is approximately 40% less expensive to construct. Additionally, Aerated Lagoons & SAGR systems incur a significantly higher operational life cycle cost including power requirements, replacement parts for the aeration system, and daily operator tasks and checks, often requiring a dedicated staff person for operation. Facultative lagoon systems are relatively low maintenance, and the required check-ups and seasonal operational tasks generally do not require a full-time operator. While operation and maintenance costs were not included in the class D opinion of probable costs, it is expected that the lifecycle costs would only further support the choice of a facultative over an aerated system.

4.0 WASTEWATER COLLECTION OPTIONS

4.1 Comparison of Gravity and Pressure Sewer Systems

The following chapter compares options for below-ground wastewater collection (gravity versus pressure sewer systems). Above-ground sewer systems in northern climates are typically only installed where presence of bedrock, permafrost, or other subsurface conditions deter below-grade installations. They require significant heating (heat-trace or other), insulation, and ongoing maintenance. Richer is not expected to have significant bedrock near surface and below-ground installation of pipe would be suitable. Above-ground sewer systems have not been considered further for this location.

4.1.1 Gravity Systems

A gravity sewer system consists of an underground pipe laid at a slope to allow collected sewage to flow by gravity to a collection point or treatment facility. Flows must be at a velocity sufficient to minimize solid deposition and generation of sewer gases. This configuration works best when the ground slope is equal to or greater than the minimum required pipe slopes. When ground slopes are less than sewer gradients, sewer depths will gradually increase along the line and the bury depth will gradually deepen.

Once ground cover depths have become practically excessive or prohibitively expensive, a lift station and forcemain are used to pump sewage to another collection point or to a higher elevation to allow continued gravity flow. Gravity sewers have the advantage of lower operating and maintenance costs. However, they can be very costly to implement where deep excavation or rock excavation is necessary, or where many lift stations are required to overcome natural elevation challenges (such as when conveying sewage a long distance over relatively flat terrain, as is the case in Richer). Gravity sewers are also susceptible to infiltration from groundwater unless special care is taken to seal manholes and pipe joints.

Generally, there are two options for Gravity Systems:

- **Shallow Bury Insulated Gravity Sewer Main:** Typically, shallow bury is approximately 1.5 m below the surface. The lines are insulated to protect from freezing.
- **Deep Bury Uninsulated Gravity Sewer Main:** Typically, deep bury is approximately 2.4 – 5.0 m burial below the surface. Deep bury mains have an advantage over the shallow insulated ones as the cost of materials is generally lower, and less material is needed during construction. With the elimination of additional methods for freeze protection, overall operation and maintenance costs are also reduced. The drawback is the higher excavation costs for the additional depth of the installation, including for the deeper manholes along the gravity sewer route.

Richer’s topography is shown below in **Figure 4-1**. Generally, the ground slopes away from a ridge starting on the west side of the community and extends east then southeast. This type of topography is generally not favorable for gravity sewer due to the need for multiple lift stations.

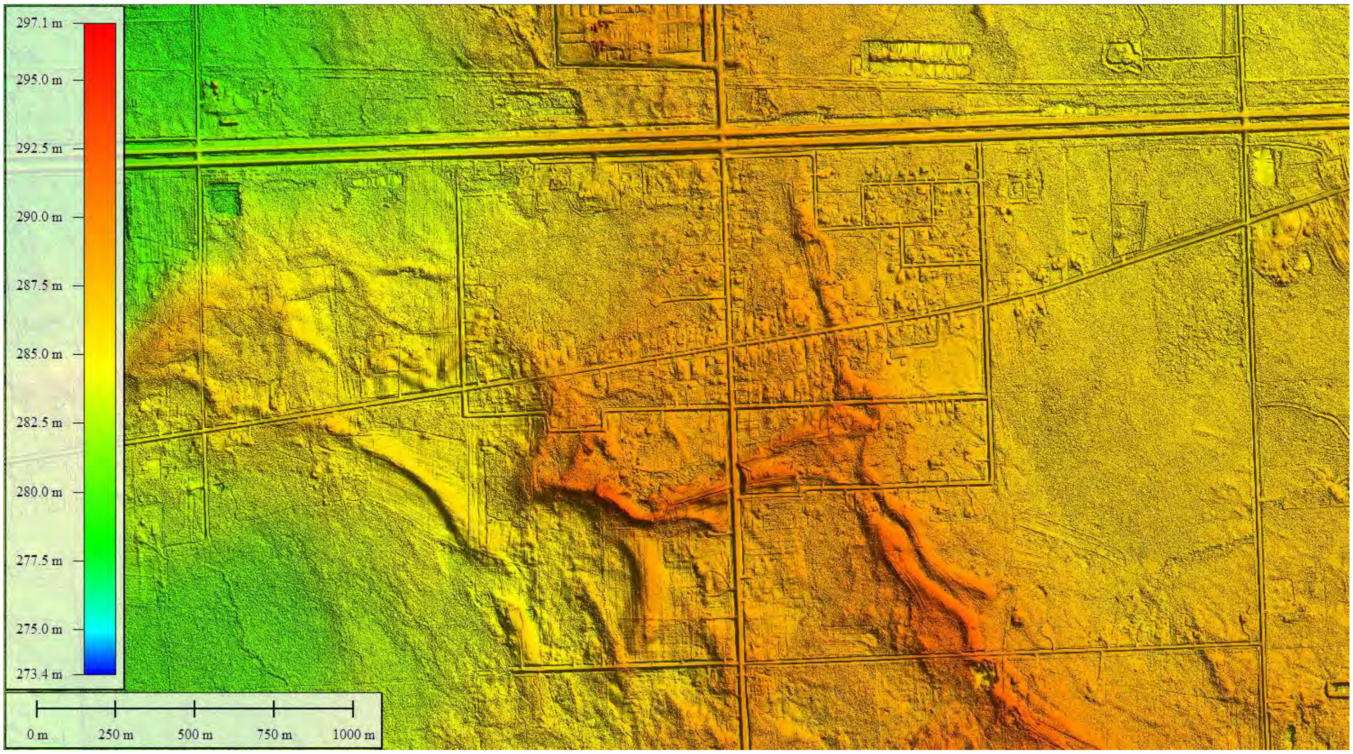

Figure 4-1: LUD of Richer Topography

4.1.2 Pressure Systems

A pressure sewer system uses small pumps at each house or building connection to convey sewage in a pressurized line to a collection point or treatment facility. Since the line uses pressure instead of gravity to facilitate sewage flow, there is no need to maintain an even gradual downwards slope in the sewer lines. Pressure mains can hence follow the general topography of the area, minimizing excavation depths for the pipe installation to the depth governed by physical and freezing protection. In addition, pressure pipe diameters are typically smaller than gravity sewers, which lowers material supply costs as compared to gravity systems. This alternative is typically more effective and economically viable in areas such as Richer where homes are spread out and require long service connections.

The design of a pressure sewer system must also take into consideration freeze protection due to the intermittent and distributed nature of pump on/off times (controlled locally at the service connections). Freeze protection for small diameter collection mains often requires introduction of controlled bleeding rates at the terminus of each line. This involves a small orifice connection from a water service line to the sewage holding tank at a designated rate to promote sufficient sewage movement along the smaller diameter dead end sections of pressure sewer systems. An additional feature is to provide “drain back” of the forcemain to the lift station. Freeze protection for large diameter pressure sewers is not as critical as it is far less likely that no contributing pumps will be “on”; sewage is normally warm and moves along continuously to the downstream treatment facility through the larger diameter mains.

Some key considerations of the pressure sewer systems are as follows:

- Higher operating and maintenance costs compared to a gravity system. This is offset by the much lower central capital cost required compared to a gravity sewer.

- Oversizing of sewer mains is required during initial installation to allow for future growth and development, which may require additional flushing during the initial years of operation as sewage moves slower and is retained longer than ultimate design conditions. (This is less of a concern for developed communities such as Richer, where it is expected that residents would connect at approximately the same time frame.)

- Higher "on property" cost for connection to the sewer system as compared to gravity sewers, as each building is required to have a holding tank and pump to connect to the system in addition to the service line from the building to the main line. This may be less of a concern in Richer, where many buildings may already have tanks that could be repurposed for use with a pressure sewer system.

- Individual residents are responsible for monitoring or maintaining their own pump. Individuals must contribute to the maintenance and upkeep of the equipment and ensure that hard solids, plastics, and rags are not put into the pumping unit. This can be managed by a combination of educational programs and a comprehensive inspection program.

For individual building service connections, two basic options exist: a grinder pump installation, or a Septic Tank Effluent Pump system (STEP).

Grinder Pump Installation: Grinder pump systems are considered medium/high pressure sewer systems. In a typical installation a small holding tank of about 220 liters would be installed at each house. Typically, a two-horsepower grinder pump is required to service a single-family home. Grinder pumps are equipped with special cutter blades to grind the solid matter in the sewage to a small size, which can be transported through a small diameter pressure sewer pipeline without clogging the pipeline. As the pumps transport mixed wastewater, routine sludge removal is not required from the holding tanks. The grinder pump system is generally more robust and requires a smaller footprint but has a larger power requirement. These systems can be installed either inside or outside the homes, providing flexibility to the homeowner to accommodate their preferences and available interior/exterior space. Indoor units carry a lower cost for supply and installation and can be easily integrated into new denser housing construction. However, the grinder pump installation does not lend itself to reuse of existing tanks as the units are supplied as complete pre-packaged stations.

Modern grinder pump systems turn on and off automatically and run for very short periods several times per day. Smart systems are available to synchronize pump controls across the entire system to balance flows and avoid peaks. Pumps are developed specifically for wastewater applications to minimize retention time and stir wastewater to keep tanks clean and prevent sediment build-up. Preventative maintenance for engineered grinder pump installations is limited. Typically, service is recommended approximately every 8-10 years. Manufacturers also recommend that the RM keep shelf spares of pumps to allow quick replacement if pumps at individual residences require repair or maintenance, as the process of swapping out pumps within an existing system is relatively simple.

STEP system: This system operates similar to a septic tank system. It uses a larger tank system than the grinder pump installation, typically a two-chamber system where a small sewage pump is located in the second (effluent) chamber. Solids settle in the first chamber and the pump conveys only the liquid to the sewer network. The settled solids are routinely removed from the tank by a sewage pump truck and hauled to a wastewater treatment facility (lagoon). Typically, solids are removed every 1-2 years depending on usage and homeowner preference.

It is possible to retrofit existing septic tanks for use in a STEP system; however, often this does not occur due to tank condition and/or location on property (septic tanks are often located at the rear of the properties whereas the sewer lines are run along the fronts). Sewage holding tanks could be reused, however a two-chamber sewage holding tank is not a typical installation.

The STEP system is viewed to have a slightly lower capital, maintenance, and operation cost to the individual house owner than a grinder pump system, if existing septic tanks can be reused and retrofitted. The STEP pumps are typically smaller (0.5 to one horsepower), requiring less upfront cost and lower operating power requirements while running. STEP systems commonly operate based on an automatic high/low water level float switch to empty the tank to the forcemain intermittently. On/off operation for the STEP pumps is less frequent compared to the Grinder system, due to the larger tank size.

The major drawback of a STEP system for Richer is that unlike the grinder pump system, a STEP system would likely require an additional lift station in Richer to serve as an intermediary collection point. This lift station would contain higher pressure pumps that would then pump the wastewater the remaining distance to the lagoon.

A conceptual schematic has been provided in Appendix B showing a conceptual layout of a pressure sewer system to collect wastewater from the Richer service area. Should the RM decide to proceed with a pressure sewer system design for Richer, the next steps would be to complete detailed analysis to confirm all forcemain and pressure sewer sizing requirements. The next step in the design process would involve the selection of the system operating pressures (i.e. detailed pump selections) to ensure that all buildings are capable of pumping against the system operating pressures, especially homes connected directly to forcemains. Retention time, septicity, and odor control in the collection system should also be considered at the next stage of design.

4.2 Evaluation of Collection System Options

High level analysis, layout, and sizing of both a gravity and pressure sewer system were completed to compare the suitability and cost of the systems to service the community. This was done at a conceptual level and further analysis and investigation would be required to confirm system requirements and refine potential options during the preliminary design stage. Both systems were deemed technically feasible for the community.

Based on the provincial LIDAR topographic data and collection system limits specified by the RM, a gravity sewer system would require three lift stations to keep sewer depths to a maximum of 6 m. Lift stations could be set up to either pump in parallel to a common forcemain or in series, where a given lift station would pump into the high end of a “main” lift station, which would then pump to the proposed lagoon. Pipe sizes would range from 250-375 mm in diameter with forcemains between 100-250 mm in diameter. The proposed system would require approximately 11.5 km of gravity sewer and 9 km of forcemain to service the specified area.

A pressure sewer system would consist of a pressure main connecting directly to the lagoon branching out to service the homes within the community. Pipe sizes would vary from 50-150 mm in size and a total length of 16.5 km of pipe would be required. Either a STEP or a grinder pump installation would be feasible, however it is likely a STEP system would require one lift station to augment the lower pressures from the pumps. The STEP system configuration would also require annual septic truck pump outs and additional organic loading to the lagoon facility, which would impact the primary cell size. For the purposes of this study a grinder pump system has been assumed.

A Class D opinion of probable capital cost of both systems is show in **Table 4-1**. The estimates include the cost for service connections to homes for each system.

Table 4-1: Wastewater Servicing Class D Opinion of Probable Cost Summary

	Gravity Sewer	Pressure Sewer
Construction Cost	$15,160,000	$10,220,000
Indirect Costs (40%)	$6,070,000	$4,090,000
Total Construction Cost	**$21,300,000**	**$14,400,000**

Tetra Tech recommends a pressure sewer system for Richer on the basis of the 32% capital cost savings presented above. The other key advantages of the proposed pressure sewer are a shallower system with smaller pipe diameters.

However, it is important to note that the Operational & Maintenance (O&M) costs for Pressure Sewer systems are typically slightly higher compared to a Gravity Sewer System (assuming the RM takes partial responsibility for maintaining or monitoring individual grinder pumps). Should the RM proceed with implementation of this system, Tetra Tech recommends the conceptual design stage include a Life Cycle Cost analysis to compare gravity and pressure sewer systems as gravity can often be cheaper over an 80-year life span due to the need to replace pumps routinely (approximately every 10 years). An important consideration for the RM is the cost-sharing arrangement (if any) for with property owners on initial cost and/or replacement cost for each unit in the pressure system.

5.0 OPINION OF PROBABLE COST (CLASS D)

Our opinion of probable construction cost for the conceptual wastewater servicing system described in the previous sections is $19,900,000.00, detailed below in Error! Reference source not found..

This opinion of probable cost is in 2024 dollars and has been developed in accordance with Canadian Construction Association Class ‘D’ level guidelines, with an expected accuracy range of 20% low to 30% high. The cost includes a 40% indirect cost allowance for contingency, engineering, administration, evolution in project scope over the course of design, and known project risks.

Table 5-1: Conceptual Design Opinion of Probable Cost (Class D)

Recommended Upgrade	Direct Costs	Indirect Cost Allowance (40%)	Total Cost
Wastewater Treatment Facility			
General Requirements	$370,000.00	$150,000.00	$520,000.00
Berm Construction & Site Works	$810,000.00	$320,000.00	$1,130,000.00
Liner & Accessories	$2,830,000.00	$1,130,000.00	$3,960,000.00
Discharge Route and Site Access	$270,000.00	$110,000.00	$380,000.00
Wastewater Collection System			
Pressure Sewer Piping (HDPE)	$3,520,000.00	$1,410,000.00	$4,930,000.00
Cleanouts	$200,000.00	$80,000.00	$280,000.00
Service Connections	$6,500,000.00	$2,600,000.00	$9,100,000.00
Total Cost	**$14,230,000.00**	**$5,690,000.00**	**$19,920,000.00**

The following key assumptions were made for the estimating of capital costs:

- The cost of imported borrow fill is representative of finding suitable borrow material on site (no hauling allowance). The cut-fill balance assumes that groundwater intrusion is not an issue (otherwise additional elevation would be required, necessitating imported fill).
- A synthetic liner has been assumed, with an integrated dewatering and degassing system. Detailed liner and under-liner systems will be established as part of the preliminary design.
- Phosphorus removal will be accomplished via manual dosing of coagulant from the water surface (from the berms of the lagoon or from a boat) with no mechanical or engineered dosing systems.
- Lagoon discharge will be via open ditch (no additional piping required).
- Grinder pumps will be installed at each residence and be capable of providing sufficient pressure to convey the sewage to the lagoon without intermediate pumping lift stations.
- The pricing for service connections assumes a unit price of $25,000 per residence. The cost range for individual grinder pump units vary from $7,500 to $13,000 for supply and $3,000 to $7,000 for installation, depending on multiple factors including whether the installation is indoor or outdoor, selected pump size, selected tank size, and the quantity of units ordered at once from the supplier. Tetra Tech has assumed unit

costs in the middle of the ranges for supply and installation of the grinder pump stations. The cost for making a service connection also includes the below-grade service piping, connections to the existing building, and an allowance for decommissioning of the existing holding or septic system.

- The wastewater collection system has been laid out based on the existing lots in the Richer collection area identified. Pipe sizing is subject to change as a result of where future development occurs during the 20-year design period. Expected locations of future developments should be identified as part of the preliminary design process.
- The total estimated cost for service connections is based on the number of properties to be connected and does not account for the pre-purchase of spare pumps or other shelf spare equipment. Manufacturer recommendations are that the regulator or operator keep approximately 1 spare pump on hand for every 15 pumps in operation.

Cost sharing of the individual grinder pumping stations would allow for potential capital project savings by passing this cost on to individual property owners. For example, if the RM covered only 50% of the estimated supply and installation cost for the grinder pumps, the RM's portion of capital costs would be reduced by approximately $1,950,000.00. Conversely, however, if the RM bears this portion of costs then they would be eligible for potential provincial-federal funding sharing. As of April 1, 2024, MWSB's capital cost sharing program has been updated to provide 50:50 provincial to municipal cost sharing for approved water and sewer capital projects. These potential cost savings have not been reflected in the totals above.

Based on the equivalent total serviced population of 1,276 in the extended service area (as described in Section 2.2.1), the estimated capital cost for the facility was calculated as approximately $15,600.00 per resident. Based on the equivalent total connected REU in the serviced area of 264 (as described in Section 2.2.2), the estimated capital cost for the facility was calculated as approximately $75,000.00 per residential dwelling. Although MWSB may cover up to 50% of eligible project costs (if funding is approved), this project carries significant capital cost and phasing of the system should be considered as part of the Preliminary Design (next stage) of this project, as stated in the following Section 6.2.

6.0 RECOMMENDATIONS

The following section outlines next steps and recommendations for implementation of a central wastewater treatment facility and wastewater collection system for Richer.

6.1 Project Configuration

Tetra Tech recommends the following configuration for the proposed wastewater treatment facility and collection system, as justified in the proceeding sections. This configuration was assumed as the basis for the opinion of probable capital costs in Section 5.0. A conceptual system layout is included in Appendix B.

6.1.1 HDPE-Lined Facultative Lagoon

Tetra Tech's recommendation for the treatment facility is a two-cell facultative lagoon system, with a synthetic (HDPE) liner (based on the recommendations of the geotechnical report), built at the proposed Site 1. The deciding advantage of the facultative lagoon option is its simple operation and low maintenance requirements, and wide use in many municipalities throughout Manitoba. The facultative lagoon is also the lower capital cost option based on Tetra Tech's Class D opinion of probable costs.

The Class D opinion of probable cost is based on the following configuration for the facultative lagoon:

Table 6-1: Proposed Lagoon Configuration

Cell	Approximate Top of Cell Dimensions (m)		Approximate Storage Volume (m^3)	Approximate Treatment Surface Area (m^2)
Primary	185	125	14,900*	19,000
Secondary	185	305	74,700	n/a
Total			**89,600**	**19,000**

*Only half of the liquid volume of the primary cell was considered as hydraulic storage capacity as per CWS guidelines.

The following design choices were made regarding the proposed lagoon configuration:

- Berm height of 2.5 m, corresponding to a maximum liquid depth of 1.5 m with 1.0 m freeboard
- Berm side slopes at 4:1
- Berm top width of 3 m
- Tiering of cells with the secondary cell approximately 0.4 m lower than the primary cell

This results in a total hydraulic capacity of 89,600 m^3, above the minimum design storage capacity of 81,700 m^3 as outlined in Section 2.3.1.2. The proposed primary lagoon also has approximately 19,000 m^2 of treatment area, above the minimum design surface area of 18,200 m^2 as outlined in Section 2.3.1.2.

6.1.2 Pressure Sewer

Tetra Tech's recommendation for the wastewater collection system is to implement a pressure sewer system for the serviced area with grinder pumps at each residential and commercial connection. Although gravity systems and pressure systems are both feasible for the community, the pressure sewer was selected due to the significantly lower construction cost.

6.2 Project Phasing

Tetra Tech recommends exploring options to phase the construction of the wastewater collection system to spread out the large capital cost required for the complete system. For example, splitting the proposed project into three main phases could help defer costs and secure funding. The first phase would be to construct the new lagoon facility and continue hauling waste from the area around Richer. The second and third phases would implement the sewer servicing in batches as funding allows.

6.2.1.1 Phase 1 – Wastewater Treatment Facility

The construction of the lagoon facility should be prioritized and is required before, or at least in parallel with, the construction of any central collection system. Hauled waste from the extended service area could be diverted as soon as the facility is in operation (potentially reducing hauling costs for Richer and the surrounding area).

Phase 1 is expected to incur a capital cost of approximately $5.6 million (including contingency) based on the Class D opinion of probable costs as described in Section 5.0.

6.2.1.2 Phase 2 – Core Wastewater Collection

For the wastewater collection system, the main trunk could be constructed first along Dawson Road, connecting approximately 74 residences and Richer School to the lagoon facility and allowing for future branches to be added as funding allows. Constructing the main branch from Richer to the lagoon first allows flexibility to connect the rest of the community as funding becomes available.

Phase 2 is expected to incur capital costs in the range of $4.3 million and $6.1 million based on the Class D opinion of probable costs as described in Section 5.0, depending on the number and configuration of individual connections made.

6.2.1.3 Phase 3 – Additional Servicing Connections

The next largest concentrated branch would be in the northeast, connecting an additional 75 residences on Godard St, Therien Dr, Nault St, and Richer Perimeter Rd. Then, as funding allows, additional branches could be added along Saindon Dr, Municipal Road 302 (north and south legs), and S E Dr, connecting 20-35 additional homes with each expansion. Final connections would include the buildings on the outer edges of the servicing area and along Richer Perimeter Road.

Phase 3 is expected to incur capital costs in the range of $4.6 million and $6.5 million based on the Class D opinion of probable costs as described in Section 5.0, depending on the number and configuration of individual connections made.

Detailed project phasing (and associated cost savings) should be examined as part of the Preliminary Design for the collection system.

6.3 Next Steps

Tetra Tech recommends the following immediate actions for the wastewater treatment facility:

- Install and monitor additional groundwater wells (piezometers) at the proposed lagoon Site 1 to confirm the groundwater elevation at the site, a key input for design.
- Advance the proposed facultative lagoon concept to Preliminary Design, with a focus on the following key considerations:
    - Further Geotechnical Investigation and Topographic Survey
    - Lagoon site plan to optimize footprint within the 3 available lots owned by the RM. The key considerations will include adjustments to the shape of the proposed primary and secondary cells, access routing, forcemain routing, offsets to nearby properties, and exploring plans for future expansions to the facility.
    - Confirm thickness of liner and requirements for under-liner systems.
    - Discharge Route Selection
    - Confirmation of Nutrient Management Strategy
    - Lagoon access road, truck dump, and truck turnaround configuration.
- Submit an Environment Act Proposal (EAP) to the province of Manitoba.

Tetra Tech recommends the following immediate actions for the wastewater collection system:

- Study Project Phasing (opportunities to stage costs for the collection system)
- Complete a life cycle cost of both Gravity and Pressure systems.
- Detailed Analysis and Preliminary Design of the collection system, including:
    - Confirmation of sewer sizing requirements.
    - Confirm areas of proposed residential and industrial subdivision or development to ensure that the collection system is laid out and sized to allow for future connections.
    - Select system operating pressures and detailed pump selections (to ensure that all buildings are capable of pumping against the system operating pressures, especially homes connected directly to forcemains).
    - Complete an analysis of retention time, septicity, and odor control in the collection system.

7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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2024-05-07

APPENDIX A

TETRA TECH'S SERVICES AGREEMENT AND LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

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If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

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This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

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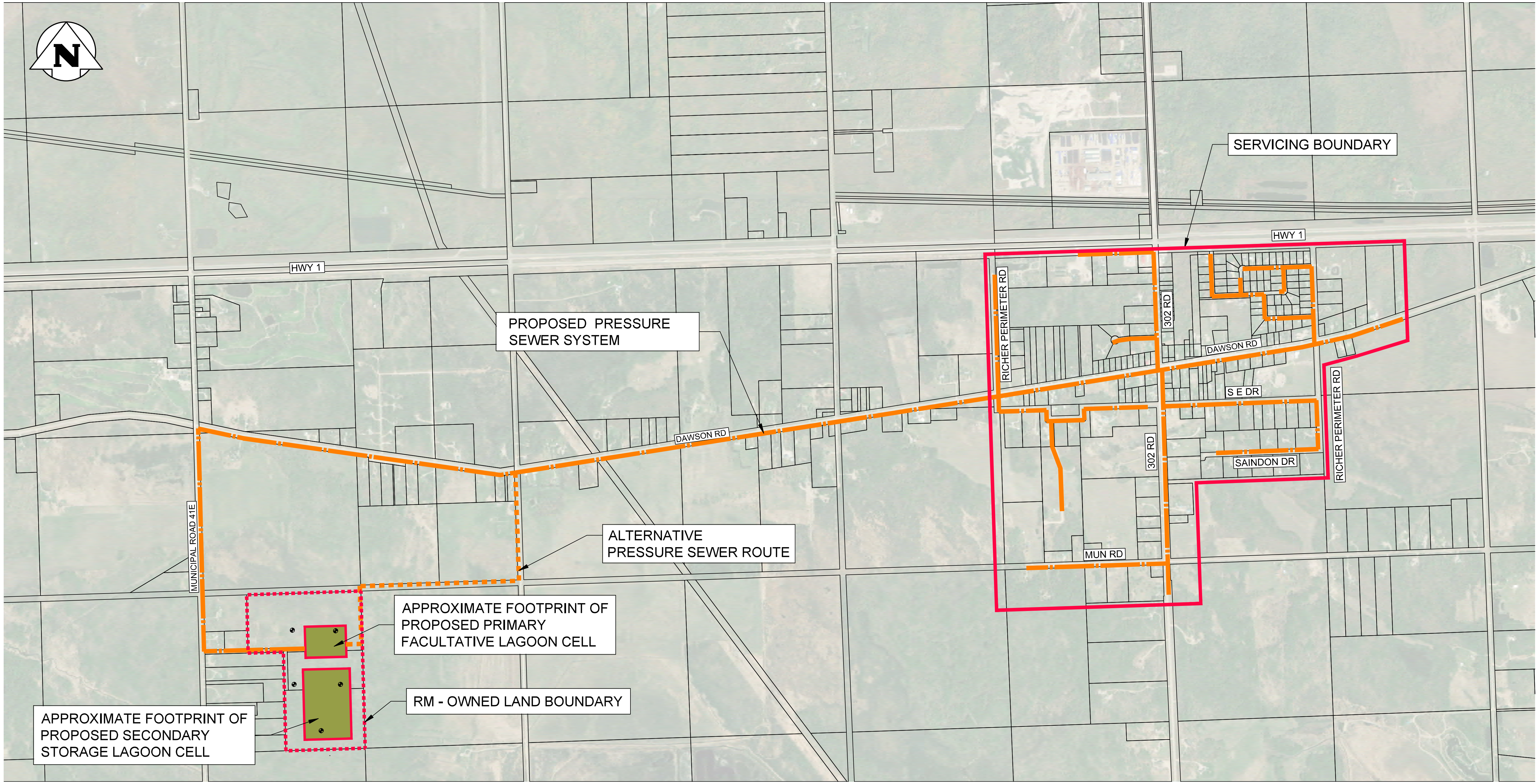
TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

APPENDIX B

LUD OF RICHER WASTEWATER SYSTEM PRESSURE SEWER AND TREATMENT FACILITY CONCEPTUAL DESIGN SKETCH



LEGEND

●	TEST PIT
━	PRESSURE SEWER

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STE. ANNE MUNICIPALITY

THE MANITOBA WATER SERVICES BOARD

TETRA TECH

PROJECT NAME:
RICHER WASTEWATER SERVICING STUDY

DRAWING DESCRIPTION:
CONCEPTUAL PRESSURE SEWER SYSTEM

PROJECT NO:
734-2315360400-SKT-C0003

APPENDIX C

GEOTECHNICAL MEMORANDUM

TECHNICAL MEMO

ISSUED FOR USE

To:	Mike McLennan, CAO, RM of Ste. Anne Travis Parsons, MWSB	**Date:**	April 30, 2024
c:	Matt Litke, EIT, Tetra Tech	**Memo No.:**	001
From:	Ryan Harras, P.Eng.	**File:**	734-2315360400-MEM-T0001-00
Subject:	Municipality of Ste. Anne: Richer Wastewater Servicing Study – Geotechnical Investigation Memo		

1.0 INTRODUCTION

1.1 General

This memo provides a summary of the geotechnical investigation completed by Tetra Tech Canada Inc. (Tetra Tech) at two (2) sites located near Richer, Manitoba currently being considered by the Rural Municipality (RM) of Ste. Anne for development of a new wastewater lagoon. The purpose of this investigation was:

(a) To identify the nature of subsurface conditions at both sites

(b) to confirm suitability of site conditions to function as foundation of naturally lined wastewater lagoon systems

(c) to provide feasibility-level geotechnical recommendations for consideration in the wastewater servicing study

1.2 Scope of Work

The geotechnical investigation was completed as part of a geotechnical allowance, and included provision of the following services:

- **Desktop Study:** Review available geotechnical information at the two proposed sites using existing available literature.
- **Geotechnical Investigation & Laboratory Testing:** Complete a one (1) day test pitting investigation for both sites, collect representative samples for subsequent laboratory testing. Also attempt to install driven point wells at both sites for groundwater level monitoring purposes.
- **Geotechnical Recommendations:** Assess the suitability of in-situ soil for use in naturally-lined wastewater lagoons and provide feasibility-level geotechnical recommendations associated with the proposed wastewater infrastructure.

The findings are presented in the subsequent sections of this memo.

2.0 DESKTOP STUDY

Tetra Tech completed a desktop review of available geotechnical and geological information in the vicinity of the RM's two (2) proposed site locations near Richer, Manitoba (henceforth referenced as "Site 1" and "Site 2") which are shown on Drawings 734-2315360400-SKT-C0001-REV A and 734-2315360400-SKT-C0002-REV B attached in Appendix A. As part of this review, the following data resources were relied upon:

- Surface Deposits Map (Department of Natural Resources, 1980)
- Surficial Geology of Winnipeg (Manitoba Geological Survey, 2004)
- GIN Basic Map Viewer

The desktop study indicates that Richer is located in an area with surficial soil deposits that vary between organic deposits, marginal glaciolacustrine sediments (sands and gravels), proximal glaciofluvial sediments (sands and gravels), and/or silt dominant glacial till. The following is a summary of the soil conditions anticipated at Site 1 and Site 2 based on the reviewed literature:

- **Site #1**: Located approximately 3.5 km southwest of Richer within Lots 83280, 83250, and 83200. Aerial photographs suggest that the site is partially forested, and available surficial geology information indicates that it is generally characterized by near-surface gravelly sand and/or silt dominant glacial till deposits, as well as organic deposits in localized low-lying areas. The available subsurface information at this site generally indicates high permeability near-surface soils that would not be considered suitable for use as in-situ liner material for a wastewater lagoon.
- **Site #2:** Located approximately 3.0 km northeast of Richer within Lot 69450. Aerial photographs suggest that the site is heavily forested, and available surficial geology information indicates that it is generally characterized by sand and/or silt dominant glacial till deposits, as well as organic deposits in localized areas. The available subsurface information at this site generally indicates high permeability near-surface soils that would not be considered suitable for use as in-situ liner material for a wastewater lagoon.

While the results of the background information review suggested that these two sites may not have in-situ soils considered favorable for use in a naturally-lined wastewater lagoon, a geotechnical investigation was completed for both sites to validate the findings of the desktop study, characterize subsurface conditions, and provide information necessary to support the provision of feasibility-level geotechnical recommendations associated with the proposed wastewater infrastructure.

3.0 GEOTECHNICAL INVESTIGATION

3.1 General

On November 8, 2023, five (5) test pits (TP23-02-01 to TP23-02-05) were completed at Site 1, and six (6) test pits (TP23-01-01 to TP23-01-06) were completed at Site 2. On November 9, 2023, two (2) driven point wells (GW23-02-01 and GW23-02-02) were installed at Site 1, and two (2) driven point wells (GW23-01-01, GW23-01-02) were installed at Site 2. The approximate locations of the test pits and driven point wells taken using a handheld GPS unit are shown on Drawings 734-2315360400-SKT-C0001-REV A and 734-2315360400-SKT-C0002-REV B attached in Appendix A. A site-specific safety plan was prepared prior to the investigation, and utility clearance certificates were obtained by Tetra Tech personnel from representatives of ClickBeforeYouDigMB and DigShaw.

Test pitting was completed by Marc Vincent Excavation using a tracked excavator to maximum depths ranging from 2.1 m to 3.4 m below ground surface (bgs). Disturbed grab samples were retrieved from test pits at select intervals. Subsurface conditions observed during excavation were documented by Tetra Tech geotechnical staff according to the Unified Classification System for soils. Other pertinent information such as groundwater and sloughing conditions were also recorded. Test pits were backfilled with excavated material and compacted using the excavator bucket to original ground surface. Samples retrieved during the field investigation were tested in Trek Geotechnical's and ALS Environmental's materials testing laboratories, both located in Winnipeg, Manitoba.

Driven point wells were installed by Tetra Tech geotechnical staff using a combination of a hand auger to dig a shallow pilot hole followed by a manually operated post-pounder to drive the well below the hand augered depth.

Test pit logs were prepared for each of the completed test pits and are attached in Appendix B. The log includes descriptions and depths of the soil units encountered, sample locations, results of laboratory testing, and other pertinent information such as observed seepage and sloughing.

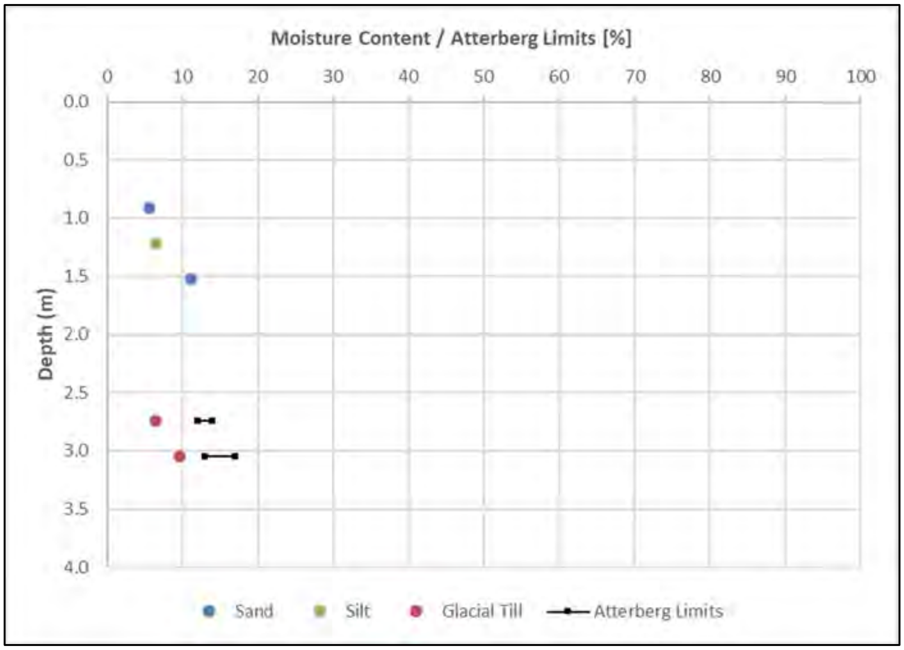
3.1.1 Laboratory Testing

Laboratory testing was completed on select soil samples collected during the test pitting. The soil testing program included the determination of index properties such as moisture content, grain size distribution (sieve analysis/hydrometer method), plasticity (Atterberg Limits), and electrochemical properties (resistivity/conductivity, sulphate content, and pH).

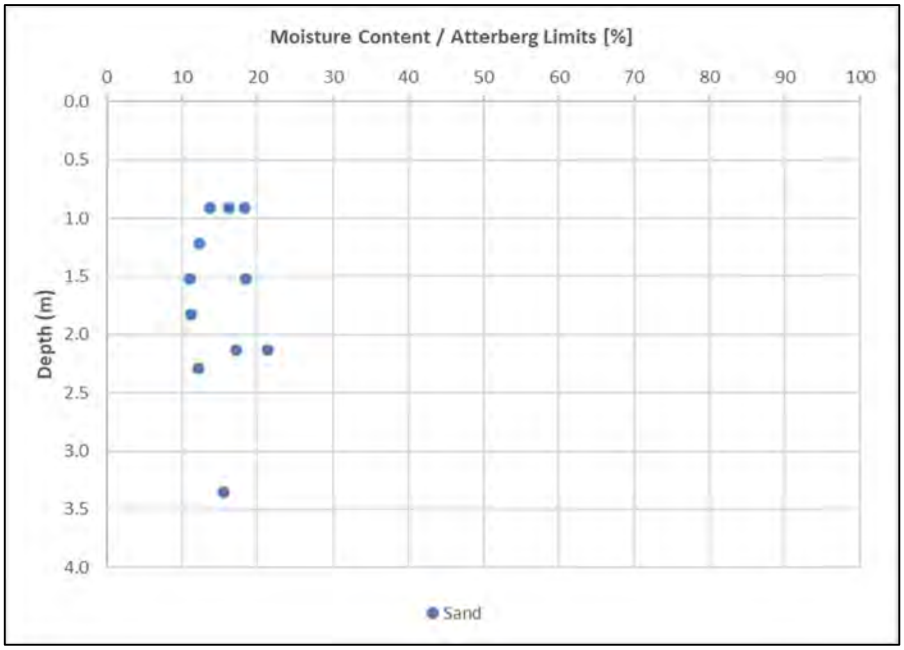
The laboratory test results are presented in Appendix B. Table 3-1 summarizes the number of tests completed, and Figure 3-1 illustrates the variation in moisture content and Atterberg Limits with depth at each site.

Table 3-1: Summary of Laboratory Testing

Test	Number (Site 1)	Number (Site 2)	Total
Moisture Content	5	11	16
Atterberg Limits	2	0	2
Grain Size Distribution (Sieve Analysis/Hydrometer Method)	4	5	9
Electrochemical (Conductivity/Resistivity, Sulphate, pH)	2	2	4



(a) Site 1



(b) Site 2

Figure 3-1: Summary of Moisture Content and Atterberg Limits vs. Depth at (a) Site 1 and (b) Site 2

3.1.2 Site 1

3.1.2.1 Subsurface Conditions

The following sections describe the subsurface conditions encountered during the test pitting investigation completed at Site 1 by Tetra Tech, including a summary of the laboratory testing results.

In descending order from grade, the general soil profile consisted of:

- Organics
- Sand
- Silt
- Glacial Till

Each of these units are described separately below.

Organics

A layer of organics approximately 0.3 m thick was encountered at ground surface in all test pits. The organic layer was generally black and moist at the time of excavation.

Sand

A layer of sand 1.2 m to 2.4 m thick was encountered beneath the organic layer in all test pits with the exception of test pit TP23-02-04. The sand contained some gravel to gravelly, trace to some silt, trace clay, trace to some cobbles, trace to some boulders, and was dry to moist and brown. A summary of the index properties of the sand layer is presented in Table 3-2.

Table 3-2: Site 1 - Summary of Index Properties of Sand

Test	Minimum Value	Maximum Value	Number of Tests
Moisture Content (%)	6	11	2
Grain Size – Gravel (%)	27		1
Grain Size – Sand (%)	61		1
Grain Size – Silt (%)	9		1
Grain Size – Clay (%)	3		1

Silt

A layer of silt 2.1 m thick was encountered beneath the organic layer in test pit TP23-02-04. The silt layer was sandy and contained some gravel, some clay, some cobbles, some boulders, and was dry and brown. A summary of the index properties of the silt are presented in Table 3-3.

Table 3-3: Site 1 - Summary of Index Properties of Silt

Test	Minimum Value	Maximum Value	Number of Tests
Moisture Content (%)	6		1
Grain Size – Gravel (%)	13		1
Grain Size – Sand (%)	34		1
Grain Size – Silt (%)	42		1
Grain Size – Clay (%)	12		1

Glacial Till

A layer of glacial till was encountered beneath the sand or silt in all test pits at depths ranging from 1.5 m to 2.7 m bgs. The glacial till layer extended to test pit termination depths ranging from 2.7 m to 3.2 m bgs on excavator refusal. The glacial till was classified as sandy silt containing some clay, trace gravel, trace cobbles, trace boulders, and was dry, brown, and of low plasticity. A summary of the index properties of the glacial till are presented in Table 3-4.

Table 3-4: Site 1 - Summary of Index Properties of Glacial Till

Test	Minimum Value	Maximum Value	Number of Tests
Moisture Content (%)	6	10	2
Atterberg – Liquid Limit (%)	14	17	2
Atterberg – Plastic Limit (%)	12	13	2
Atterberg – Plasticity Index (%)	2	4	2
Grain Size – Gravel (%)	7	8	2
Grain Size – Sand (%)	34	35	2
Grain Size – Silt (%)	44	46	2
Grain Size – Clay (%)	14		2

3.1.2.2 Seepage, Sloughing, and Groundwater Conditions

Seepage and sloughing was not encountered during excavation of the test pits at Site 1. It should be noted that groundwater levels, seepage, and sloughing levels in excavations may vary seasonally, annually, or as a result of construction activities.

Tetra Tech attempted to install two (2) driven point wells at Site 1 to a proposed depths of 2.4 m bgs to permit long term groundwater monitoring. However, during installation premature driving refusal was met at both locations likely due to the presence of gravel, cobble, boulder, and dense soils, and so the wells did not reach the proposed depths. Table 3-5 provides a summary of the installation details for the driven point wells at Site 1.

Table 3-5: Site 1 – Driven Point Wells

Well ID	Well 1	Well 2
Northing (m)	5502277	5501999
Easting (m)	679092	679101
Tip Depth (m bgs)	0.75	0.86
Screened Length	0.54 m bgs to 0.22 m ags[1]	0.66 m bgs to 0.10 m ags[1]
Stickup (m ags[1])	1.21	1.70

[1] ags: above ground surface

No post-installation monitoring visits were completed as part of this scope, and as such, no groundwater measurements are currently available for Site 1.

3.1.2.3 Electrochemical Test Results

Electrochemical testing was completed on two (2) soil samples collected from test pits TP23-02-01 and TP23-02-05 at Site 1 to determine soil sulphate content, pH of soil, and soil resistivity/conductivity. A summary of the test results is provided in Table 3-6.

Table 3-6: Site 1 - Summary of Electrochemical Test Results

Soil Unit	Sample ID / Depth (m)	Sulfate Content (%)	pH	Conductivity (mS/cm)	Resistivity (ohm*cm)
Glacial Till	G1 / 2.4	< 0.050	8.13	0.174	5750
Sand	G7 / 1.5	< 0.050	7.98	0.146	6850

The results of the sulphate testing indicate that the glacial till and sand soils tested are classified less than moderate (S-3) class of exposure to sulphate attack according to CAN/CSA A23.1-M94 (*Concrete Materials and Methods of Concrete Construction*). This should be verified with additional sampling and testing during subsequent design phases for buried concrete structures.

Based on the results of the resistivity testing, the glacial till and sand soils tested are classified as moderately corrosive for buried metal.

3.1.3 Site 2

3.1.3.1 Subsurface Conditions

The following sections describe the subsurface conditions encountered during the test pitting investigation completed at Site 2 by Tetra Tech, including a summary of the laboratory testing results.

In descending order from grade, the general soil profile consisted of:

- Organics
- Sand
- Gravel

Each of these units are described separately below.

Organics

A layer of organics ranging from 0.3 m to 0.8 m thick was encountered at ground surface in all test pits. The organic layer was generally black and moist at the time of excavation.

Sand

A layer of sand of varying composition was encountered beneath the organics layer in all test pits, extending to test pit termination depths ranging from 2.1 m to 3.4 m bgs in all test pits with the exception of test pit TP23-01-05 where it terminated at a depth of 1.2 m bgs above a gravel layer. This layer was also characterized by the presence of trace to some clay, trace cobbles, trace boulders, and was generally observed to be moist to wet and light brown to light grey. A summary of the index properties of the sand layer is presented in Table 3-7.

Table 3-7: Site 2 - Summary of Index Properties of Sand

Test	Minimum Value	Maximum Value	Number of Tests
Moisture Content (%)	11	21	11
Grain Size – Gravel (%)	4	47	5
Grain Size – Sand (%)	41	87	5
Grain Size – Silt (%)	3	41	5
Grain Size – Clay (%)	1	13	5

Gravel

A layer of gravel was encountered beneath the sand layer in test pit TP23-01-05 extending from 1.2 m bgs to test pit termination depth at 2.1 m bgs. The gravel layer was sandy, contained some cobbles, trace boulders, and was wet and light grey.

3.1.3.2 Seepage, Sloughing, and Groundwater Conditions

Seepage was observed at depths varying from 1.5 m to 2.7 m bgs during excavation of all test pits with the exception of test pit TP23-01-06. Sloughing was encountered in all test pits at depths ranging from 1.2 m to 2.1 m bgs. Detailed information about the nature and location of the sloughing and/or seepage are provided on the test pits logs included in Appendix A.

Tetra Tech attempted to install two (2) driven point wells at Site 2 to a proposed depths of 2.4 m bgs to permit long term groundwater monitoring. However, during installation premature driving refusal was met at both locations likely due to the presence of gravel, cobble, boulder, and dense soils, and so the wells did not reach the proposed depths. Table 3-8 provides a summary of the installation details for the driven point wells at Site 2.

Table 3-8: Site 2 – Driven Point Wells

Well ID	Well 3	Well 4
Northing (m)	5506957	5507078
Easting (m)	684957	685010
Tip Depth (m bgs)	2.06	2.08
Screened Length	1.85 m bgs to 1.09 m bgs	1.88 m bgs to 1.12 m bgs
Stickup (m ags[1])	1.42	1.40

[1] ags: above ground surface

No post-installation monitoring visits were completed as part of this scope, and as such, no groundwater measurements are currently available for Site 2.

3.1.3.3 Electrochemical Test Results

Electrochemical testing was completed on two (2) soil samples collected from test pits TP23-01-01 and TP23-01-05 at Site 1 to determine soil sulphate content, pH of soil, and soil resistivity/conductivity. A summary of the test results is provided in Table 3-9.

Table 3-9: Site 2 - Summary of Electrochemical Test Results

Soil Unit	Sample ID / Depth (m)	Sulfate Content (%)	pH	Conductivity (mS/cm)	Resistivity (ohm*cm)
Sand and Gravel	G1 / 0.9	< 0.050	7.74	0.0657	15200
Gravel	G11 / 2.0	< 0.050	7.82	0.107	9340

The results of the sulphate testing indicate that the tested soils are classified less than moderate (S-3) class of exposure to sulphate attack according to CAN/CSA A23.1-M94 (*Concrete Materials and Methods of Concrete Construction*). This should be verified with additional sampling and testing during subsequent design phases for buried concrete structures.

Based on the results of the resistivity testing, the tested soils are classified as mildly corrosive to moderately corrosive for buried metal.

4.0 GEOTECHNICAL RECOMMENDATIONS

Based on the soil types encountered during the geotechnical investigation, a naturally-lined wastewater lagoon is not considered to be a feasible design option for Site 1 or Site 2. The hydraulic conductivity of the sands, gravels, silts, and glacial silt till soils that were observed are not anticipated to meet the Province of Manitoba's (the Province) hydraulic conductivity requirement of 1×10^{-7} cm/s (or less) for clay-lined lagoons. As a result, should either of these sites be selected for development of a new wastewater lagoon, consideration will need to be given to either incorporating a synthetic liner (geomembrane or geosynthetic clay liner) or constructing the lagoon liner out of imported clay liner material that meets the Province's requirements.

Although soil conditions encountered at both Site 1 and Site 2 are not conducive to a clay-lined lagoon, they are anticipated to provide adequate foundation support for the proposed lagoon and associated infrastructure provided appropriate construction techniques are followed. It is worthwhile noting that Site 1 was generally characterized by a thinner layer of organics, less variability in soil types between test pits, and less frequent observations of seepage and sloughing during excavation of the test pits when compared to Site 2. These comparisons should be considered when evaluating whether to proceed with Site 1 or Site 2 for the proposed infrastructure.

Additional geotechnical design and construction recommendations for consideration at the feasibility study stage are provided below:

- The driven point wells at Site 1 could not be installed to sufficient depths to provide meaningful or reliable groundwater level measurements. Post-installation monitoring of the Site 1 wells is therefore not recommended.
- The driven point wells at Site 2 should be monitored by the RM (or designated representative) approximately once every 2 to 3 months to provide groundwater monitoring data for consideration in subsequent phases of design.
- In the absence of groundwater monitoring data at either site, a groundwater level of 1.0 m bgs and 0.5 m bgs can be assumed for Site 1 and Site 2, respectively. To minimize potential uplift forces on the lagoon liner, the base of the lagoon should not extend below these recommended groundwater depths. The proposed design groundwater levels should be reviewed and revised as required during subsequent phases of design by incorporating groundwater monitoring data from the existing and/or new groundwater monitoring instrumentation.
- At this time, lagoon berm slopes not exceeding 3H:1V up to a maximum height of 2.5 m constructed out of the near-surface cohesionless soils encountered at Site 1 and Site 2 are anticipated to be stable.
- Synthetic liners (if used) should be designed in accordance with the requirements of the supplier and installed and tested by experienced and qualified Contractors.
- Clay lined lagoons (if used) should be designed, constructed, inspected, and tested in accordance with the Province's requirements for compacted clay liners. The clay liner should be a minimum of 1.0 m thick measured normal to the lagoon slopes and floor and have a confirmed hydraulic conductivity of 1 x 10^{-7} cm/s or less.
- Organics within the footprint of the proposed infrastructure should be stripped and stockpiled for future use to cover side slopes and protect against erosion.
- The exposed subgrade should be scarified to a minimum depth of 200 mm and compacted to minimum 95% Standard Proctor Maximum Dry Density (SPMDD) within +/- 2% of the optimum moisture content (OMC). If unsuitable materials such as organics, silts, random fill, soft soils, or boulders are encountered within the subgrade, they should be excavated and replaced with suitable compacted material. Care should be taken to prevent ponding of water on the exposed subgrade during construction using adequate site grading.
- A proof-rolling procedure using a loaded tandem truck should be completed on the prepared subgrade to identify any soft areas prior to placement of fill above the subgrade level. The proof-rolling procedure should be developed and observed by a qualified geotechnical engineer.
- Prior to placement, fill materials should be well-mixed, free of deleterious materials, and have had all large boulders removed. Cohesionless fill (such as sands, gravels, sandy silts) should be placed in layers not exceeding 300 mm in loose thickness and compacted to 98% SPMDD within +/- 2% OMC. Cohesive soils (such as imported clay for use as clay liner) should be well-mixed, free of deleterious materials, and placed in layers not exceeding 200 mm in loose thickness and compacted to 95% SPMDD within +2% OMC.

- Subgrade preparation and fill placement is not recommended during the winter, as freezing of the subgrade and placement of frozen fill materials shall not be permitted during construction.
- Riprap armoring should be placed along the interior slopes of the lagoon to protect the synthetic liner or clay-liner from erosion, and the remaining lagoon slopes vegetated as soon as possible to protect against erosion.
- Given the frequency of cobbles and boulders that were encountered in the test pits at both sites, it is recommended that open-cut methods be used in favor of trenchless methods for installation of utility lines at these sites. The method of excavation and temporary support of excavation sidewalls shall be the responsibility of the Contractor and subject to applicable Manitoba Workplace Health and Safety regulations related to excavation and trench safety standards.

Geotechnical recommendations for consideration in subsequent phases of design of the proposed lagoon are provided below:

- Complete slope stability and settlement analyses for the proposed lagoon berms once the location and configuration of the lagoon are more well-defined.
- Assess the potential impact of hydraulic uplift pressures on the synthetic or clay liner. Depending on the severity of the uplift pressure, this may require an increase to the floor elevation of the lagoon, specification of a minimum depth of water to be present within the lagoon at all times to act as ballast, and/or design of an underdrain system.
- A supplementary geotechnical investigation should be completed at the preferred site(s) during subsequent phases of design. The purpose of this additional investigation would be to better characterize the lateral and vertical soil variability within the footprint of the proposed infrastructure (including the lagoon and any associated infrastructure). It is recommended that this supplementary investigation utilize test holes rather than test pits to allow for investigation to greater depths than could be achieved by the test pits (ideally to the depth of influence of the proposed infrastructure) and also permit completion of in-situ soil strength testing (such as Standard Penetration Tests).
- Given the anticipated variability in groundwater conditions and the inability for the driven point wells to reach the desired depths, consideration should be given to installing and monitoring standpipe piezometers at the preferred site. The piezometric information obtained from the standpipe piezometers would inform the slope stability analyses, the assessment of hydraulic uplift pressures acting at the base of the lagoon (or synthetic liner, if used), and the provision of suitable construction recommendations.
- Additional sampling and testing of potential borrow materials (including native soils and/or imported borrow materials) should be completed to inform the lagoon berm slope stability and settlement analyses and provide suitable construction recommendations including fill placement and compaction criteria.

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Manitoba Water Services Board (MWSB) and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than MWSB, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

6.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

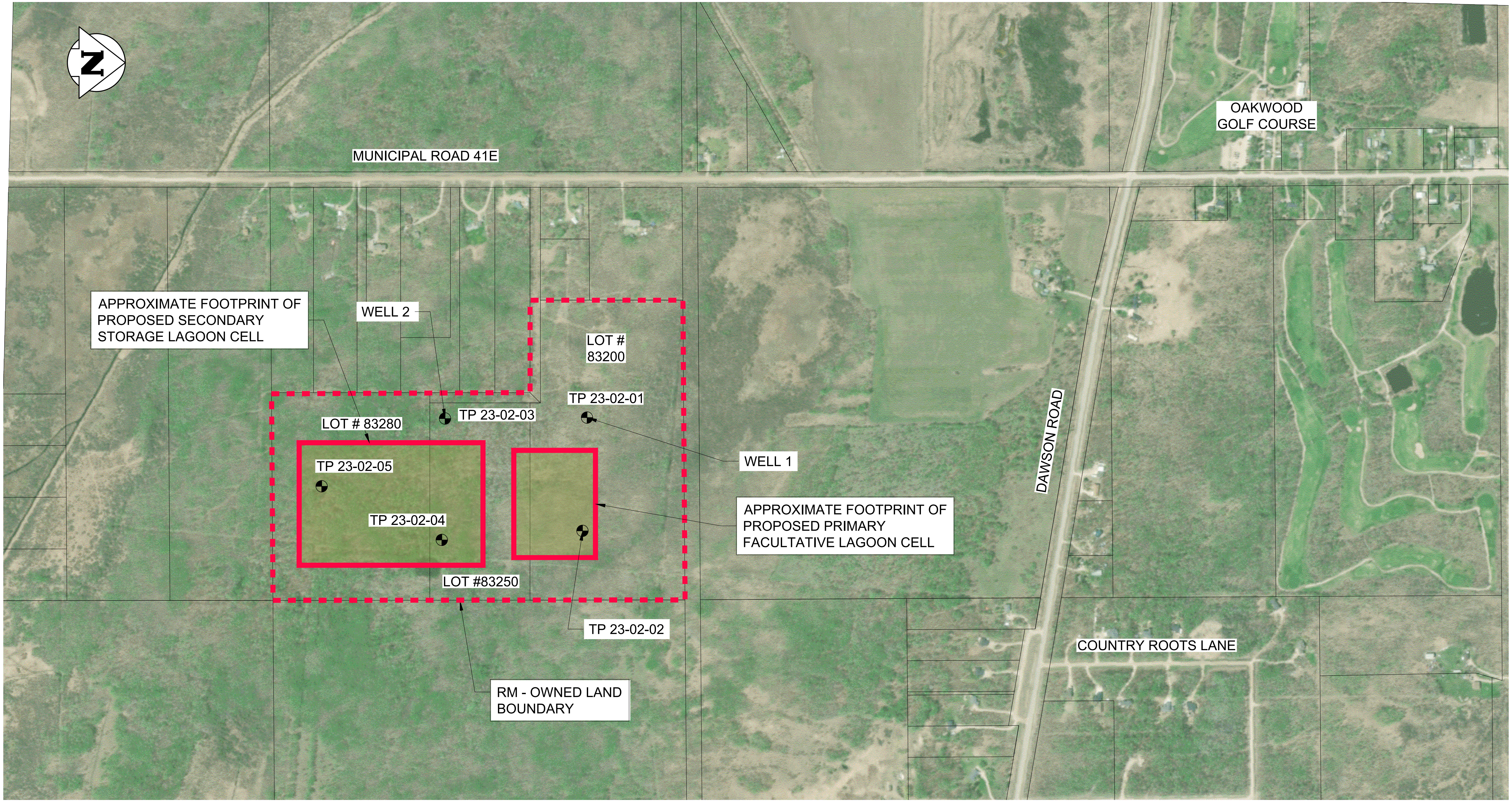
Respectfully submitted,
Tetra Tech Canada Inc.

734-2315360400-MEM-T0001-00 734-2315360400-MEM-T0001-00 734-2315360400-MEM-T0001-00	734-2315360400-MEM-T0001-00 734-2315360400-MEM-T0001-00 734-2315360400-MEM-T0001-00
Prepared by: Ryan Harras, P.Eng. Geotechnical Engineer Dams and Geotechnics Direct Line: 780.405.4987 Ryan.Harras@tetratech.com	Reviewed by: Chaitan Sandhu, M.Sc., P.Eng., PMP Principal Geotechnical Engineer Dams and Geotechnics Direct Line: 431.554.1374 Chaitan.Sandhu@tetratech.com

RH/km

APPENDIX A

TEST PIT LOCATION PLAN



METRIC

WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

150 0 100 200 300m

1:7500

LEGEND

◐	TEST PIT
TP 23-02-04	TEST PIT NAME

STE. ANNE MUNICIPALITY

THE MANITOBA WATER SERVICES BOARD

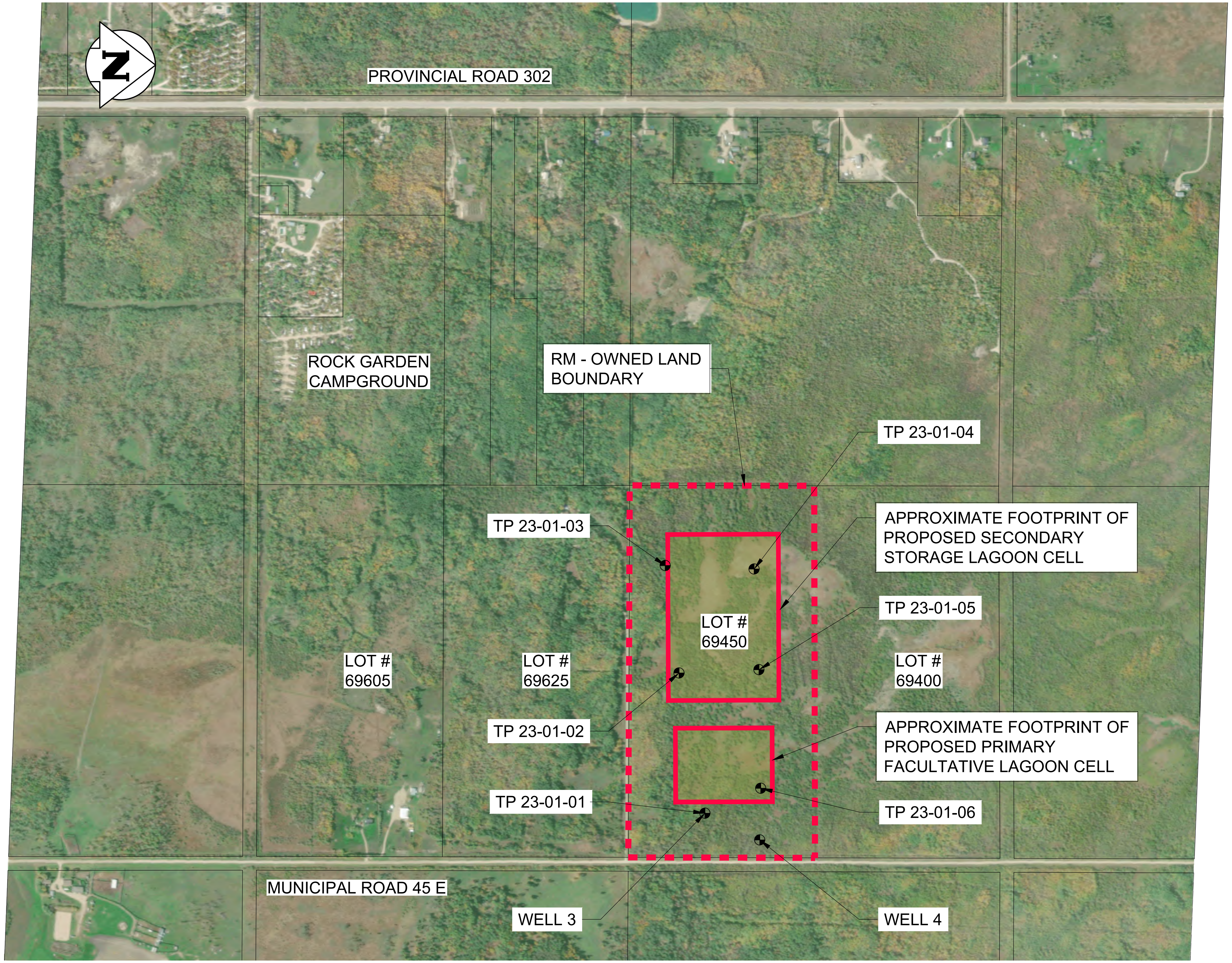
TETRA TECH

PROJECT NAME:
RICHER WASTEWATER SERVICING STUDY

DRAWING DESCRIPTION:
RICHER PROPOSED LAGOON FOOTPRINT. SITE 1

PROJECT NO:
734-2315360400-SKT-C000-REV A

A3 (432 x 279)



METRIC

WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

1:10000

100 0 100 200 300 400 500m

LEGEND

●	TEST PIT / WELL
TP 23-02-04	TEST PIT NAME

STE. ANNE MUNICIPALITY

THE MANITOBA WATER SERVICES BOARD

TETRA TECH

PROJECT NAME:
RICHER WASTEWATER SERVICING STUDY

DRAWING DESCRIPTION:
RICHER PROPOSED LAGOON FOOTPRINT. SITE 2

PROJECT NO:
734-2315360400-SKT-C0002-REV B

A3 (432 x 279)

APPENDIX B

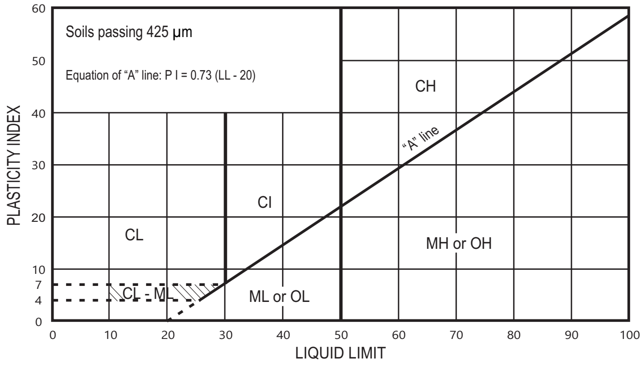
TEST PIT LOGS

MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS More than 50% retained on 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on 4.75 mm sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% Pass 75 µm sieve More than 12% Pass 75 µm sieve 5% to 12% Pass 75 µm sieve GW, GP, SW, SP GM, GC, SM, SC Borderline Classification requiring use of dual symbols	$C_U = D_{60} / D_{10}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above "A" line or plasticity index greater than 7	
	SANDS More than 50% of coarse fraction passes 4.75 mm sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = D_{60}/D_{10}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above "A" line or plasticity index greater than 7	
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS	Liquid limit <50	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity			
		Liquid limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
	CLAYS Above "A" line on plasticity chart negligible organic content	Liquid limit <30	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays			
		Liquid limit 30-50	CI	Inorganic clays of medium plasticity, silty clays			
		Liquid limit >50	CH	Inorganic clays of high plasticity, fat clays			
	ORGANIC SILTS AND CLAYS	Liquid limit <50	OL	Organic silts and organic silty clays of low plasticity			
		Liquid limit >50	OH	Organic clays of medium to high plasticity			
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils			

For classification of fine-grained soils and fine fraction of coarse-grained soils.

PLASTICITY CHART



*Based on the material passing the 75 mm sieve
Reference: ASTM Designation D2487, for identification procedure
see D2488. USC as modified by PFRA

SOIL COMPONENTS

FRACTION	SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY MASS OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENTAGE	DESCRIPTOR
GRAVEL coarse fine	75 mm 19 mm	19 mm 4.75 mm	>35 % 21 to 35 % 10 to 20 % >0 to 10 %	"and" "y-adjective" "some" "trace"
SAND coarse medium fine	4.75 mm 2.00 mm 425 µm	2.00 mm 425 µm 75 µm		
SILT (non plastic) or CLAY (plastic)	75 µm		as above but by behavior	

OVERSIZE MATERIAL

Rounded or Subrounded	
COBBLES	75 mm to 300 mm
BOULDERS	>300 mm
Not rounded	
ROCK FRAGMENTS	>75 mm
ROCKS	>0.76 cubic metre in volume

BOREHOLE KEYSHEET

Water Level Measurement

- ▼ Measured in standpipe, piezometer or well
- ▽ Inferred

Sample Types

- ▤ A-Casing
- ◨ Core
- ▒ Disturbed, Bag, Grab
- ▥ HQ Core
- ◹ Jar
- ◪ Jar and Bag
- ⧓ 75 mm SPT
- ◢ No Recovery
- ☒ Split Spoon/SPT
- ▥ Tube
- ◥ CRREL Core

Backfill Materials

- ■ Asphalt
- ▒ Bentonite
- ▦ Cement/ Grout
- ▧ Drill Cuttings
- ▦ Grout
- ● Gravel
- ▦ Sand
- ▥ Slough
- ▦ Topsoil Backfill
- ▩ Undisturbed

Lithology - Graphical Legend[1]

- ■ Asphalt
- ▩ Bedrock
- ○ Cobbles/Boulders
- ▨ Clay
- ■ Coal
- ▦ Concrete
- ▩ Fill
- ○ Gravel
- ▦ Limestone
- ◇ Mudstone
- ▤ Organics
- ▦ Peat
- ▦ Sand
- ☒ Sandstone
- ▤ Shale
- ▥ Silt
- ☒ Siltstone
- ▩ Conglomerate
- ▦ Topsoil
- ▩ Till

1. The graphical legend is an approximation and for visual representation only. Soil strata may comprise a combination of the basic symbols shown above. Particle sizes are not drawn to scale

TETRA TECH

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075 mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERMS	RELATIVE DENSITY	N (blows per 0.3 m)
Very Loose	0 to 20%	0 to 4
Loose	20 to 40%	4 to 10
Compact	40 to 75%	10 to 30
Dense	75 to 90%	30 to 50
Very Dense	90 to 100%	greater than 50

The number of blows, N, on a 51 mm O.D. split spoon sampler of a 63.5 kg weight falling 0.76 m, required to drive the sampler a distance of 0.3 m from 0.15 m to 0.45 m.

FINE GRAINED SOILS (major portion passing 0.075 mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERMS	UNCONFINED COMPRESSIVE STRENGTHS (kPa)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

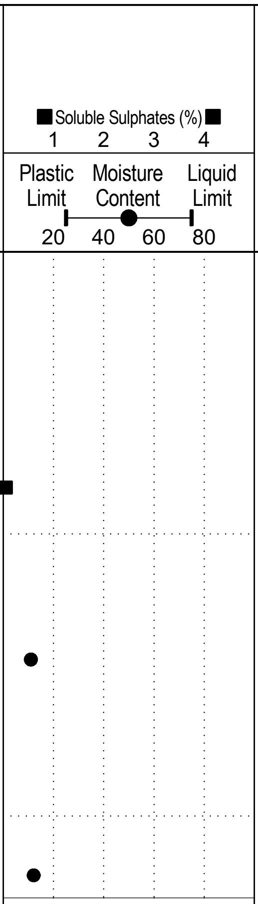
Data presented hereon is for the sole use of the stipulated client. Tetra Tech is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech will provide it upon written request.

MWSB

Testpit No: **TP23-01-01**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684957 E; 5506957 N; Z 14

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Moisture Content (%)	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)				0
		SAND AND GRAVEL - trace silt, trace cobbles, trace boulders, moist, light brown				1
		- (Conductivity - 0.066 mS/cm; pH - 7.74; Resistivity - 15,200 ohm*cm)	▨	G1		
		- (Gravel - 46.5%; Sand - 50.1%; Silt - 2.8%; Clay - 0.7%)	▨	G2	11	
		- wet	▨	G3	12.1	
		END OF TESTPIT (2.29 metres) slough - 2.13 metres during excavation seepage - 2.13 metres during excavation Note: Stopped due to sloughing				



Contractor: Marc Vincent Excavation	Completion Depth: 2.29 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

TETRA TECH

MWSB

Testpit No: **TP23-01-02**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684655 E; 5506889 N; Z 14

Method	Soil Description	Sample Type	Sample Number	Moisture Content (%)
Excavated	ORGANICS - moist, black			
	SAND - some gravel, trace silt, trace clay, moist, light brown			
	- (Gravel - 10.6%; Sand - 82.4%; Silt - 5.3%; Clay - 1.7%)	■	G4	12.3
	- gravelly, trace cobbles, trace boulders, wet	■	G5	11.1
	END OF TESTPIT (2.90 metres) slough - 1.52 metres during excavation seepage - 1.52 metres during excavation Note: Stopped due to sloughing			

Plastic Limit — Moisture Content ● — Liquid Limit: 20 40 60 80

TETRA TECH

Contractor: Marc Vincent Excavation	Completion Depth: 2.9 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

MWSB

Testpit No: **TP23-01-03**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684423 E; 5506850 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)						0
		SAND - gravelly, trace cobbles, trace boulders, trace silt, light brown						1
		SAND AND SILT - some clay, trace gravel, moist, light grey						3
				▇	G6	18.4	●	
		- wet						
		- (Gravel - 5.7%; Sand - 40.9%; Silt - 40.7%; Clay - 12.7%)		▇	G7	15.4	●	
		END OF TESTPIT (3.35 metres) slough - 2.13 metres during excavation seepage - 2.74 metres during excavation Note: Stopped due to sloughing						11
5								16

TETRA TECH

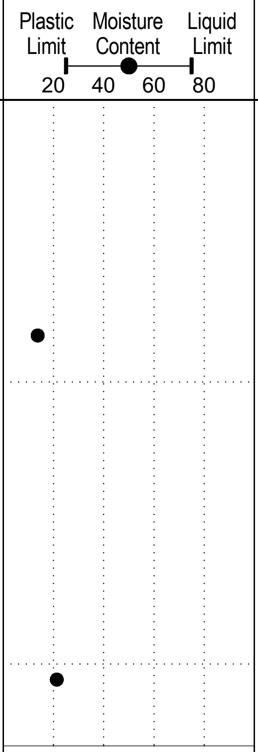
Contractor: Marc Vincent Excavation	Completion Depth: 3.35 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

MWSB

Testpit No: **TP23-01-04**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684423 E; 5507043 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)	Depth (ft)
0	Excavated	ORGANICS - moist, black					0
		SAND - gravelly, trace cobbles, trace boulders, trace silt, trace clay, moist, light brown - (Gravel - 28.7%; Sand - 64.1%; Silt - 6.1%; Clay - 1.1%)		■	G8	13.7	
1							
		SAND AND SILT - some clay, trace gravel, moist, light grey		■	G9	21.3	
2							
		END OF TESTPIT (2.29 metres) slough - 1.22 metres during excavation seepage - 1.83 metres during excavation Note: Stopped due to sloughing					



Contractor: Marc Vincent Excavation	Completion Depth: 2.29 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

TETRA TECH

MWSB

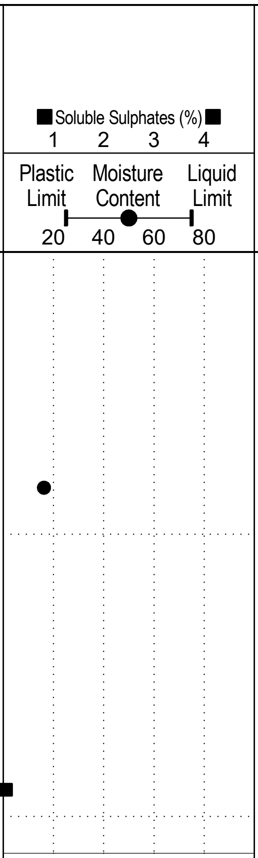
Testpit No: **TP23-01-05**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684641 E; 5507062 N; Z 14

Method: Excavated

Soil Description	Sample Number	Moisture Content (%)
ORGANICS - moist, black, (300 mm thick)		
SAND - gravelly, trace cobbles, trace boulders, trace silt, moist, light brown	G10	16.2
GRAVEL - sandy, some cobbles, trace boulders, wet, light grey - (Conductivity - 0.107 mS/cm; pH - 7.82; Resistivity - 9,340 ohm*cm)	G11	

END OF TESTPIT (2.13 metres)
slough - 1.52 metres during excavation
seepage - 1.52 metres during excavation
Note: Stopped due to sloughing



Contractor: Marc Vincent Excavation	Completion Depth: 2.13 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

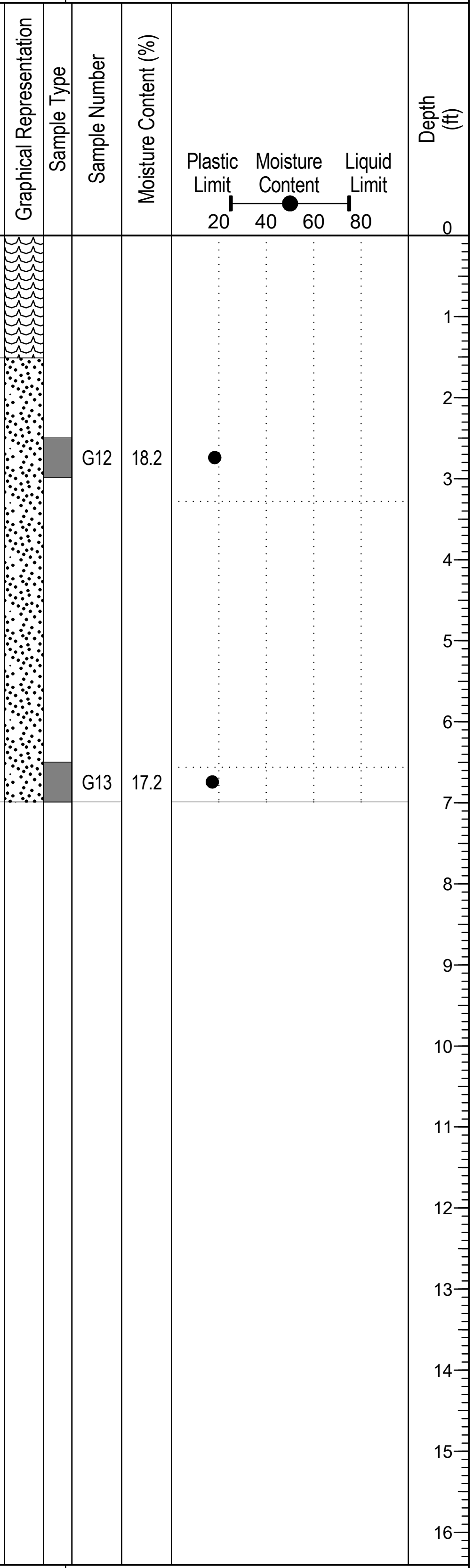
MWSB

Testpit No: **TP23-01-06**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 2	
Richer, Manitoba	UTM: 684898 E; 5507076 N; Z 14

Method: Excavated

Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)
ORGANICS - moist, black				
SAND - gravelly, trace cobbles, trace boulders, moist, light brown		■	G12	18.2
- trace silt, trace gravel, no visible cobbles or boulders, light grey				
- (Gravel - 4.1%; Sand - 86.6%; Silt - 8.4%; Clay - 0.9%)		■	G13	17.2
END OF TESTPIT (2.13 metres) slough - 1.22 metres during excavation seepage - none encountered during excavation Note: Stopped due to sloughing				



Depth (m): 0, 1, 2, 3, 4, 5

Contractor: Marc Vincent Excavation	Completion Depth: 2.13 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

MWSB

Testpit No: **TP23-02-01**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 1	
Richer, Manitoba	UTM: 679092 E; 5502277 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)	■Soluble Sulphates (%)■ 1 2 3 4 Plastic Limit — Moisture Content — Liquid Limit 20 40 60 80	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)						0
		SAND - some gravel, some cobbles, some boulders, trace silt, dry to moist, brown						1 2 3
1								4
		SILT (TILL) - sandy, some clay, trace to some gravel, trace cobbles, trace boulders, dry, low plastic, light brown						5 6
2								7
		- (Conductivity - 0.174 mS/cm; pH - 8.13; Resistivity - 5,750 ohm*cm)		▇	G1		■	8 9
3								10
		END OF TESTPIT (3.20 metres) slough - none during excavation seepage - dry during excavation Note: Stopped due to refusal on boulders						11 12
4								13 14 15 16
5								

TETRA TECH

Contractor: Marc Vincent Excavation	Completion Depth: 3.2 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

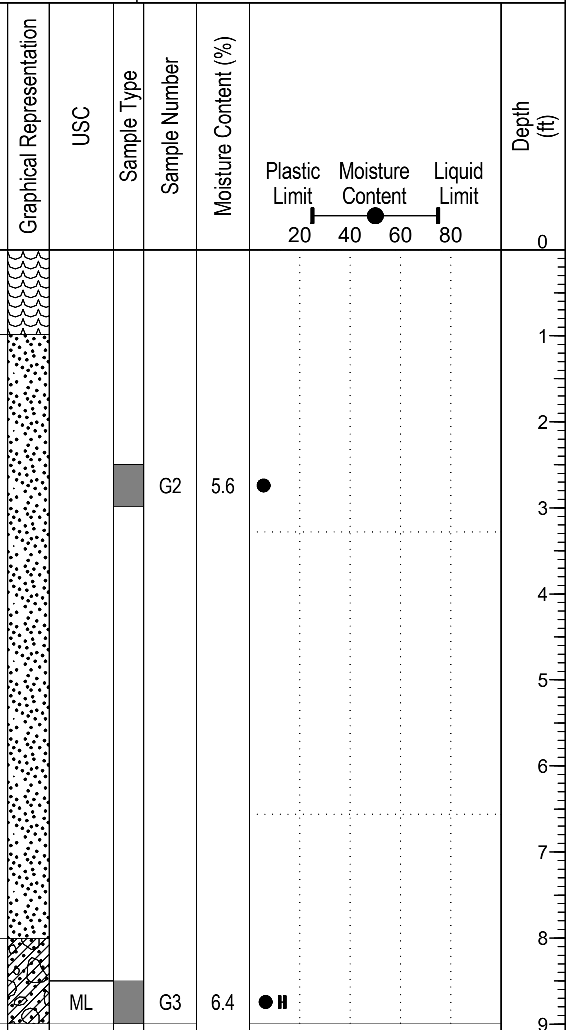
MWSB

Testpit No: **TP23-02-02**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 1	
Richer, Manitoba	UTM: 679314 E; 5502274 N; Z 14

Depth (m)	Method	Soil Description	USC	Sample Type	Sample Number	Moisture Content (%)
0	Excavated	ORGANICS - moist, black, (300 mm thick)				
		SAND - gravelly, some cobbles, some boulders, trace silt, trace clay, dry, brown				
		- (Gravel - 27.4%; Sand - 60.8%; Silt - 9.3%; Clay - 2.5%)		■	G2	5.6
		SILT (TILL) - sandy, some clay, trace gravel, trace cobbles, trace boulders, dry, low plastic, brown				
		- (Gravel - 6.5%; Sand - 34.1%; Silt - 45.7%; Clay - 13.7%)	ML	■	G3	6.4

END OF TESTPIT (2.74 metres)
slough - none during excavation
seepage - dry during excavation
Note: Stopped due to refusal in dense till



Contractor: Marc Vincent Excavation	Completion Depth: 2.74 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

TETRA TECH

MWSB

Testpit No: **TP23-02-03**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 1	
Richer, Manitoba	UTM: 679101 E; 5501999 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit ├ Moisture Content ● ┤ Liquid Limit 20 40 60 80	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)						0
		SAND - some silt, trace gravel, dry, brown						1 2 3
1				■	G4	11.1	●	4 5
2								6 7 8
		SILT (TILL) - sandy, some clay, trace gravel, trace cobbles, trace boulders, dry, low plastic, brown						9
3		END OF TESTPIT (2.90 metres) slough - none during excavation seepage - dry during excavation Note: Stopped due to refusal on boulders						10 11 12
4								13 14 15 16
5								

TETRA TECH

Contractor: Marc Vincent Excavation	Completion Depth: 2.9 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

MWSB

Testpit No: **TP23-02-04**

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 1	
Richer, Manitoba	UTM: 679339 E; 5501999 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	USC	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit ⊢ Moisture Content ● ⊣ Liquid Limit 20 40 60 80	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)							0
		SILT - sandy, some gravel, some clay, some cobbles, some boulders, dry, brown							1 2 3
1		- (Gravel - 12.8%; Sand - 33.6%; Silt - 42.2%; Clay - 11.5%)			■	G5	6.4	●	4 5 6
2									7 8
		SILT (TILL) - sandy, some clay, trace gravel, trace cobbles, trace boulders, dry, low plastic, brown							9
3		- (Gravel - 7.6%; Sand - 34.5%; Silt - 44.1%; Clay - 13.8%)		CL-ML	■	G6	9.7	●⊢⊣	10
		END OF TESTPIT (3.20 metres) slough - none during excavation seepage - dry during excavation Note: Stopped due to refusal in dense till							11 12 13
4									14 15 16
5									

TETRA TECH

Contractor: Marc Vincent Excavation	Completion Depth: 3.2 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

Testpit No: **TP23-02-05**

MWSB

Project: Richer Wastewater Service Study	Project No: ENG.DMPR03108-01
Location: Site 1	
Richer, Manitoba	UTM: 679240 E; 5501761 N; Z 14

Depth (m)	Method	Soil Description	Graphical Representation	Sample Type	Sample Number	Moisture Content (%)	■Soluble Sulphates (%)■ 1 2 3 4 / Plastic Limit, Moisture Content ●, Liquid Limit 20 40 60 80	Depth (ft)
0	Excavated	ORGANICS - moist, black, (300 mm thick)						0
		SAND - some gravel, some cobbles, some boulders, trace silt, dry, brown						
		- (Conductivity - 0.146 mS/cm; pH - 7.98; Resistivity - 6,850 ohm*cm)		▆	G7		■	
		SILT (TILL) - sandy, some clay, trace gravel, trace cobbles, trace boulders, dry, low plastic, brown						
		END OF TESTPIT (2.74 metres) slough - none during excavation seepage - dry during excavation Note: Stopped due to refusal in dense till						

Contractor: Marc Vincent Excavation	Completion Depth: 2.74 m
Equipment Type: Excavator	Start Date: 2023 November 8
Logged By: RH	Completion Date: 2023 November 8
Reviewed By: CS	Page 1 of 1

APPENDIX C

LABORATORY TESTING RESULTS

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

November 23, 2023 Our File No. 1000-011-11

Ryan Harris, P.Eng.,
Tetra Tech Inc.
400 - 161 Portage Ave
Winnipeg, MB
R3B 0Y4

RE Lab Testing Results – WW Lagoon FS, Richer, MB – L23-578

Please see the attached Lab testing report for the above noted project. This report contains moisture content determination, Atterberg Limits, and particle size distribution (Hydrometer method). Samples were delivered to TREK on November 14, 2023.

If you have any questions or require additional information or clarifications, please contact Angela at 204.792.8458.

Kind Regards,

TREK Geotechnical

Review Control:

Prepared By: KF	*Reviewed By:* AFK	*Checked By:* NJF

Lab No. L23-578				Testing Required													
Hole No.	Sample No.	Depth	Sampling Method	Moisture	Special	Unconfined	Waxed Sample	Atterberg	Proctor: Standard	Gradation	Hydrometer	Consolidation Rebound	Electrochem				Soil Description
TP23-01-01																	
	G2	5	G	X							X						SAND - gravelly
	G3	7.5	G	X													
TP23-01-02	G4	4	G	X							X						SAND
	G5	6	G	X													SAND - gravelly
TP23-01-03	G6	5	G	X													SAND
	G7	11	G	X							X						
TP23-01-04	G8	3	G	X							X						SAND - gravelly
	G9	7	G	X													SAND
TP23-01-05	G10	3	G	X													SAND - gravelly
TP23-01-06	G12	3	G	X													SAND - gravelly
	G13	7	G	X							X						SAND
TP23-02-01																	
TP23-02-02	G2	3	G	X							X						SAND
	G3	9	G	X				X			X						TILL
TP23-02-03	G4	5	G	X													SAND
TP23-02-04	G5	4	G	X							X						SAND
	G6	10	G	X				X			X						TILL
TP23-02-05																	

Sampling Method
S - Split Spoon
T - Shelby Tube
C - Core Barrel
G - Auger

Field Tech: RH

Date Sampled: 2023-11-08

Requested By: Ryan Harras

Requisition Date: November 14/2023

Client: MWSB

Project: WW Lagoon FS

Job Number: 704-ENG.DMPR03108-01

Task Number: 1

TETRA TECH

Location: Richer, MB

Sheet 1 of 1

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Moisture Content Report
ASTM D2216-98

Project No. 1000-001-11
Client Tetra Tech
Project WW Lagoon FS

Sample Date 08-Nov-23
Test Date 15-Nov-23
Technician DS

Test Pit	TP23-01-01	TP23-01-01	TP23-01-02	TP23-01-02	TP-01-03	TP-01-03
Depth (m)	1.5	2.3	1.2	1.8	1.5	3.4
Sample #	G2	G3	G4	G5	G6	G7
Tare ID	M57	J82	E96	AB53	E16	E32
Mass of tare	6.8	7.1	6.9	6.7	6.7	6.8
Mass wet + tare	495.0	471.7	429.8	457.7	425.3	440.3
Mass dry + tare	446.5	421.7	383.6	412.8	360.3	382.5
Mass water	48.5	50.0	46.2	44.9	65.0	57.8
Mass dry soil	439.7	414.6	376.7	406.1	353.6	375.7
Moisture %	11.0%	12.1%	12.3%	11.1%	18.4%	15.4%

Test Pit	TP23-01-04	TP23-01-04	TP23-01-05	TP23-01-06	TP23-01-06	TP23-02-02
Depth (m)	0.9	2.1	0.9	0.9	2.1	0.9
Sample #	G8	G9	G10	G12	G13	G2
Tare ID	Q69	E02	M36	J85	M53	E97
Mass of tare	6.8	6.8	6.8	6.8	6.9	6.9
Mass wet + tare	416.2	412.5	368.5	367.6	433.1	401.2
Mass dry + tare	367.0	341.3	318.1	312.0	370.7	380.2
Mass water	49.2	71.2	50.4	55.6	62.4	21.0
Mass dry soil	360.2	334.5	311.3	305.2	363.8	373.3
Moisture %	13.7%	21.3%	16.2%	18.2%	17.2%	5.6%

Test Pit	TP23-02-02	TP23-02-03	TP23-02-04	TP23-02-04		
Depth (m)	2.7	1.5	1.2	3.0		
Sample #	G3	G4	G5	G6		
Tare ID	J44	E17	E75	Z104		
Mass of tare	6.8	6.8	7.1	6.8		
Mass wet + tare	459.9	339.7	525.5	420.2		
Mass dry + tare	432.8	306.4	494.5	383.6		
Mass water	27.1	33.3	31.0	36.6		
Mass dry soil	426.0	299.6	487.4	376.8		
Moisture %	6.4%	11.1%	6.4%	9.7%		

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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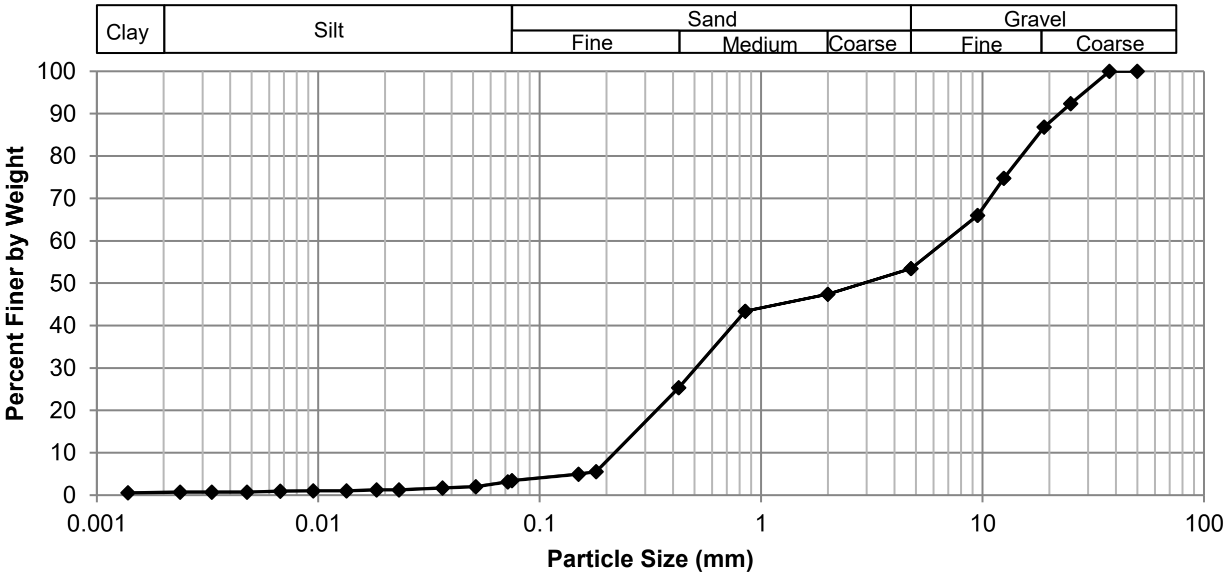
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-01-01
Sample #	G2
Depth (m)	1.5
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

Gravel	46.5%
Sand	50.1%
Silt	2.8%
Clay	0.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	53.47	0.0750	3.42
37.5	100.00	2.00	47.42	0.0718	3.11
25.0	92.36	0.850	43.41	0.0514	2.00
19.0	86.85	0.425	25.33	0.0365	1.70
12.5	74.80	0.180	5.56	0.0232	1.25
9.50	65.98	0.150	4.96	0.0184	1.24
4.75	53.47	0.075	3.42	0.0134	1.03
				0.0095	1.02
				0.0067	0.94
				0.0048	0.71
				0.0033	0.71
				0.0024	0.74
				0.0014	0.55

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-01-02
Sample #	G4
Depth (m)	1.2
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

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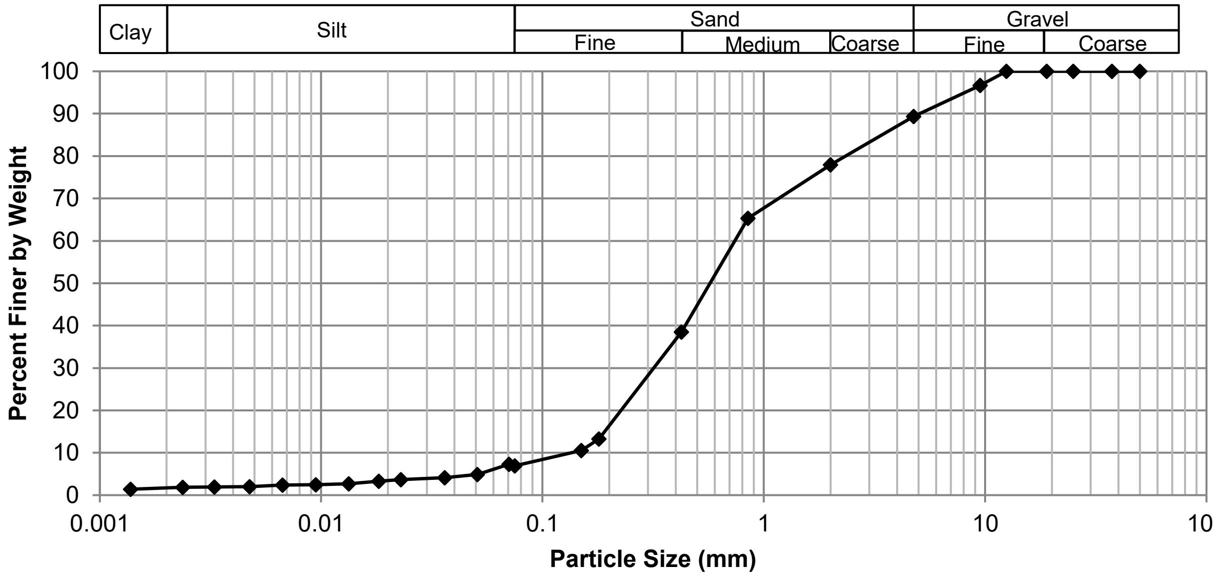
Gravel	10.6%
Sand	82.4%
Silt	5.3%
Clay	1.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	89.38	0.0750	6.94
37.5	100.00	2.00	77.91	0.0707	7.32
25.0	100.00	0.850	65.35	0.0509	4.88
19.0	100.00	0.425	38.48	0.0362	4.15
12.5	100.00	0.180	13.27	0.0229	3.66
9.50	96.66	0.150	10.54	0.0182	3.28
4.75	89.38	0.075	6.94	0.0133	2.69
				0.0095	2.43
				0.0067	2.41
				0.0047	2.04
				0.0033	1.92
				0.0024	1.84
				0.0014	1.40

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-01-03
Sample #	G7
Depth (m)	3.4
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

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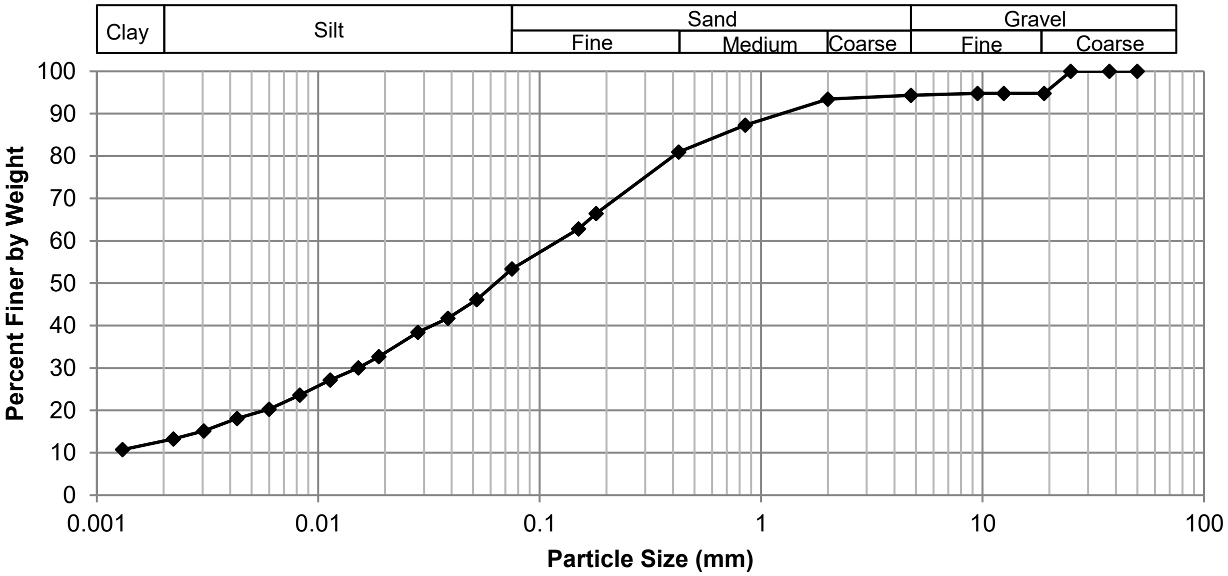
Gravel	5.7%
Sand	40.9%
Silt	40.7%
Clay	12.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	94.32	0.0750	53.39
37.5	100.00	2.00	93.41	0.0520	46.13
25.0	100.00	0.850	87.30	0.0385	41.77
19.0	94.76	0.425	80.98	0.0282	38.41
12.5	94.76	0.180	66.48	0.0188	32.72
9.50	94.76	0.150	62.81	0.0152	30.07
4.75	94.32	0.075	53.39	0.0113	27.17
				0.0083	23.65
				0.0060	20.27
				0.0043	18.08
				0.0030	15.16
				0.0022	13.30
				0.0013	10.74

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-011-11
Client Tetra Tech
Project WW Lagoon FS, Richer, MB

Test Pit TP23-01-04
Sample # G8
Depth (m) 0.9
Sample Date 08-Nov-23
Test Date 17-Nov-23
Technician DS

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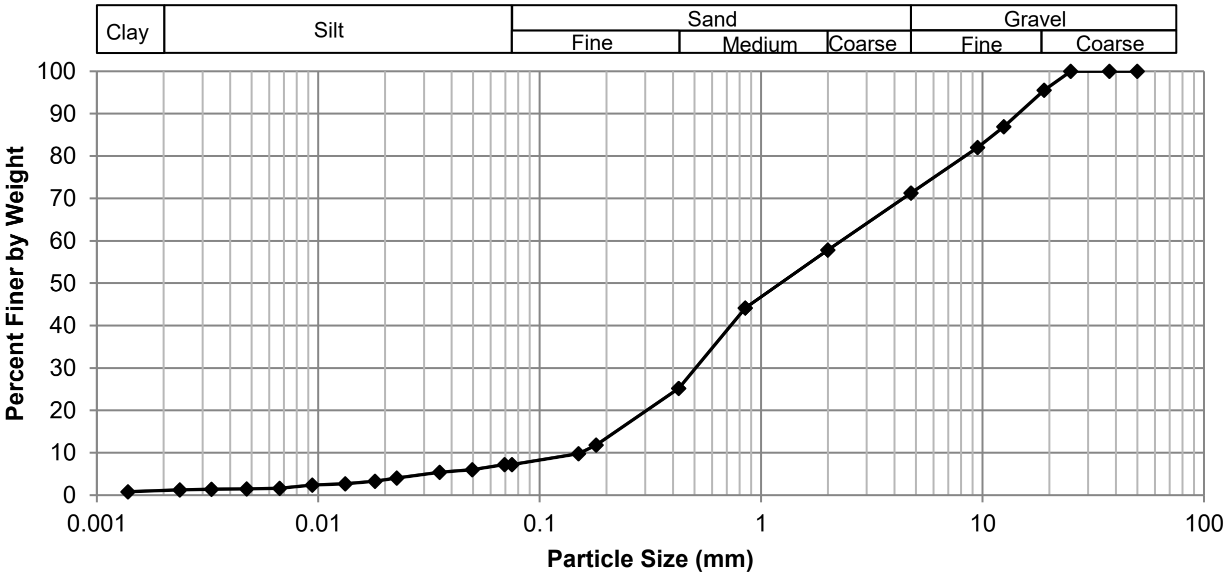
Gravel	28.7%
Sand	64.1%
Silt	6.1%
Clay	1.1%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	71.28	0.0750	7.20
37.5	100.00	2.00	57.83	0.0695	7.18
25.0	100.00	0.850	44.19	0.0497	6.02
19.0	95.54	0.425	25.23	0.0354	5.39
12.5	86.91	0.180	11.83	0.0227	4.03
9.50	82.02	0.150	9.80	0.0181	3.30
4.75	71.28	0.075	7.20	0.0133	2.68
				0.0094	2.39
				0.0067	1.65
				0.0048	1.47
				0.0033	1.38
				0.0024	1.23
				0.0014	0.81

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-01-06
Sample #	G13
Depth (m)	2.1
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

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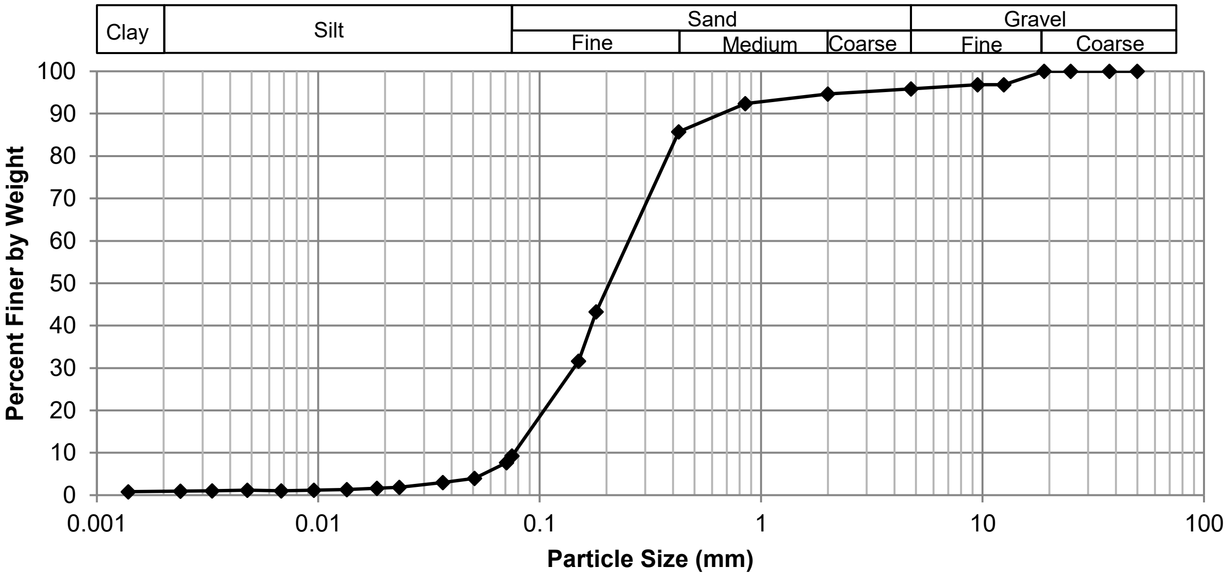
Gravel	4.1%
Sand	86.6%
Silt	8.4%
Clay	0.9%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	95.87	0.0750	9.30
37.5	100.00	2.00	94.62	0.0710	7.65
25.0	100.00	0.850	92.39	0.0509	3.97
19.0	100.00	0.425	85.70	0.0365	3.01
12.5	96.81	0.180	43.23	0.0233	1.83
9.50	96.81	0.150	31.61	0.0184	1.66
4.75	95.87	0.075	9.30	0.0135	1.36
				0.0096	1.19
				0.0068	1.02
				0.0048	1.17
				0.0033	1.02
				0.0024	0.92
				0.0014	0.82

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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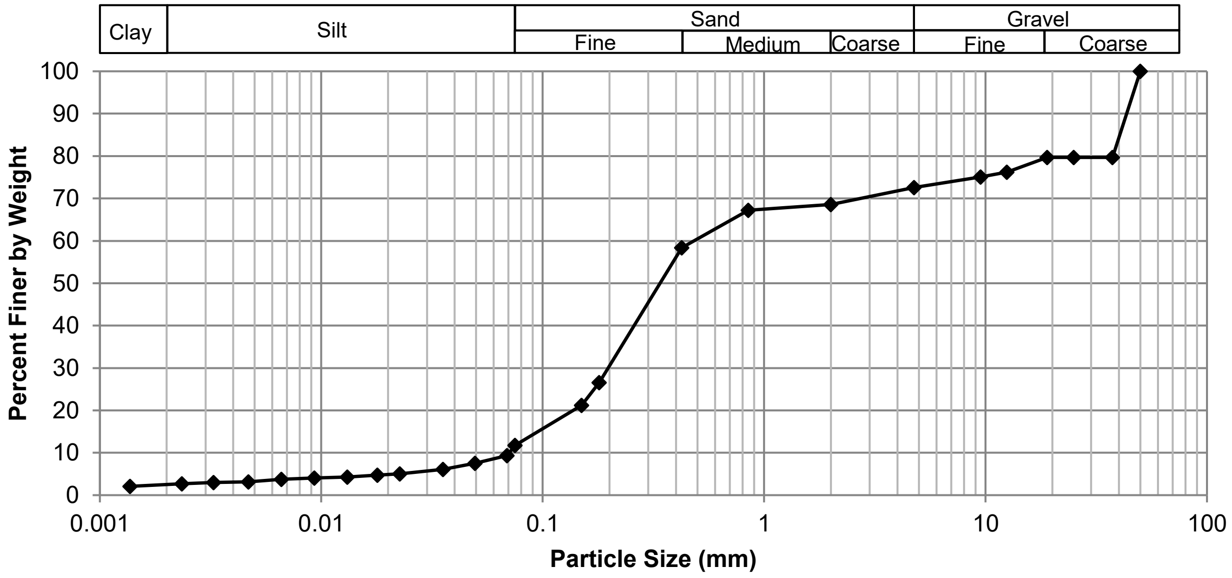
Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-02-02
Sample #	G2
Depth (m)	0.9
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

Gravel	27.4%
Sand	60.8%
Silt	9.3%
Clay	2.5%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	72.60	0.0750	11.75
37.5	79.70	2.00	68.58	0.0690	9.32
25.0	79.70	0.850	67.23	0.0495	7.50
19.0	79.70	0.425	58.35	0.0354	6.10
12.5	76.21	0.180	26.57	0.0226	5.03
9.50	75.08	0.150	21.21	0.0180	4.69
4.75	72.60	0.075	11.75	0.0131	4.28
				0.0093	4.05
				0.0066	3.71
				0.0047	3.18
				0.0033	2.96
				0.0024	2.67
				0.0014	2.08

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Atterberg Limits
ASTM D4318-10e1

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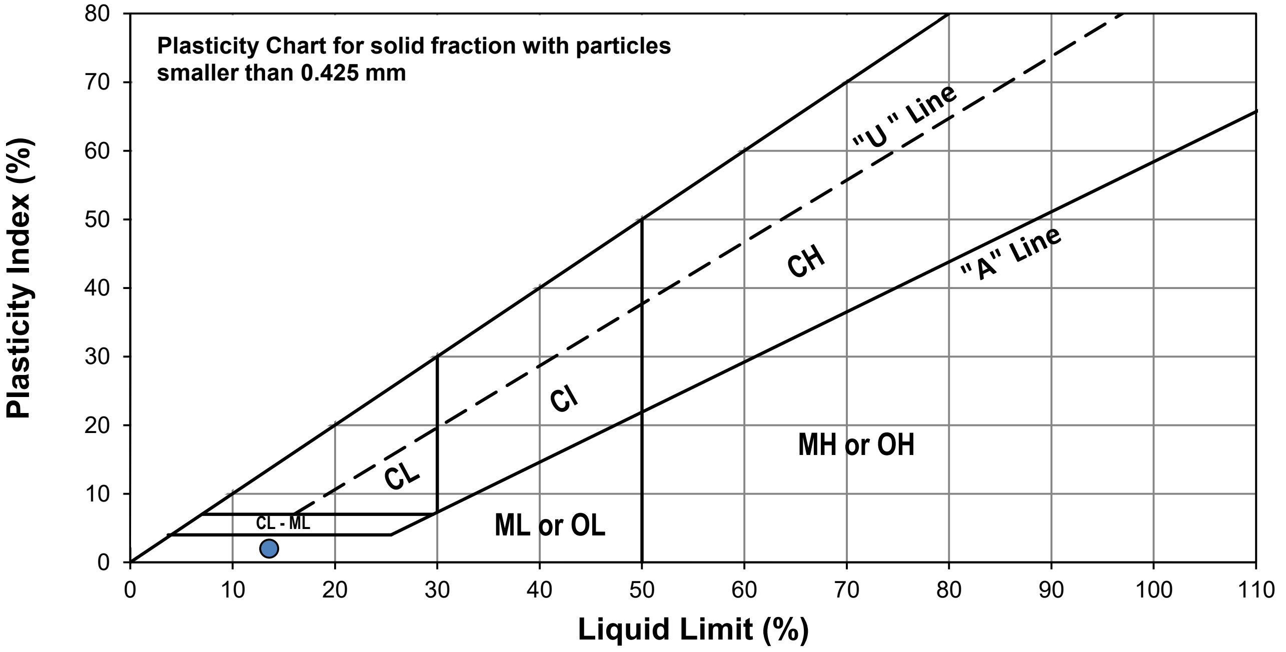
Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Hole	TP23-02-02
Sample #	G3
Depth (m)	2.7
Sample Date	08-Nov-23
Test Date	22-Nov-23
Technician	KF

Liquid Limit	14
Plastic Limit	12
Plasticity Index	2

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	16	21	31		
Mass Tare (g)	14.199	14.135	14.127		
Mass Wet Soil + Tare (g)	24.773	24.200	31.051		
Mass Dry Soil + Tare (g)	23.457	22.969	29.074		
Mass Water (g)	1.316	1.231	1.977		
Mass Dry Soil (g)	9.258	8.834	14.947		
Moisture Content (%)	14.215	13.935	13.227		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	13.827	13.945			
Mass Wet Soil + Tare (g)	24.982	22.570			
Mass Dry Soil + Tare (g)	23.830	21.666			
Mass Water (g)	1.152	0.904			
Mass Dry Soil (g)	10.003	7.721			
Moisture Content (%)	11.517	11.708			

Note: Additional information recorded/measured for this test is available upon request.

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-02-02
Sample #	G3
Depth (m)	0.9
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

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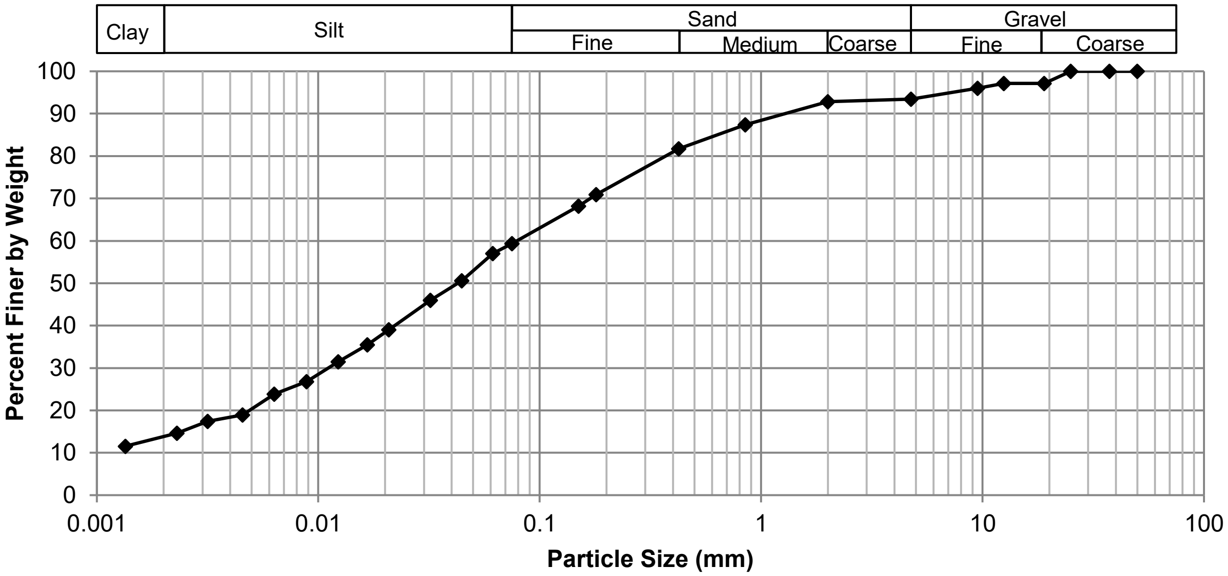
Gravel	6.5%
Sand	34.1%
Silt	45.7%
Clay	13.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	93.47	0.0750	59.34
37.5	100.00	2.00	92.82	0.0614	57.01
25.0	100.00	0.850	87.41	0.0445	50.62
19.0	97.14	0.425	81.73	0.0321	45.98
12.5	97.14	0.180	70.90	0.0208	39.01
9.50	96.01	0.150	68.21	0.0167	35.49
4.75	93.47	0.075	59.34	0.0123	31.47
				0.0089	26.78
				0.0063	23.84
				0.0046	18.90
				0.0032	17.45
				0.0023	14.64
				0.0013	11.56

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Tel: 204.975.9433 Fax: 204.975.9435

Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-011-11
Client Tetra Tech
Project WW Lagoon FS, Richer, MB

Test Pit TP23-02-04
Sample # G5
Depth (m) 1.2
Sample Date 08-Nov-23
Test Date 17-Nov-23
Technician DS

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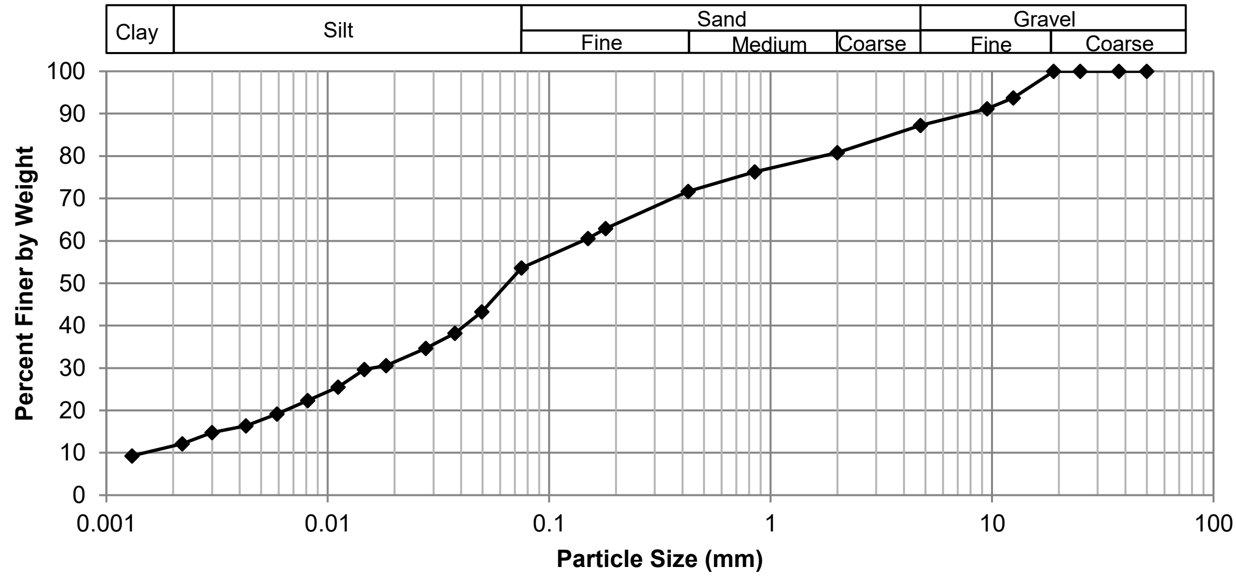
Gravel	12.8%
Sand	33.6%
Silt	42.2%
Clay	11.5%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	87.25	0.0750	53.65
37.5	100.00	2.00	80.84	0.0496	43.23
25.0	100.00	0.850	76.25	0.0376	38.18
19.0	100.00	0.425	71.65	0.0277	34.64
12.5	93.74	0.180	62.95	0.0183	30.59
9.50	91.16	0.150	60.57	0.0146	29.69
4.75	87.25	0.075	53.65	0.0111	25.54
				0.0081	22.36
				0.0059	19.18
				0.0043	16.40
				0.0030	14.76
				0.0022	12.14
				0.0013	9.29

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Atterberg Limits
ASTM D4318-10e1

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For specific tests as listed on www.ccil.com

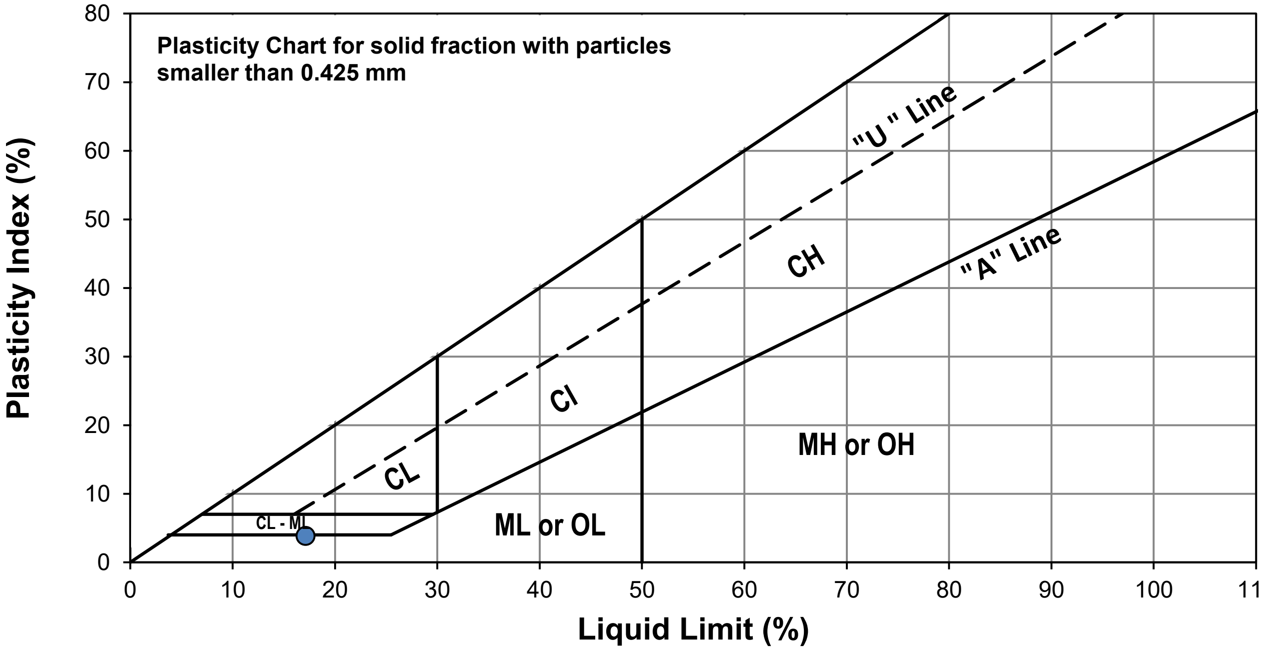
Project No. 1000-011-11
Client Tetra Tech
Project WW Lagoon FS, Richer, MB

Test Hole TP23-02-04
Sample # G6
Depth (m) 3.0
Sample Date 08-Nov-23
Test Date 22-Nov-23
Technician KF

Liquid Limit	17
Plastic Limit	13
Plasticity Index	4

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	17	26	32		
Mass Tare (g)	13.978	14.233	14.067		
Mass Wet Soil + Tare (g)	24.680	30.368	26.187		
Mass Dry Soil + Tare (g)	23.088	28.019	24.432		
Mass Water (g)	1.592	2.349	1.755		
Mass Dry Soil (g)	9.110	13.786	10.365		
Moisture Content (%)	17.475	17.039	16.932		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.130	14.305			
Mass Wet Soil + Tare (g)	23.131	27.357			
Mass Dry Soil + Tare (g)	22.088	25.811			
Mass Water (g)	1.043	1.546			
Mass Dry Soil (g)	7.958	11.506			
Moisture Content (%)	13.106	13.436			

Note: Additional information recorded/measured for this test is available upon request.

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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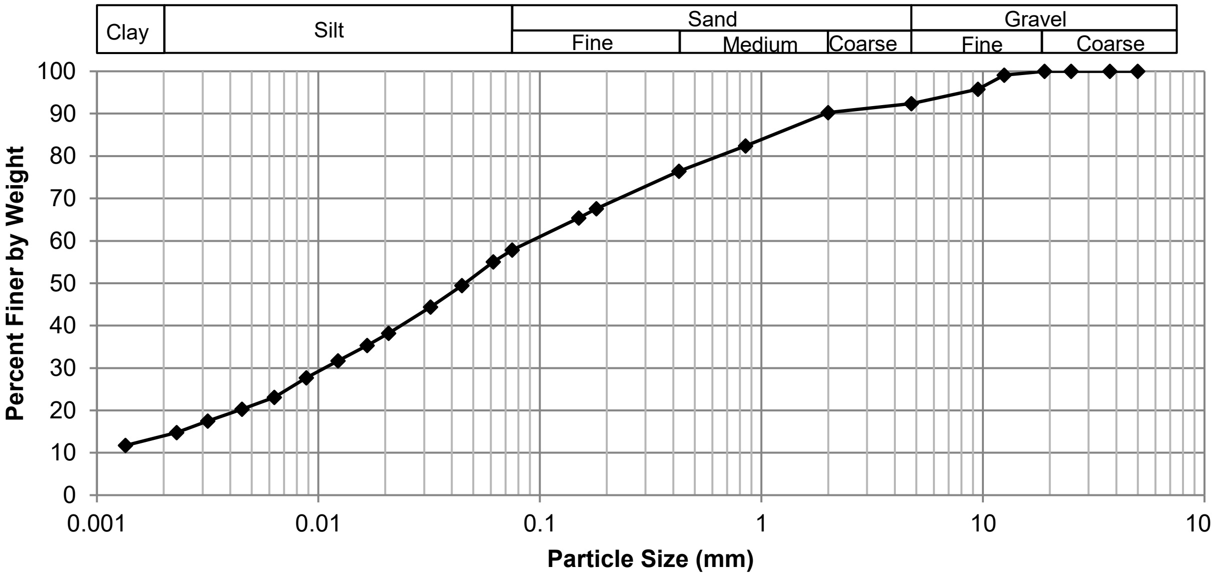
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No.	1000-011-11
Client	Tetra Tech
Project	WW Lagoon FS, Richer, MB
Test Pit	TP23-02-04
Sample #	G6
Depth (m)	3.0
Sample Date	08-Nov-23
Test Date	17-Nov-23
Technician	DS

Gravel	7.6%
Sand	34.5%
Silt	44.1%
Clay	13.8%

Particle Size Distribution Curve



Gravel		**Sand**		**Silt and Clay**	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	92.36	0.0750	57.88
37.5	100.00	2.00	90.23	0.0616	55.05
25.0	100.00	0.850	82.39	0.0445	49.46
19.0	100.00	0.425	76.44	0.0321	44.39
12.5	99.10	0.180	67.58	0.0208	38.18
9.50	95.81	0.150	65.44	0.0166	35.30
4.75	92.36	0.075	57.88	0.0123	31.69
				0.0088	27.69
				0.0063	23.12
				0.0045	20.29
				0.0032	17.47
				0.0023	14.76
				0.0013	11.72

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CERTIFICATE OF ANALYSIS

Work Order	: **WP2329748**	Page	: 1 of 3
Client	: **Tetra Tech Canada Inc.**	Laboratory	: ALS Environmental - Winnipeg
Contact	: Ryan Harras	Account Manager	: Judy Dalmaijer
Address	: 400-161 Portage Ave East Winnipeg MB Canada R3B 0Y4	Address	: 1329 Niakwa Road East, Unit 12 Winnipeg MB Canada R2J 3T4
Telephone	: ----	Telephone	: +1 204 255 9720
Project	: RICHER, MB	Date Samples Received	: 15-Nov-2023 11:22
PO	: 704-ENG-DMPR03108-01	Date Analysis Commenced	: 18-Nov-2023
C-O-C number	: ----	Issue Date	: 29-Nov-2023 16:45
Sampler	: ----		
Site	: ----		
Quote number	: Platinum 2023 Standing Offer (Q88763)		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Greg Pokocky	Manager - Inorganics	Inorganics, Waterloo, Ontario
Katarzyna Glinka	Analyst	Inorganics, Calgary, Alberta
Nik Perkio	Inorganics Analyst	Inorganics, Waterloo, Ontario

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances

LOR: Limit of Reporting (detection limit).

Unit	*Description*
%	percent
mS/cm	millisiemens per centimetre
ohm cm	ohm centimetres (resistivity)
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Soil**

(Matrix: **Soil/Solid)**

				Client sample ID	**TP23-01-01 G1 @ 3'**	**TP23-01-05 G11 @ 6.5'**	**TP23-02-01 G1 @ 8'**	**TP23-02-05 G7 @ 5'**	**----**
				Client sampling date / time	08-Nov-2023 12:00	08-Nov-2023 12:00	08-Nov-2023 12:00	08-Nov-2023 12:00	----
Analyte	*CAS Number*	*Method/Lab*	*LOR*	*Unit*	**WP2329748-001**	**WP2329748-002**	**WP2329748-003**	**WP2329748-004**	**--------**
					Result	Result	Result	Result	----
Physical Tests									
Conductivity (1:2 leachate)	----	E100-L/WT	0.00500	mS/cm	0.0657	0.107	0.174	0.146	----
pH (1:2 soil:CaCl2-aq)	----	E108A/WT	0.10	pH units	7.74	7.82	8.13	7.98	----
Resistivity	----	EC100R/WT	100	ohm cm	15200	9340	5750	6850	----
Inorganics									
Sulfate, total, ion content	14808-79-8	E246.SO4/CG	0.050	%	<0.050	<0.050	<0.050	<0.050	----

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **WP2329748**	Page	: 1 of 6
Client	: **Tetra Tech Canada Inc.**	Laboratory	: ALS Environmental - Winnipeg
Contact	: Ryan Harras	Account Manager	: Judy Dalmaijer
Address	: 400-161 Portage Ave East Winnipeg MB Canada R3B 0Y4	Address	: 1329 Niakwa Road East, Unit 12 Winnipeg, Manitoba Canada R2J 3T4
Telephone	: ----	Telephone	: +1 204 255 9720
Project	: RICHER, MB	Date Samples Received	: 15-Nov-2023 11:22
PO	: 704-ENG-DMPR03108-01	Issue Date	: 29-Nov-2023 16:46
C-O-C number	: ----		
Sampler	: ----		
Site	: ----		
Quote number	: Platinum 2023 Standing Offer (Q88763)		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- <u>No</u> Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group : Analytical Method	*Method*	*Sampling Date*	*Extraction / Preparation*				*Analysis*			
Container / Client Sample ID(s)			*Preparation Date*	*Holding Times*		*Eval*	*Analysis Date*	*Holding Times*		*Eval*
				Rec	*Actual*			*Rec*	*Actual*	
Inorganics : Total Sulfate ion in soil by acidic boiling water extraction, IC										
LDPE bag TP23-01-01 G1 @ 3'	E246.SO4	08-Nov-2023	23-Nov-2023	180 days	15 days	✓	23-Nov-2023	28 days	0 days	✓
Inorganics : Total Sulfate ion in soil by acidic boiling water extraction, IC										
LDPE bag TP23-01-05 G11 @ 6.5'	E246.SO4	08-Nov-2023	23-Nov-2023	180 days	15 days	✓	23-Nov-2023	28 days	0 days	✓
Inorganics : Total Sulfate ion in soil by acidic boiling water extraction, IC										
LDPE bag TP23-02-01 G1 @ 8'	E246.SO4	08-Nov-2023	23-Nov-2023	180 days	15 days	✓	23-Nov-2023	28 days	0 days	✓
Inorganics : Total Sulfate ion in soil by acidic boiling water extraction, IC										
LDPE bag TP23-02-05 G7 @ 5'	E246.SO4	08-Nov-2023	23-Nov-2023	180 days	15 days	✓	23-Nov-2023	28 days	0 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
LDPE bag TP23-01-01 G1 @ 3'	E100-L	08-Nov-2023	21-Nov-2023	30 days	13 days	✓	22-Nov-2023	30 days	14 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
LDPE bag TP23-01-05 G11 @ 6.5'	E100-L	08-Nov-2023	21-Nov-2023	30 days	13 days	✓	22-Nov-2023	30 days	14 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
LDPE bag TP23-02-01 G1 @ 8'	E100-L	08-Nov-2023	23-Nov-2023	30 days	15 days	✓	23-Nov-2023	30 days	15 days	✓

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group : Analytical Method Container / Client Sample ID(s)	*Method*	*Sampling Date*	*Extraction / Preparation*				*Analysis*			
			Preparation Date	*Holding Times*		*Eval*	*Analysis Date*	*Holding Times*		*Eval*
				Rec	*Actual*			*Rec*	*Actual*	
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
LDPE bag TP23-02-05 G7 @ 5'	E100-L	08-Nov-2023	23-Nov-2023	30 days	15 days	✓	23-Nov-2023	30 days	15 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
LDPE bag TP23-01-01 G1 @ 3'	E108A	08-Nov-2023	18-Nov-2023	30 days	10 days	✓	21-Nov-2023	30 days	13 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
LDPE bag TP23-01-05 G11 @ 6.5'	E108A	08-Nov-2023	18-Nov-2023	30 days	10 days	✓	21-Nov-2023	30 days	13 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
LDPE bag TP23-02-01 G1 @ 8'	E108A	08-Nov-2023	18-Nov-2023	30 days	10 days	✓	21-Nov-2023	30 days	13 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
LDPE bag TP23-02-05 G7 @ 5'	E108A	08-Nov-2023	18-Nov-2023	30 days	10 days	✓	21-Nov-2023	30 days	13 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Soil/Solid**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1245509	2	27	7.4	5.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1243535	1	18	5.5	5.0	✓
Total Sulfate ion in soil by acidic boiling water extraction, IC	E246.SO4	1250176	1	17	5.8	5.0	✓
Laboratory Control Samples (LCS)							
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1245509	4	27	14.8	10.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1243535	1	18	5.5	5.0	✓
Total Sulfate ion in soil by acidic boiling water extraction, IC	E246.SO4	1250176	2	17	11.7	10.0	✓
Method Blanks (MB)							
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1245509	2	27	7.4	5.0	✓
Total Sulfate ion in soil by acidic boiling water extraction, IC	E246.SO4	1250176	1	17	5.8	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by “mod”).

Analytical Methods	*Method / Lab*	*Matrix*	*Method Reference*	*Method Descriptions*
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L ALS Environmental - Waterloo	Soil/Solid	CSSS Ch. 15 (mod)/APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Conductance is measured in the fluid that is observed in the upper layer.
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A ALS Environmental - Waterloo	Soil/Solid	MECP E3530	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C) and is carried out in accordance with procedures described in the Analytical Protocol (prescriptive method). A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling, or decanting and then analyzed using a pH meter and electrode.
Total Sulfate ion in soil by acidic boiling water extraction, IC	E246.SO4 ALS Environmental - Calgary	Soil/Solid	CSA-A23.2-3B	The dried solid is mixed with water and acid then heated. After filtration the liquid is ready for analysis by IC with conductivity detector.
Resistivity Calculation for Soil Using E100-L	EC100R ALS Environmental - Waterloo	Soil/Solid	APHA 2510 B	Soil Resistivity (calculated) is determined as the inverse of the conductivity of a 2:1 water:soil leachate (dry weight). This method is intended as a rapid approximation for Soil Resistivity. Where high accuracy results are required, direct measurement of Soil Resistivity by the Wenner Four-Electrode Method (ASTM G57) is recommended.

Preparation Methods	*Method / Lab*	*Matrix*	*Method Reference*	*Method Descriptions*
Leach 1:2 Soil:Water for pH/EC	EP108 ALS Environmental - Waterloo	Soil/Solid	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL	The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water.
Leach 1:2 Soil : 0.01CaCl2 - As Received for pH	EP108A ALS Environmental - Waterloo	Soil/Solid	MOEE E3137A	A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling or decanting and then analyzed using a pH meter and electrode.
Total ion Sulfate in soil or concrete preparation	EP246.T ALS Environmental - Calgary	Soil/Solid	CSA-A23.2B	The dried solid is mixed with water and acid then heated. After filtration the liquid is ready for analysis.

QUALITY CONTROL REPORT

Work Order	: **WP2329748**	Page	: 1 of 4
Client	: Tetra Tech Canada Inc.	Laboratory	: ALS Environmental - Winnipeg
Contact	: Ryan Harras	Account Manager	: Judy Dalmaijer
Address	: 400-161 Portage Ave East Winnipeg MB Canada R3B 0Y4	Address	: 1329 Niakwa Road East, Unit 12 Winnipeg, Manitoba Canada R2J 3T4
Telephone	:	Telephone	: +1 204 255 9720
Project	: RICHER, MB	Date Samples Received	: 15-Nov-2023 11:22
PO	: 704-ENG-DMPR03108-01	Date Analysis Commenced	: 18-Nov-2023
C-O-C number	: ----	Issue Date	: 29-Nov-2023 16:46
Sampler	: ---- ----		
Site	: ----		
Quote number	: Platinum 2023 Standing Offer (Q88763)		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Reference Material (RM) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Greg Pokocky	Manager - Inorganics	Waterloo Inorganics, Waterloo, Ontario
Katarzyna Glinka	Analyst	Calgary Inorganics, Calgary, Alberta
Nik Perkio	Inorganics Analyst	Waterloo Inorganics, Waterloo, Ontario

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: **Soil/Solid**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 1243535)											
WP2329664-001	Anonymous	pH (1:2 soil:CaCl2-aq)	----	E108A	0.10	pH units	8.02	8.04	0.249%	5%	----
Physical Tests (QC Lot: 1245509)											
WT2337872-001	Anonymous	Conductivity (1:2 leachate)	----	E100-L	5.00	µS/cm	0.0711 mS/cm	70.0	1.56%	20%	----
Physical Tests (QC Lot: 1247500)											
WT2337901-001	Anonymous	Conductivity (1:2 leachate)	----	E100-L	10.0	µS/cm	14.6 mS/cm	14400	1.24%	20%	----
Inorganics (QC Lot: 1250176)											
EO2310717-001	Anonymous	Sulfate, total, ion content	14808-79-8	E246.SO4	500	mg/kg	0.066 %	620	30	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Soil/Solid**

Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	*Result*	*Qualifier*
Physical Tests (QCLot: 1245509)						
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	<5.00	----
Physical Tests (QCLot: 1247500)						
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	<5.00	----
Inorganics (QCLot: 1250176)						
Sulfate, total, ion content	14808-79-8	E246.SO4	500	mg/kg	<500	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Soil/Solid**

					Laboratory Control Sample (LCS) Report				
					Spike	*Recovery (%)*	*Recovery Limits (%)*		
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	*Concentration*	*LCS*	*Low*	*High*	*Qualifier*
Physical Tests (QCLot: 1243535)									
pH (1:2 soil:CaCl2-aq)	----	E108A	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 1245509)									
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	1409 µS/cm	99.0	90.0	110	----
Physical Tests (QCLot: 1247500)									
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	1409 µS/cm	101	90.0	110	----
Inorganics (QCLot: 1250176)									
Sulfate, total, ion content	14808-79-8	E246.SO4	500	mg/kg	10000 mg/kg	100	90.0	110	----

Reference Material (RM) Report

A Reference Material (RM) is a homogenous material with known and well-established analyte concentrations. RMs are processed in an identical manner to test samples, and are used to monitor and control the accuracy and precision of a test method for a typical sample matrix. RM results are expressed as percent recovery of the target analyte concentration. RM targets may be certified target concentrations provided by the RM supplier, or may be ALS long-term mean values (for empirical test methods).

Sub-Matrix:

					Reference Material (RM) Report				
					RM Target	Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Reference Material ID	Analyte	CAS Number	Method	Concentration	RM	Low	High	Qualifier
Physical Tests (QCLot: 1245509)									
	RM	Conductivity (1:2 leachate)	----	E100-L	1970.3 µS/cm	104	70.0	130	----
Physical Tests (QCLot: 1247500)									
	RM	Conductivity (1:2 leachate)	----	E100-L	1970.3 µS/cm	106	70.0	130	----
Inorganics (QCLot: 1250176)									
	RM	Sulfate, total, ion content	14808-79-8	E246.SO4	33400 mg/kg	94.7	80.0	120	----

12 - 1329 Niakwa Rd. E.
Winnipeg, Manitoba R2J 3T4
Tel: (204) 255-9720
Fax: (204) 255-9721
Toll Free: 1 800 607 7555

Chain of Custody / Analytical Request Form

WORK ORDER NO:

FOR LABORATORY USE ONLY (SHADED AREAS)

LAB NO.:

Sample Condition Upon Receipt: ☐ ACCEPTABLE ☐ NON ACCEPTABLE

DATE RECEIVED: NOV 15 2023

☐ Frozen ☐ Cold ☐ Ambient ☐ Broken ☐ Leakage ☐ Incorrect Sample Container

TIME RECEIVED: 11:22

COMMENT:

BY: SB TEMP: 12.8

Date Sampled: NOV. 8, 2023 Time: 12 : 00 A.M. ☐ P.M. ☑

Date Required:

Location: RICHER, MB
(Town, Community, City)

Submitter's Name Printed: RYAN HARRAS

Sample Submitted By:

Community Code Number:

Rural Municipality/LGC/UVD:

SAMPLE TYPE

PLEASE PRINT & PRESS FIRMLY

DRINKING WATER
- ☐ Untreated Well
- ☐ Treated Well
- ☐ Treated Municipal
- ☐ Non-Treated Municipal
- ☐ Water-Surface-Raw
- ☐ Water-Surface-Treated

PURPOSE OF TEST
☐ Private ☐ Real Estate ☐ Water Main

NON-DRINKING WATER
- ☐ Sewage/Waste Water
- ☐ Lake/River
- ☐ Swimming Pool
- ☐ Whirl Pool
- ☐ Other:

NOTES & CONDITIONS
1. Quote number **MUST BE** provided to insure proper pricing.
2. Failure to properly complete all portions of this form may delay analysis.
3. ALS's liability limited to cost of analysis.

SERVICE REQUESTED
☑ **REGULAR** ☐ **PRIORITY** (50% SURCHARGE) ☐ **EMERGENCY** (100% SURCHARGE) ☐ **SAME DAY** (200% SURCHARGE)

LAB NUMBER	SAMPLE IDENTIFICATION
	TP23-01-01 G1@3'
	TP23-01-05 G11@6.5'
	TP23-02-01 G1@8'
	TP23-02-05 G7@5'

Environmental Division
Winnipeg
Work Order Reference
WP2329748
Telephone : +1 204 255 9720

ALS CUSTOMER #: QUOTE #:

REPORT TO BE SENT TO

NAME: RYAN HARRAS
COMPANY: TETRA TECH
ADDRESS: 400-161 PORTAGE AVE. E
CITY/TOWN: WINNIPEG / PROV.: MB
POSTAL CODE: R3B 0Y4
PHONE: 204-803-9356
BY: MAIL ☐ FAX ☐ (FAX NUMBER)
E-MAIL ☑ RYAN.HARRAS@TETRATECH.COM (EMAIL ADDRESS)

CC
NAME:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:
PHONE:
BY: MAIL ☐ FAX ☐ (FAX NUMBER)
E-MAIL ☐ (EMAIL ADDRESS)

Analyses required

CONDUCTIVITY / RESISTIVITY
pH
SULPHATE CONTENT.

BILLING ADDRESS SAME AS REPORT TO ☑

NAME:
COMPANY:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:

PAYMENT PARTICULARS (CASH NOT ACCEPTED)

☑ INVOICE NEEDED / CLIENT'S P.O. NO. 704-ENG.DMPR03108-01
☐ INTERAC
☐ CHEQUE Subtotal $
☐ VISA G.S.T. $
☐ MASTERCARD Total $

* OUR POLICY IS NOT TO ACCEPT SAMPLES FROM THE PRIVATE CITIZEN WITHOUT PREPAYMENT

SAMPLING INSTRUCTIONS ON REVERSE SIDE
ALS ENVIRONMENTAL
12 - 1329 Niakwa Rd. E., Winnipeg, MB Canada R2J 3T4
Phone: +1 204 255 9720 Fax: +1 204 255 9721 **www.alsglobal.com**
A Campbell Brothers Limited Company

SUBMITTER COPY

ENTERED IN LIMS BY:

APPENDIX D

LIMITATIONS ON USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client’s expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.