Technical Document LA24041A

Application for Amendment

NRCB Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* to amend a permit for a confined feeding operation, manure collection area and/or manure storage facility(ies). ("Permit" means an NRCB-issued or grandfathered approval, registration, or authorization, including a grandfathered municipal development permit.)

NRCB USE ONLY

☐ Approval ☐ Registration ☑ Authorization

AMENDMENT

NRCB Application number: LA24041A

Date Stamp: NRCB APPLICATION 07 AUG 2025 RECEIVED

CONTACT INFORMATION

Applicant Information

Name:	Corporate Name (if applicable)	
DAVID M WAIDNER	Raley Colony	
Address: (Street/P.O. Box) Box 2700		
City/Town: CARDSTON	Province: AB	Postal Code: T0K 0K0

Agent consent *(if applicable)*

I, _____, hereby give consent for _____
(name of applicant) *(name of agent and company)*

to act on my behalf or as my agent for this application.

Signed this ____day of _____, 20____. _____
Signature of Applicant

LOCATION OF DEVELOPMENT

Which permit do you wish to amend? (List permit number and issuing agency.)	kA 24 041
Legal Land Description(s)	SE 13-4-25 (Qtr-Sec-Twp-Rg-W Mer)

APPLICATION DISCLOSURE

This information is collected under the authority of the *Agricultural Operation Practices Act (AOPA)*, and is subject to the provisions of the *Freedom of Information and Protection of Privacy Act*. This information is public unless the NRCB grants a written request that certain sections remain private.

Any construction prior to obtaining an NRCB permit is an offence and is subject to enforcement action, including prosecution.

I, the applicant, or applicant's agent, have read and understand the statements herein and acknowledge that the information provided in this application is true to the best of my knowledge.

[redacted]
Date of signing

Aug 7/25
Signature

Corporate name (if applicable)

DAVID M WAIDNER
Print name

Application for Amendment – contd.

NRCB Natural Resources Conservation Board

AMENDMENT INFORMATION REQUIREMENTS

Instructions:
For each part of your permit that you would like amended, please detail what change you would like made and why, and how your proposed change will meet the AOPA requirements. You may attach additional pages to this form to provide this information.

Please note that an approval officer may require a page (or pages) of the Part 2 application forms to be completed as part of this application for amendment, depending on what changes are proposed.

Change dimensions of new Lagoon,
New dimension : 83 x 83 x 7M
with 3.M. belowground level

AO Comment: The dimensions of the EMS, permitted in LA24041, were 81 m x 81 m x 7 m deep.
The total depth below ground level was proposed to be 7 m.
The EMS, as constructed is only 3 m below ground level and 2 m wider and 2 m longer.
No other changes proposed.

NRCB Natural Resources Conservation Board

NRCB USE ONLY

ALL SIGNATURES IN FILE ☒ YES ☐ NO

DATES OF APPROVAL OFFICER SITE VISITS

April 22, 2025	

CORRESPONDENCE WITH MUNICIPALITIES AND REFERRAL AGENCIES

Date deeming letters sent: August 8, 2025

Municipality: Cardston County

☒ letter sent ☒ response received ☒ written/email ☐ verbal ☐ no comments received

Alberta Health Services: NA

☐ letter sent ☐ response received ☐ written/email ☐ verbal ☐ no comments received

Alberta Environment and Parks: ☐ N/A

☒ letter sent ☒ response received ☐ written/email ☐ verbal ☒ no comments received

Alberta Transportation: ☒ N/A

☐ letter sent ☐ response received ☐ written/email ☐ verbal ☐ no comments received

Alberta Regulatory Services: ☒ N/A

☐ letter sent ☐ response received ☐ written/email ☐ verbal ☐ no comments received

Other: Blood Tribe ☐ N/A

☒ letter sent ☐ response received ☐ written/email ☐ verbal ☒ no comments received

Other: Altalink Mgmt ☐ N/A

☒ letter sent ☐ response received ☐ written/email ☐ verbal ☒ no comments received

LIQUID MANURE STORAGE: Earthen manure storage (EMS): Compacted soil liner

*(complete a copy of this section for **EACH** proposed earthen liquid manure storage facility with a compacted soil liner)*

Facility description / name *(as indicated on site plan)*

1. lagoon (EMS)

2. _____

Manure storage capacity *(complete a separate row of this table for each cell of the EMS)*

	Length (m)	Width (m)	Total depth (m)	Depth below ground level (m)	Slope run:rise			NRCB USE ONLY	
					Inside end walls	Inside side walls	Outside walls	Calculated storage capacity (excl. 0.5 m freeboard) (m^3)	Filled in lower ¼? Y/N
1.	83	83	7	3	3:1	3:1	~~4:1~~ 4:1	24,616 m^3	yes
2.							4:1		
							TOTAL CAPACITY	24,616 m3	

Surface water control systems

Describe the run-on and runoff control system

Berm

Sealing

Describe sealing practices for piping, etc. that penetrates the liner

with apron around inlet pipe and splash pad

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Requirements met: ☒ YES ☐ NO

Liner protection

Describe how the inside walls, bottom and outside walls are protected from erosion

outside walls seeded in grass, inside walls bare but with splash pad

Describe how the physical integrity of the liner will be maintained from other damage

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Requirements met: ☒ YES ☐ NO

LIQUID MANURE STORAGE: Earthen manure storage (EMS): Compacted soil liner (cont.)

Compacted soil liner details

Thickness of compacted liner 1.0 (m)		Provide compacted liner details (as required)	
Soil texture	~ 30 % sand	~50 % silt	~10-20 % clay
Atterberg limits	Plastic limit	Liquid limit	Plasticity index
Hydraulic conductivity	Hydraulic conductivity (cm/s) 2.1E-08		
	Describe test standard used ASTM D5084-Method A		

Additional information *(attach copies of soil test reports)*

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Requirements met: ☒ YES ☐ NO

Condition required: ☐ YES ☒ NO

Report attached: ☒ YES ☐ NO

No conditions required. Already constructed

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Liquid manure storage volume calculator attached: ☐ YES ☒ NO

Depth to water table: **3.2 m blg** Requirements met: ☒ YES ☐ NO **(X)**

Depth to uppermost groundwater resource: **No UGR identified Below 10 m of ground level** Requirements met: ☒ YES ☐ NO

(X) No water table was encountered within 1 m of the construction zone during construction

ERST completed: ☒ see ERST page for details

Surface water control systems

Requirements met: ☒ YES ☐ NO Details/comments:

Compacted soil liner details

Liner specification comments (e.g. compaction, moisture content, thickness):

Meets AOPA requirements

Leakage detection system required: ☐ YES ☒ NO If yes, please explain why.

Dennis' Dirtworx Ltd
PO Box 1341
Coaldale, AB T1M 1N2
Office Phone (403) 345-3539
Fax (403) 345-4813

June 6, 2025

Hutterian Brethren Church of West Raley
Box 2700, Cardston AB T0K 0K0

Dear David:

Please be advised Dennis Dirtworx has completed the Earthen Liquid Manure Storage facility, NRCB Application Approval # LA24041 dated May 12, 2025 at land location SE-13-4-25-W4M. As per the approval, construction started on the 81m x 81m x 7m deep facility. Soil drill samples advised that there was a possibility of water table issues and the construction crew did in fact encounter water at 1114.00 elevation using survey format UTM, NAD 83, Zone 12 North. Construction was stopped and a new design was implemented that included a sloped bottom to the facility at the request of the Colony. The 1.0 meter compacted liner subgrade was then started at 1114.37 in the low corner of the facility and built above that including the banks . Finished elevation of liner at it's lowest point is 1115.37 as per Dimensioned.PDF. Survey data asbpond.csv is included as attachment as well as ASBPOND.xml both of which are in the survey format listed above. New dimensions and capacities for the facility are included in the aforementioned PDF and Profile A is included to bring clarity to the structure built. Original soil sample testing done by Roseke Engineering and completed compaction testing (also by Roseke) are included for certification.

Please be advised that Corina Weisbach or an NRCB representative of her choosing will need to do a visual inspection of the Earthen Liquid Manure Storage facility, prior to releasing the facilities usage.

Please feel free to contact me if there are any questions.

Dan Dyck
Dennis Dirtworx
403-892-6823

PROFESSIONAL ENGINEER ALBERTA
BERNIE C. ROSEKE
#66728
13 June 2025

PERMIT TO PRACTICE
ROSEKE ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID: 66728
DATE: 2025-06-13
PERMIT NUMBER: 11347
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

NUCLEAR DENSITY FIELD TEST REPORT

ROSEKE ENGINEERING
3614 - 18th Avenue North
Lethbridge, AB T1H 5S7

CLIENT:	Dennis Dirtworx Ltd.	ATTENTION: Dan Dyck	REL JOB NO.: 243-068		Dennis' Dirtworx Ltd. 1009 13th Avenue Coaldale, AB T1M 0E4
PROJECT:	West Raley Hutterite Colony Pond	CONSULTANT:	PO NO.:		
LOCATION:	Cardston County, AB	ACTIVITY: Compaction - Berms & Liner	INSPECTOR: Z. Wittke		
REPORT NO.: #1	CONTRACTOR: Dennis Dirtworx Ltd.	SPECIFIED COMPACTION: 95.0 % Minimum	SPECIFIED MOISTURE: ± 3.0%		DATE: 30-May-2025

TEST NO.	DATE TESTED	GRADE DEPTH (m)	TEST LOCATION	SOIL TYPE	PROBE DEPTH	DENSITY MODE	STANDARD PROCTOR (ASTM D698)		Material Percent Oversized	CONSTRUCTED			% PROCTOR DENSITY (ASTM 6938)	REMARKS
							DENSITY (kg/m³)	MOISTURE		DENSITY (kg/m³) (Initial)	DENSITY (kg/m³) (Corrected)	MOISTURE		
1	30-May-25	@ Grade	20m E of NE Toe	CLAY	300	NDT	1723	18.4%		1640		18.0%	95.2%	Berm
2	30-May-25	@ Grade	20m W of SE Toe	CLAY	300	NDT	1723	18.4%		1671		17.5%	97.0%	Berm
3	30-May-25	@ Grade	28m W, 20m S of SE Toe	CLAY	300	NDT	1723	18.4%		1642		16.9%	95.3%	Berm
4	30-May-25	@ Grade	20m S, 10m E of SE Toe	CLAY	300	NDT	1723	18.4%		1678		18.9%	97.4%	Berm
5	30-May-25	@ Grade	20m S, 3m W of SW Toe	CLAY	300	NDT	1723	18.4%		1661		17.8%	96.4%	Berm
6	30-May-25	@ Grade	5m S, 20m W of SW Toe	CLAY	300	NDT	1723	18.4%		1639		20.6%	95.1%	Berm
7	30-May-25	@ Grade	25m N, 20m W of SW Toe	CLAY	300	NDT	1723	18.4%		1644		16.2%	95.4%	Berm
8	30-May-25	@ Grade	20m W of NW Toe	CLAY	300	NDT	1723	18.4%		1666		20.3%	96.7%	Berm
9	30-May-25	@ Grade	20m N, 7m W of NW Toe	CLAY	300	NDT	1723	18.4%		1712		19.3%	99.4%	Berm
10	30-May-25	@ Grade	20m N, 15m E of NW Toe	CLAY	300	NDT	1723	18.4%		1711		18.1%	99.3%	Berm
11	30-May-25	@ Grade	20m N, 13m W of NW Toe	CLAY	300	NDT	1723	18.4%		1690		19.0%	98.1%	Berm
12	30-May-25	@ Grade	10m N, 8m W of SE Toe	CLAY	300	NDT	1604	21.7%		1577		22.6%	98.3%	Liner / Bottom
13	30-May-25	@ Grade	20m N, 8m W of SE Toe	CLAY	300	NDT	1604	21.7%		1572		22.9%	98.0%	Liner / Bottom
14	30-May-25	@ Grade	9m S, 8m W of NE Toe	CLAY	300	NDT	1604	21.7%		1575		20.8%	98.2%	Liner / Bottom
15	30-May-25	@ Grade	15m N, 20m W of SE Toe	CLAY	300	NDT	1604	21.7%		1574		22.8%	98.1%	Liner / Bottom
16	30-May-25	@ Grade	7m N, 20m W of SE Toe	CLAY	300	NDT	1604	21.7%		1580		21.9%	98.5%	Liner / Bottom
17	30-May-25	@ Grade	6m N, 13m E of SW Toe	CLAY	300	NDT	1604	21.7%		1572		20.5%	98.0%	Liner / Bottom
18	30-May-25	@ Grade	20m N, 15m E of SW Toe	CLAY	300	NDT	1604	21.7%		1593		22.6%	99.3%	Liner / Bottom
19	30-May-25	@ Grade	10m S, 14m E of NW Toe	CLAY	300	NDT	1604	21.7%		1591		20.6%	99.2%	Liner / Bottom
20	30-May-25	@ Grade	9m S, 14m E of NW Toe	CLAY	300	NDT	1604	21.7%		1582		19.0%	98.6%	Liner / Bottom
21	30-May-25	@ Grade	20m N, 7m E of SW Toe	CLAY	300	NDT	1604	21.7%		1580		20.8%	98.5%	Liner / Bottom
22														
23														
24														
25														
26														
			AVERAGE	CLAY								Moisture % 19.9%	Compaction % 97.6%	

Additional Comments:
Surface density testing completed

Distribution List:
1. Dan D - dand@dennisdirtworx.ca

Authorized Signatures:

Materials Technologist: Zayne Wittke

Contractor's Representative

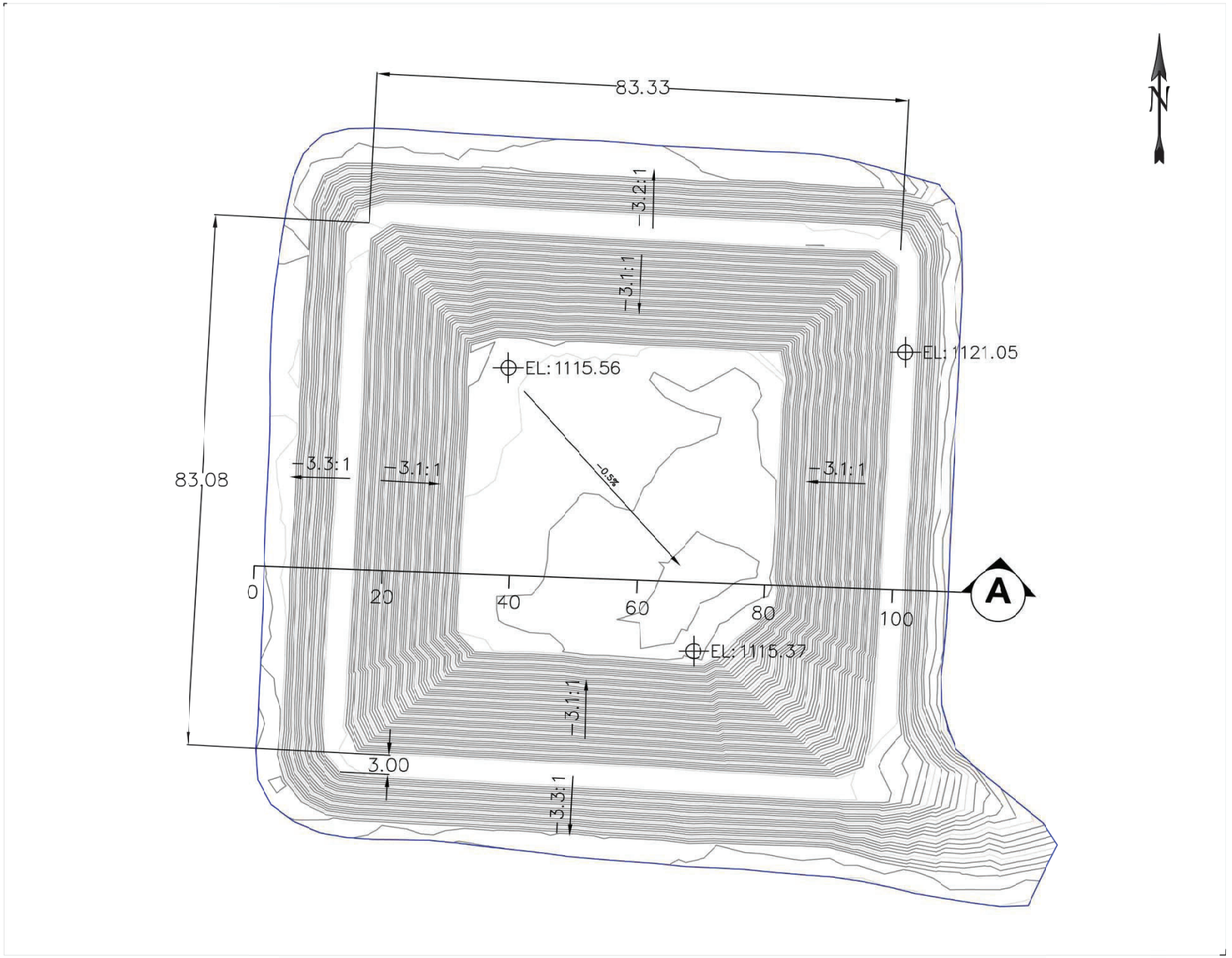
Reviewed By: Devon Rowley

Project Manager

PROFESSIONAL ENGINEER ALBERTA
BERNIE C. ROSEKE
#66728
13 June 2025

PERMIT TO PRACTICE
ROSEKE ENGINEERING LTD.
RM SIGNATURE:
RM APEGA ID: 66728
DATE: 2025-06-13
PERMIT NUMBER: 11347
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

The data presented herein is for the sole use of the client indicated. Roseke Engineering is no responsible or liable for use of this report by other parties without the knowledge and consent of Roseke Engineering Ltd. The testing services reported herein have been performed in accordance with recognized industry standards unless otherwise noted. No other warranty is made. The test data shown does not include or represent any interpretation or opinion of specification compliance or material sutiability. Should engineering interpretation be required, please provide written reuqest to Roseke Engineering Ltd.



Notes:

1. All Dimensions Metric Meters

2. Origina design:
   -81.0 m x 81.0 m x 7.0m
   -Total capacity
   5,769,571 Gallons
   -Design Capacity (freeboard 0.5m)
   5,074,359 Gallons

3. Constructed asbuilt:
   -Dimensions as shown
   -Colony requested sloped floor to SE as shown
   -Inner and outer slopes grades as shown
   -Top bank width as shown
   -Total Capacity (calculated using CAD)
   5,406,404 Gallons
   -Asbuilt Capacity (freeboard 0.5m)
   4,676,546 Gallons

PROFESSIONAL ENGINEER ALBERTA BERNIE C. ROSEKE

#66728
13 June 2025

PERMIT TO PRACTICE
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RM SIGNATURE:
RM APEGA ID: 66728
DATE: 2025-06-13
PERMIT NUMBER: 11347
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Dennis Dirtworx LTD

Dimensioned

Date	June 2025	Drawn	Dan Dyck
Scale	NTS	Job #	24-397

Notes:

1. Location:
   -SE-13-4-25-W4M

PROFESSIONAL ENGINEER ALBERTA
BERNIE C. ROSEKE

#66728
13 June 2025

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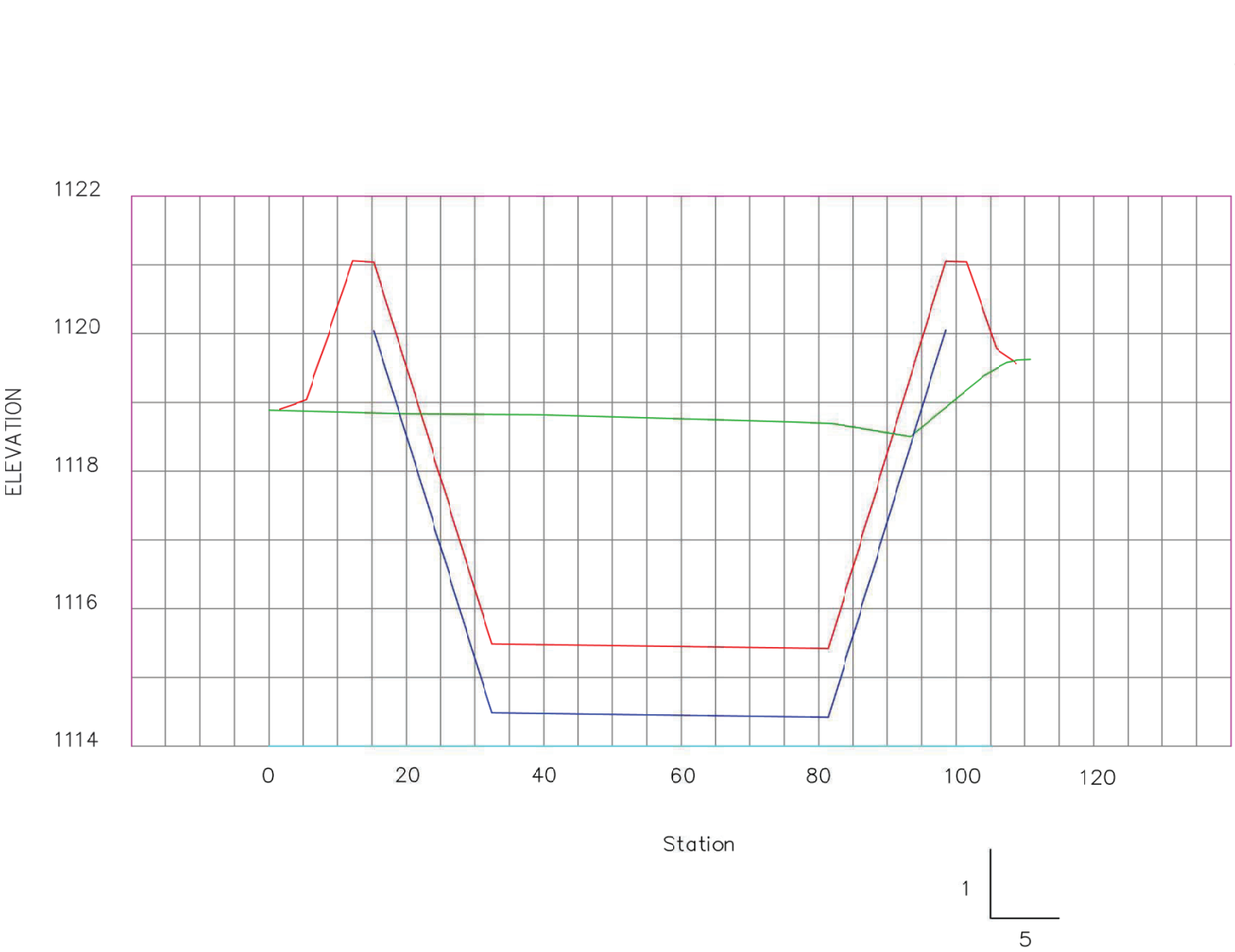
Dennis Dirtworx LTD

Earthview

Date	June 2025	Drawn	Dan Dyck
Scale	NTS	Job #	24-397



Notes:

1. All Dimensions Metric Meters
2. Asbuilt Pond Profile
3. Origina Ground Profile
4. Subgrade Liner
5. Water Table
   -Encountered by construction crew at elevation 1114.00
   -Surveyed in UTM, NAD 83, Zone 12 N

PROFESSIONAL ENGINEER ALBERTA BERNIE C. ROSEKE

#66728
13 June 2025

PERMIT TO PRACTICE
ROSEKE ENGINEERING LTD.
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The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Dennis Dirtworx LTD

Profile A

Date	June 2025	Drawn	Dan Dyck
Scale	NTS	Job #	24-397

ROSEKE ENGINEERING

GEOTECHNICAL EVALUATION

West Raley Hutterite Colony Pond
Cardston County, AB

Prepared For:
West Raley Hutterite Colony
Township Road 42
Cardston County, AB

Prepared By:
Roseke Engineering Ltd.
3614 – 18 Avenue N.
Lethbridge, AB T1H 5S7

Table of Contents

1 Introduction

This project consists of the construction of a new liquid manure storage pond at the West Raley Hutterite Colony in Cardston County, AB. The planned development location is existing pasture / cropland at NE-12-04-25-W4. At the time of drilling, the site had been stripped of topsoil and was generally sloping southeast.

The intent of this geotechnical investigation was to confirm the subsurface stratigraphy at the site, perform in-situ hydraulic permeability testing, and confirm soil suitability as a naturally occurring protective layer for groundwater resources as defined by the *Water Act*, incorporated in the Standards and Administration Regulation under the Agricultural Operations Practices Act (AOPA). A site plan, including borehole locations, is included as Appendix B of this report.

2 Scope of Work

The scope of work for this geotechnical evaluation consisted of the drilling of three (3) boreholes, a laboratory testing program to assist in soil classification and determination of engineering properties, in-situ hydraulic permeability testing, and this report which summarizes the recommendations for the proposed expansion. At the time of field drilling, it was understood that the bottom of the storage facility was anticipated to be 5 m below the existing ground level. Therefore, each of the boreholes were advanced to 16.8 m in order to meet the minimum required depth of investigation as per the National Resources Conservation Board (NRCB)'s requirements outlined in the *Technical Guideline Agdex 096-63* (Agdex 096-63).

3 Geotechnical Work

The fieldwork for the geotechnical investigation was performed on November 15th, 2024, to assess subsurface conditions at the site and install a groundwater monitoring well and standpipes. A drill rig utilizing a 150 mm solid stem continuous flight auger from Chilako Drilling Services Ltd. of Coaldale, AB was used for drilling operations. Roseke (REL)'s field representative was Mr. Christopher Allard, C.E.T. Field operations and sampling were completed under the supervision of REL's field representative. The encountered subsurface soils were logged in the field using visual and tactile methods, and samples were placed in labelled plastic bags for transport, laboratory testing, and future reference. Open boreholes were checked for groundwater and general stability prior to backfilling.

A 51 mm diameter PVC monitoring well was installed in BH001 to determine groundwater levels and conduct in-situ hydraulic conductivity testing on subsoils ≥6 m in depth, as per Agdex 096-63 requirements. 25mm PVC standpipes were installed in the remaining two boreholes to monitor groundwater depths. Borehole logs summarizing soil and groundwater stratigraphy, conditions, and test information are located in Appendix A. On November 28th, 2024, during a site visit to monitor groundwater levels, REL's field representative noted that heavy equipment on site had destroyed and buried the monitoring well in BH001 and the standpipe in BH002 which were re-installed on December 9th, 2024. Installation supervision of the replacement well by REL's field representative confirmed the same subsurface stratigraphy and depths noted in the original borehole logs from November 15th, 2024.

Physical laboratory testing including moisture content, particle size analysis, standard Proctor moisture/density analysis, and ASTM D5084 hydraulic conductivity testing was performed on the collected soil samples to determine engineering properties of the site's soils. Moisture content testing was completed on all retrieved soil samples. Results are presented in Appendix C.

4 Soil Stratigraphy

It should be noted that geological conditions are innately variable. At the time of preparation of this report, information on subsurface stratigraphy was available only at discreet borehole locations. In order to develop recommendations from this information, it is necessary to make some assumptions concerning conditions other than at the borehole locations. Adequate field reviews should be provided during construction to check that these assumptions are reasonable.

The general subsurface conditions at the site consisted predominantly of an upper layer of silty clay till strata, underlain by sandy silt, and bedrock in descending order. The following sections provide a summary of the soils encountered in the borehole logs. The subsurface conditions encountered are summarized in the attached borehole logs in Appendix A.

4.1 Clay Till

Clay till was encountered at the surface in all boreholes and was present to approximate depths of 6.1 m to 6.4 m. The clay till was described as silty with some to a trace of sand and a trace of gravel, and was stiff, moist to very moist, medium plastic, and olive to olive brown. The clay till ranged in moisture content from 15.6% to 24.0%. Particle size analysis indicated a soil texture of clay to clay loam.

4.2 Silt

Silt was encountered beneath the clay till in all boreholes and ranged to depths of approximately 12.2 m to 15.2 m. The silt was described as sandy to trace sand, clayey to trace clay, and was soft, very moist to wet, low to non-plastic, and olive to olive brown. The silt ranged in moisture content from 8.2% to 22.9%. Particle size analysis indicated a soil texture of loam to silt loam.

4.3 Bedrock

Bedrock (mudstone) was encountered beneath the silt in all boreholes and was present to the maximum depth drilled. The mudstone was described as weak, friable, damp to moist, and mottled red & grey to red. The mudstone ranged in moisture content from 4.6% to 10.6%.

5 Groundwater Conditions

At the time of drilling, significant seepage and sloughing was noted in all the boreholes. It is expected that the seepage and sloughing came from the silt layer underlying the upper clay till strata.

The depth to groundwater was measured on December 16th, 2024. The follow table summarizes the groundwater monitoring data.

Borehole ID	Depth of Standpipe Below Ground Surface (m)	Depth to Groundwater from Ground Surface (m)	Approximate Groundwater Elevation (m)
BH001	7.6	3.3	1115.7
BH002	16.8	3.5	1115.2
BH003	16.5	3.7	1115.3

Approximate elevations were provided by Dennis' Dirtworx Ltd.

It is anticipated that groundwater will be encountered during the construction of the storage facility. Groundwater levels should be monitored prior to and during all construction activities to confirm that construction does not take place within 1 m of the groundwater table, as per NRCB requirements. It is anticipated that groundwater control measures such as pumping will be necessary. It should be noted that soil moisture and groundwater levels at the site may fluctuate in response to climatic events.

6 Results and Recommendations

The following recommendations are based on borehole information and are intended to assist designers. Recommendations should not be construed as providing instructions to contractors, who should form their own opinions about site conditions. It is possible that subsurface conditions beyond the borehole locations may vary from those observed. If significant variations are found before or during construction, REL should be contacted so that we can reassess our findings, if necessary.

All recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction and that all construction will be carried out by suitably qualified contractors, experienced in earthworks construction. An adequate level of monitoring is considered to be:

- For earthworks, full-time monitoring and compaction testing.

All such monitoring should be carried out by suitably qualified persons, independent of the contractor. One of the purposes of providing an adequate level of monitoring is to check those recommendations, based on information collected at discreet borehole locations, are applicable to other areas of the site.

6.1 Hydraulic Conductivity Testing

The following subsections summarize the in-situ and laboratory hydraulic conductivity tests conducted as part of this geotechnical investigation. The intent of these tests was to determine if the naturally occurring protective layer beneath the liquid manure storage facility meets the required minimum equivalent thickness of 10 m of material with a hydraulic conductivity (K) of no more than 1×10^{-6} cm/s, per Agdex 096-63, or to provide recommendations for a compacted clay liner / layered liner system to meet these requirements.

6.1.1 In-Situ Testing

In-situ hydraulic conductivity testing was carried out in the groundwater monitoring well installed in BH001. A machine slotted screened section was installed 1 m below the anticipated bottom of the storage facility from 6.0 m to 7.5 m in depth. Backfill of the monitoring well consisted of removing as much slough as possible with the drill auger before filling the borehole with bentonite chips from the bottom of borehole to the bottom of the screened section where filter sand was installed to 0.3 m above the screened section (to account for backfill settlement and migration of fines from the upper bentonite plug), and finally bentonite chips were installed to the ground surface in order to seal the test screen section.

Upon monitoring the groundwater depth prior to testing, it was found that the static groundwater level was >3.0 m above the screen section, indicating that the test layer was saturated and, therefore, rising head hydraulic conductivity was deemed an appropriate test method. Hydraulic conductivity testing was carried out over two days on December 16th and 17th, 2024.

The results of the in-situ hydraulic conductivity testing were calculated using the Hvorslev method. The formula used to determine the in-situ hydraulic conductivity is as follows:

$$K_n = \frac{r^2}{2 \cdot L \cdot T_L} \cdot ln\left(\frac{L}{R}\right)$$

Where: K_n = hydraulic conductivity (cm/s)
r = effective radius of the well (cm)
L = screen length
T_L = time lag factor (when $h_t/H_0 = 0.37$)
R = radius of the well including filter zone

Based on the results of the in-situ testing, a hydraulic conductivity of the naturally occurring protective layer (K_n) value of 7.92×10^{-7} cm/s was determined for the silt (loam to silt loam) layer underlying the storage facility. Further test data is included in Appendix C.

6.1.2 Laboratory Testing

Composite samples from depths of 0 m to 4 m of the upper clay till layer from both BH002 and BH003 were tested for particle size analysis, standard Proctor density, and hydraulic conductivity (ASTM D5084) as per section 4 of the NRCB's *Technical Guidelines Agdex 096-64* (Agdex 096-64). Particle size analyses were conducted at Down To Earth Labs Inc.'s Lethbridge laboratory and indicated a soil texture of clay to clay loam for the upper clay till. Hydraulic conductivity testing was conducted by Solum Consultants Ltd.'s Calgary laboratory and indicated a hydraulic conductivity of 2.1×10^{-8} cm/s and 2.8×10^{-8} cm/s at 95% Standard Proctor Maximum Dry Density (SPMDD). As per Agdex 096-64, the most conservative (highest) of the hydraulic conductivity results is to be compared to regulations and, additionally, the laboratory results used in the calculation of equivalent liner thickness is to be increased one order of magnitude to determine the design hydraulic conductivity of the liner material (K_L) achievable in-field. Therefore, a K_L value of 2.8×10^{-7} cm/s was determined for the clay (clay to clay loam) liner material. It should be noted that the particle size analysis result for sample 2B5 was disregarded as a result of erroneously sampling bedrock and is not considered representative of the naturally occurring protective layer.

Laboratory test results are included in Appendix C.

6.2 Aquifer and Groundwater Resource Identification

The Water Act defines an aquifer as "an underground water bearing formation that is capable of yielding water." As such, the aquifer encountered beneath the storage facility can be considered a confined aquifer as it pertains to NRCB technical guidelines. As part of the NRCB's investigation requirements, it is necessary to identify the uppermost groundwater resource (UGR) of a storage facility site. A groundwater resource is defined according to the Standards and Administration Regulation under AOPA as

(g.1) "an aquifer below the site of a confined feeding operation or manure storage facility"

i) that is being used as a water supply for the purposes of domestic use; or

ii) if no aquifer referred to in subclause (i) exists,

(A) An aquifer that has a sustained yield of 0.76 litres per minute or more and a total dissolved solids concentration of 4000 milligrams per litre or less as determined by well records, well drilling logs,

hydrogeological maps, hydrogeological reports or other evidence satisfactory to the approval officer or the board, and

(B) If there is more than one aquifer that meets the requirements of paragraph (A), the aquifer that an approval officer or the Board considers to be best suited for development as a water supply for the purposes of domestic use;

The following subsections address these criteria used to identify a UGR as they pertain to the site in question.

6.2.1 Aquifer Usage

During email correspondence on February 3rd, 2024, with Mr. Dave Waldner of the West Raley Hutterite Colony, it was confirmed that there are currently no wells on the colony for domestic use. A review of historic well records also indicated that there are no other domestic wells within 1.6 km of the storage facility site. Based on these findings and confirmation from the Colony that there are no domestic use wells on the Colony, it is determined that the site does not meet criteria (i) to be considered a groundwater resource.

6.2.2 Long-Term Sustained Yield – Farvolden Method

As per Appendix 1 of the NRCB's *Technical Guidelines Agdex 096-62* (Agdex 096-62), "*for a geological unit to meet the definition of a groundwater resource, it must have a bulk hydraulic conductivity of 1 x 10^{-6} m/s or greater and a sufficient thickness to support a sustained yield of 0.76 l/min (1.2667 x 10^{-5} m^3/s) or greater.*" In order to calculate the theoretical long-term sustained yield of the silt layer, the Farvolden Method formula was used. The formula is as follows:

$$Q20 = 0.68 \cdot T \cdot Ha \cdot 0.7$$

$$T = K \cdot b$$

Where: Q20 = the 20-year sustained yield (m^3/s)
T = transmissivity of the geological unit (m^2/s)
K = bulk hydraulic conductivity (m/s)
b = thickness of geological unit
H_a = available head (m)

Based on the in-situ hydraulic conductivity test results and observed thicknesses of the silt layer, the theoretical long-term sustained yield of the confined geological unit is calculated to range from 9.2E-08 m^3/s at the thickest encountered depth, to 6.1E-08 m^3/s at the thinnest encountered depth, and averaged 7.7E-08 m^3/s overall. These results indicate that the confined aquifer encountered beneath the storage facility does not meet the required minimum sustained yield as outlined in Agdex 096-62 and, therefore, does not meet criteria (ii) to be considered a groundwater resource.

6.3 Groundwater Protection Recommendations

The NRCB's *Technical Guideline Adgex 096-61* (Agdex 096-61)'s methodology was used to determine the required minimum thickness of the compacted soil layer in order to meet the minimum thickness and hydraulic conductivity requirements specified in the regulation (10 m of material @ 1E-06 cm/s) for a liquid manure storage facility. The formula used to determine the minimum thickness of the compacted soil liner is as follows:

$$\frac{b}{K} = \frac{b_L}{K_L} + \frac{b_n}{K_n}$$

Where: b = required equivalent thickness (10 m)
K = required minimum hydraulic conductivity (1E-06 cm/s)
b_L = required minimum thickness of compacted soil liner (m)
K_L = design hydraulic conductivity of compacted soil liner (cm/s)
b_n = minimum encountered thickness of naturally occurring protective layer (m)
K_n = hydraulic conductivity of naturally occurring protective layer (cm/s)

Based on the in-situ hydraulic conductivity test results, laboratory test results, observed soil layer depths, and the above formula, it is determined that a multi-layered system comprised of a compacted soil liner 0.75 m in thickness, in combination with the naturally occurring protective layer beneath, will be sufficient in order to meet the minimum required thickness and hydraulic conductivity protective layer requirements for a liquid manure storage facility.

6.4 Trench Excavations

Excavations should be carried out in accordance with the Alberta Occupational Health and Safety (OH&S) Regulations. For this project, the depth for the majority of the excavations is assumed to be less than 3.0 m below existing ground surface. Excavations to deeper depths may require special considerations. The following recommendations notwithstanding, the responsibility of trench and all excavation cutslopes resides with the Contractor and should take into consideration site-specific conditions concerning soil stratigraphy and groundwater. All excavations should be reviewed by a geotechnical engineer prior to personnel working within the base of the excavation.

Temporary excavations within the firm to stiff clay till soils which are to be deeper than 1.5 m should have the sides shored and braced or the slopes should be cut back no steeper than 1.0 horizontal to 1.0 vertical (1H:1V)

Flatter sideslopes may be required in some areas if groundwater is encountered. In these instances, the excavation configuration design should be reviewed by experienced personnel, prior to allowing personnel to enter the base of the excavation.

Any encountered groundwater seepage should be directed towards sumps for removal. Conventional construction sump pumps should be capable of groundwater control.

Temporary surcharge loads, such as spill piles, should not be allowed within a distance equal to the depth of the excavation from an unsupported excavation face or 3.0 m, whichever is greater, while mobile equipment should be kept back at least 3.0 m. All excavation sideslopes should be checked regularly for signs of sloughing, especially after rainfall periods. Small earth falls from the sideslopes are a potential source of danger to workmen and must be guarded against.

6.5 Storage Pond Construction

Final design of this project should consider, in detail, the subgrade preparation of the proposed ponds so that the base of the ponds is founded on competent materials. Based on REL's experience with local soils, it is anticipated that interbedded seams of silt and sand may be encountered throughout the upper clay till, therefore thoroughly mixing and blending all liner material will be critical for the long-term performance of the compacted soil liner.

All surficial vegetation, topsoil, and any organic material within the proposed pond area should be stripped and removed. Following this removal, the area may be graded for pond construction. Due to the encountered groundwater

depths, standpipes and wells should be monitored prior to construction to ensure that pond bottom construction does not take place within 1 m of the water table, as per NRCB requirements. It is anticipated that groundwater mitigation measures such as pumping will be necessary in order to maintain this separation.

A minimum 300 mm subgrade preparation should be conducted prior to installation of compacted soil liner, including scarifying the subgrade soil, moisture conditioning, and recompacting to a minimum of 98% of SPMDD with moisture content of 0% to +2% of Optimum Moisture Content (OMC). Select engineered fill should be used for the compacted soil liner and should be placed in lifts of no greater than 150 mm compacted thickness, uniformly mixed and compacted to a minimum density of 95% of SPMDD at ±2% of OMC. The subgrade surface below the compacted soil liner should be relatively level to control liner thickness, and proof-rolled to provide a proper base for compacting the first liner lift to the specified density. General recommendations for compaction can be found in Appendix D. Proof-rolling should be supervised by experienced geotechnical personnel, specific requirements and methods for proof-rolling should be prepared during construction in consultation with REL.

It is important for the pond berm to be well constructed to avoid settlement, slumping, and erosion; and to provide good support for liners, erosion protection, and vehicles. Subgrade preparation comprises removal of topsoil and any soft, compressible soils from the berm area, and compacting the scarified surface to at least 98% of SPMDD. Fill lifts for berm construction should be level, uniform, and horizontally parallel. The pond berm backfill materials should be moisture conditioned to within ±2% of OMC values and compacted to 95% of SPMDD in lifts not exceeding 150 mm in compacted thickness. As discussed above, any excavated low plastic clay or silty / sandy material not suitable as a liner may be used for the core and outer shell of the berms.

A compacted soil liner should be constructed by placing controlled local clay soils, from the top 0 m to 4 m, up to the design elevation or thickness on the bottom of the ponds and interior slopes of the berms. The clay liner soils should be uniformly moisture conditioned to the compaction standards noted above. At the completion of compaction, at final design grade, the pond bases should be proof-rolled using a relatively large smooth-drum roller. This smooth rolled surface provides a much smoother base, which greatly reduces the surface area for water absorption and swelling.

In areas where an interior clay liner is placed on an existing slope, it is important to specify that a system of 'notching' the existing subgrade be implemented. This notching technique ensures a good bond between the clay liner and adjacent material to minimize the risk of developing a failure plane parallel to the interior slope face.

It is recommended to fill the ponds as soon as possible following completion of construction to prevent excessive drying and cracking of the compacted soil liner. It is recommended to develop a construction Quality Assurance Control Plan (QACP) before construction, such that construction quality is monitored and maintained throughout the construction process.

6.6 Liner Materials and Compaction

Compacted soil liner material should consist of a medium plastic clay from the upper clay till strata (0 m to 4 m) not containing organics or deleterious materials and should be compacted to the compaction standard specified in section 6.5. At all times, compacted soil liner material should be visually inspected during placement to isolate any inclusions of silt or sand material which should be separated and removed from the compacted liner area.

Low to medium plastic clay is generally considered suitable for use as general engineered fill. It should be free of organic and deleterious material.

Backfill density testing should be utilized to ensure the backfill compaction and moisture is sufficient wherever backfill is placed.

6.7 Borehole Reclamation

Once it is determined that the boreholes, standpipes, and monitoring wells are no longer needed, they should be reclaimed as per the NRCB's *Technical Guideline Agdex 096-50 Reclamation of Groundwater Monitoring Wells.*

7 Conclusions

Based on the observed geotechnical soil and groundwater conditions, as well as field and laboratory test results, it is concluded that the confined aquifer at the site does not meet the requirements to be considered a groundwater resource. Therefore, a multi-layered system comprised of a compacted soil liner no less than 0.75 m in thickness, in combination with the minimum encountered depth of naturally occurring protective loam to silt loam layer, is anticipated to meet or exceed the minimum equivalent protective layer requirements as per NRCB technical guidelines.

8 Closure

We trust that this report meets your current requirements, and we are pleased to provide assistance in the completion of this project. Please do not hesitate to contact me if you have any comments, questions, or concerns.

Respectfully submitted by:

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PROFESSIONAL ENGINEER ALBERTA
BERNIE C. ROSEKE
#66728
25 February 2025

PERMIT TO PRACTICE
ROSEKE ENGINEERING LTD.
RM SIGNATURE:
RM APEGA ID: 66728
DATE: 2025-02-25
PERMIT NUMBER: 11347
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Appendix A – BOREHOLE LOGS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm 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 TERM	RELATIVE DENSITY	N (blows per 0.3m)
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 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm 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 TERM	UNCONFINED COMPRESSIVE STRENGTH (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.

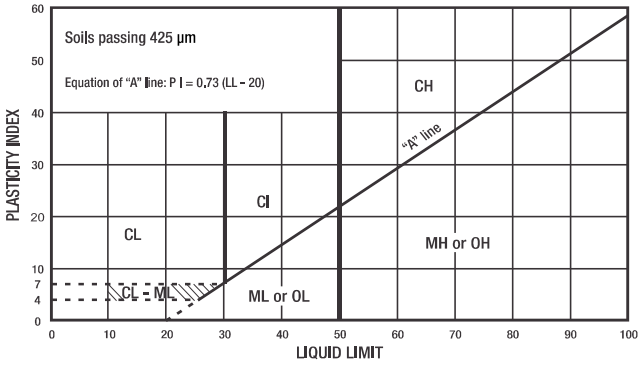
MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION
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
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	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
			SP	Poorly graded sands and gravelly sands, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
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
	SILTS 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
	CLAYS Above "A" line on plasticity chart negligible organic content Liquid limit 30-50		CI	Inorganic clays of medium plasticity, silty clays
	CLAYS Above "A" line on plasticity chart negligible organic content 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
	ORGANIC SILTS AND CLAYS Liquid limit >50		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils

LABORATORY CLASSIFICATION CRITERIA		
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	
	Not meeting both criteria for GW	
	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
	Atterberg limits plot above "A" line or plasticity index greater than 7	
	$C_U = D_{60}/D_{10}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
	Not meeting both criteria for SW	
	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
	Atterberg limits plot above "A" line or plasticity index greater than 7	

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 PASSING	SIEVE SIZE RETAINED	DEFINING RANGES OF PERCENTAGE BY MASS OF MINOR COMPONENTS: PERCENTAGE	DESCRIPTOR
GRAVEL				
coarse	75 mm	19 mm	>35 %	"and"
fine	19 mm	4.75 mm	21 to 35 %	"y-adjective"
SAND				
coarse	4.75 mm	2.00 mm	10 to 20 %	"some"
medium	2.00 mm	425 µm		
fine	425 µm	75 µm	>0 to 10 %	"trace"
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

Project: West Raley Colony Liquid Manure Storage Pond	NE-12-04-25-W4	BOREHOLE NO: **BH001**
Client: West Raley Hutterite Colony		PROJECT NO: REL243068
	Solid Stem Auger	ELEVATION: 1119 m

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | NO RECOVERY

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

Depth (m) / Water Level	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	BLOWS /150 mm	PLASTIC M.C. LIQUID (20 40 60 80)	▲ VANE SHEAR (kPa) ▲ (100 200 300 400) ■ N-VALUE ■ (20 40 60 80) ◆ UNCONF. SHEAR STR. (kPa) ◆ (50 100 150 200) ● POCKETPEN. (kPa) ● (100 200 300 400)	SOIL TEXTURE	WELL INSTALLATION	Elevation (m)
0		Clay Till - silty, trace sand and gravel, stiff, moist, medium to high plastic, olive to olive brown								1119
1				B1						1118
2								Clay to Clay Loam		1117
3 ▼		- moist to very moist								1116
4				B2						1115
5										1114
6		- some sand								1113
7		Silt - sandy, some clay, soft, very moist, low to non-plastic, olive to olive brown		B3				Loam		1112
8										1111
9										1110
10		- trace to some sand, wet		B4				Silt Loam		1109
11										1108
12										1107
13										1106
14				B5				Loam		1105
15										1104
16		Bedrock (mudstone) - weak, friable, mottled red and grey		B6						1103
17		End of borehole at 16.8 m, approximately 6.7 m of sloughing and seepage. 51 mm monitoring well re-installed to 7.6 m and screened as indicated on December 9, 2024. Depth to groundwater as indicated when measured on December 16, 2024.								1102
18										1101
19										1100
20										1099
21										1098
22										1097
23										1096
24										1095
25										1094
26										1093
27										1092
28										

LOGGED BY: CA	COMPLETION DEPTH: 16.76 m
REVIEWED BY: BR	COMPLETION DATE: 24-11-15

Project: West Raley Colony Liquid Manure Storage Pond	NE-12-04-25-W4	BOREHOLE NO: **BH002**
Client: West Raley Hutterite Colony		PROJECT NO: REL243068
	Solid Stem Auger	ELEVATION: 1118.7 m

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | NO RECOVERY

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

Depth (m) / Water Level	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	BLOWS /150 mm	SOIL TEXTURE	SLOTTED PIEZOMETER	Elevation (m)
0		Clay Till - silty, trace sand and gravel, stiff, moist, medium to high plastic, olive to olive brown		B1		Clay to Clay Loam		1118
1								1117
2								1116
3 ▼				B2				1115
4								1114
5		- some sand						1113
6								1112
7		Silt - sandy, trace clay, soft, wet, low to non-plastic, olive to olive brown, laminations of sand and clay		B3		Silt Loam		1111
8								1110
9								1109
10		- some clay		B4		Loam		1108
11								1107
12								1106
13		Bedrock (mudstone) - weak, friable, mottled red and grey		B5				1105
14								1104
15		- red						1103
16								1102
17		End of borehole at 16.8 m, approximately 6.1 m of sloughing and seepage. Standpipe re-installed to 16.8 m on December 9, 2024. Depth to groundwater as indicated when measured on December 16, 2024.						1101
18								1100
19								1099
20								1098
21								1097
22								1096
23								1095
24								1094
25								1093
26								1092
27								1091
28								

PLASTIC — M.C. — LIQUID (20 40 60 80)

▲ VANE SHEAR (kPa) ▲ (100 200 300 400)

■ N-VALUE ■ (20 40 60 80)

◆ UNCONF. SHEAR STR. (kPa) ◆ (50 100 150 200)

● POCKETPEN. (kPa) ● (100 200 300 400)

LOGGED BY: CA	COMPLETION DEPTH: 16.76 m
REVIEWED BY: BR	COMPLETION DATE: 24-11-15

Project: West Raley Colony Liquid Manure Storage Pond	NE-12-04-25-W4	BOREHOLE NO: **BH003**
Client: West Raley Hutterite Colony		PROJECT NO: REL243068
	Solid Stem Auger	ELEVATION: 1119 m

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | NO RECOVERY

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

Depth (m) / Water Level	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	BLOWS /150 mm	SOIL TEXTURE	Elevation (m)
0		Clay Till - silty, trace sand and gravel, stiff, moist, medium to high plastic, olive to olive brown		B1		Clay to Clay Loam	1118
1							1117
2							1116
3				B2			1115
4							1114
5							1113
6		- some sand					1112
7		Silt - sandy, some clay, soft, wet, low to non-plastic, olive to olive brown, laminations of sand and clay		B3		Silt Loam	1111
8							1110
9							1109
10		- some clay		B4		Loam	1108
11							1107
12							1106
13		- sandy clayey		B5		Loam	1105
14		Bedrock (mudstone) - weak, friable, mottled red and grey					1104
15							1103
16							1102
17		Practical auger refusal at 16.5 m, approximately 7.6 m of sloughing and seepage. Standpipe installed to 16.5 m. Depth to groundwater as indicated when measured on December 16, 2024.					1101
18							1100
19							1099
20							1098
21							1097
22							1096
23							1095
24							1094
25							1093
26							1092
27							
28							

PLASTIC — M.C. — LIQUID (20 40 60 80)

▲ VANE SHEAR (kPa) ▲ (100 200 300 400)

■ N-VALUE ■ (20 40 60 80)

◆ UNCONF. SHEAR STR. (kPa) ◆ (50 100 150 200)

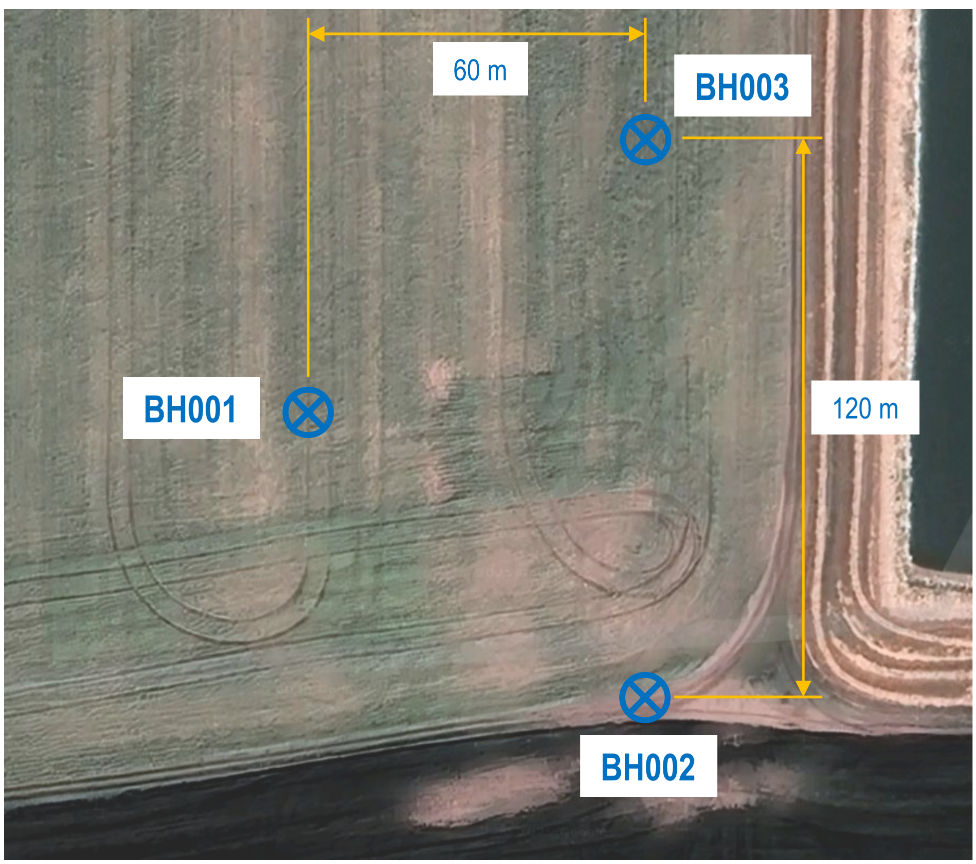
● POCKETPEN. (kPa) ● (100 200 300 400)

SLOTTED PIEZOMETER

LOGGED BY: CA	COMPLETION DEPTH: 16.46 m
REVIEWED BY: BR	COMPLETION DATE: 24-11-15

Appendix B – BOREHOLE LOCATION PLAN


N
Raley
Hwy-5
Site Location
Approximate Coordinates:
49.2839, -113.2350


60 m
BH003
BH001
120 m
BH002

Appendix C – FIELD / LABORATORY TEST RESULTS

MOISTURE CONTENT

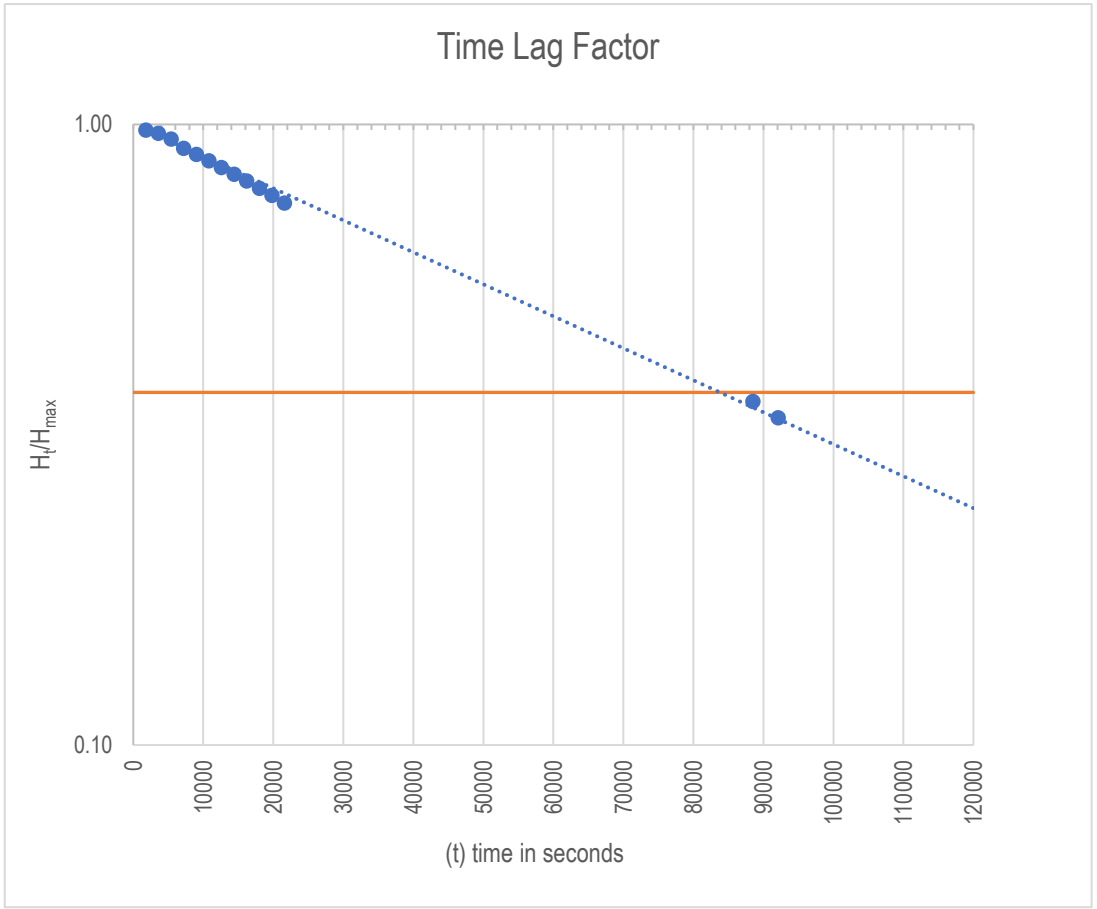
JOB #	JOB DESCRIPTION	PROJECT
REL243068	West Raley Colony Pond	Evaluation

Borehole ID	Sample ID	Depth (m)	Tare Mass (g)	Wet + Tare (g)	Dry + Tare (g)	Moisture %
BH001	1B1	0.9	6.4	264.1	214.2	24.0
	1B2	3.7	6.4	309.7	265.0	17.3
	1B3	6.7	6.4	279.5	248.9	12.6
	1B4	9.8	6.4	346.0	287.7	20.7
	1B5	14.3	6.4	274.5	233.7	17.9
	1B6	16.0	6.4	236.2	214.1	10.6
BH002	2B1	0.9	6.4	283.1	245.8	15.6
	2B2	3.7	6.4	283.9	239.9	18.8
	2B3	6.7	6.4	282.6	231.1	22.9
	2B4	9.8	6.4	275.3	244.1	13.1
	2B5	12.8	6.5	36.0	34.7	4.6
BH003	3B1	0.9	6.4	257.9	218.5	18.6
	3B2	3.7	6.4	261.5	222.7	17.9
	3B3	6.7	6.4	304.0	264.4	15.3
	3B4	10.4	6.4	245.6	218.3	12.9
	3B5	13.1	6.4	112.9	104.8	8.2

In-Situ Hydraulic Conductivity Testing - Rising Head - Hvorslev's Method

Depth of Groundwater From Top of Well Prior to Test (cm)	371	Time Lag Factor (s)	84,000

	Date	Time	Depth to Groundwater from Top of Well (cm)
t_0 =	2024-12-16	10:10	466
t_1 =	2024-12-16	10:40	464
t_2 =	2024-12-16	11:10	463
t_3 =	2024-12-16	11:40	461
t_4 =	2024-12-16	12:10	458
t_5 =	2024-12-16	12:40	456
t_6 =	2024-12-16	13:10	454
t_7 =	2024-12-16	13:40	452
t_8 =	2024-12-16	14:10	450
t_9 =	2024-12-16	14:40	448
t_{10} =	2024-12-16	15:10	446
t_{11} =	2024-12-16	15:40	444
t_{12} =	2024-12-16	16:10	442
t_{13} =	2024-12-17	10:45	405
t_{14} =	2024-12-17	11:45	403



Down To Earth Labs Inc.
The Science of Higher Yields

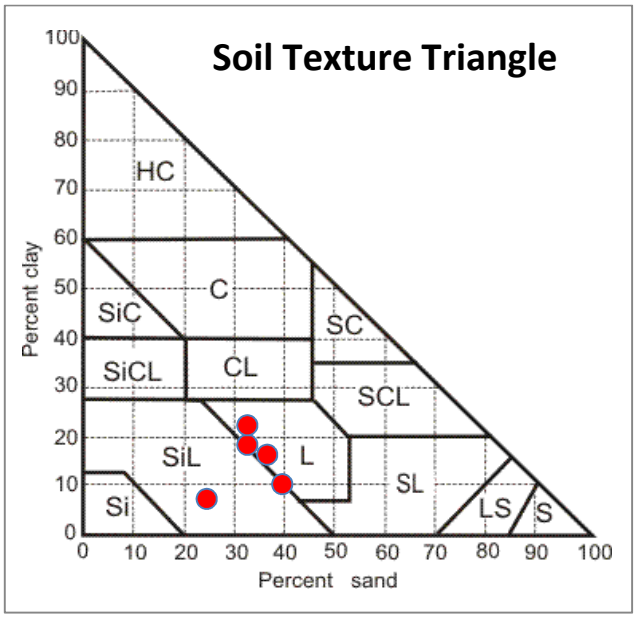
Christopher Allard
101 Riverine Lane West
Lethbridge, AB T1K 5V6

Report #: 200284
Report Date: 2024-12-17
Received: 2024-11-28
Completed: 2024-12-02
Test Done: ST

Project : REL243-068 West Raley Colony - Liquid Manure Pond
PO:

3510 6th Ave North
Lethbridge, AB T1H 5C3
403-328-1133
www.downtoearthlabs.com
info@downtoearthlabs.com

Analyte	Units	Sample ID: 241128N001	241128N002	241128N003	241128N004	241128N005
		Cust. Sample ID: 1B3	1B4	1B5	2B3	2B4
Sand	%	32.8	39.8	36.8	24.7	32.8
Silt	%	49.2	50.2	47.2	68.3	45.2
Clay	%	18.0	10.0	16.0	7.0	22.0
Soil Texture	-	Loam	Silt Loam	Loam	Silt Loam	Loam



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Christopher Allard
101 Riverine Lane West
Lethbridge, AB T1K 5V6

Report #: 200284
Report Date: 2024-12-17
Received: 2024-11-28
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Test Done: ST

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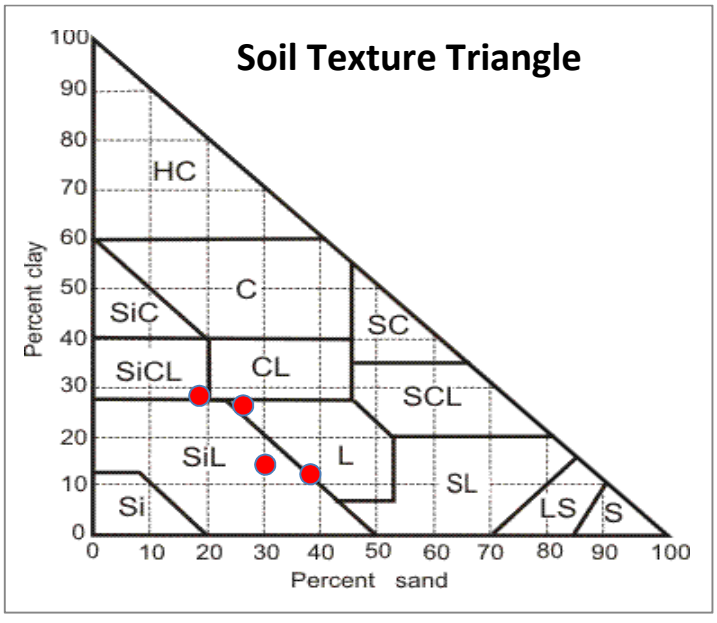
Analyte	Units	Sample ID: 241128N006 Cust. Sample ID: 2B5	241128N007 3B3	241128N008 3B4	241128N009 3B5
Sand	%	18.8	30.5	38.5	26.6
Silt	%	53.2	55.5	49.5	47.4
Clay	%	28.0	14.0	12.0	26.0
Soil Texture	-	Silty Clay Loam	Silt Loam	Loam	Loam



Raygan Boyce - Chemist

Down To Earth Labs Inc.
The Science of Higher Yields

Roseke Engineering Ltd.
3614 18 Ave N
Lethbridge, T1H 5S7
Canada

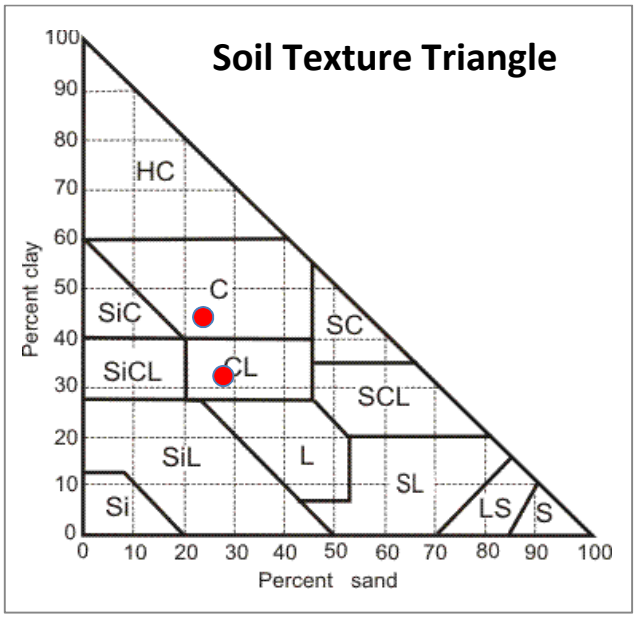
Report #: 201848
Report Date: 2025-01-08
Received: 2025-01-06
Completed: 2025-01-08
Test Done: ST

Project :

PO:

3510 6th Ave North
Lethbridge, AB T1H 5C3
403-328-1133
www.downtoearthlabs.com
info@downtoearthlabs.com

		Sample ID:	250106O027	250106O028
		Cust. Sample ID:	BH002/Bulk Sample	BH003/Bulk Sample
Analyte	**Units**			
Sand	%		24.0	28.0
Silt	%		32.0	40.0
Clay	%		44.0	32.0
Soil Texture	-		Clay	Clay Loam



Raygan Boyce - Chemist

SOLUM CONSULTANTS LTD.

GEOTECHNICAL & MATERIAL TESTING LABORATORY

Geo-Lab Report

Revision # 0

Report Date:	*January 26, 2025*
Client:	*Roseke Engineering Ltd.*
Address:	*3614 18 Ave. N, Lethbridge, AB T1H 5S7*
Attn:	*Chris Allard*
Project No:	*243068*
Project Name:	*West Raley Colony*
Solum Job No.:	*18401250107(6)*

Sample Received Date: January 7, 2025

Sample Quantity: 2 bags

Test	Quantity	Destination
HYDRAULIC CONDUCTIVITY (FINES)(Method A)(Flexible Wall)	2	D5084

President: Saad Farag

#9, 3620 29 ST NE, Calgary, AB T1Y 5Z8

phone: (403)250-3035
Cell: (403)619-7250

solum@mymts.net
solumconsultantsltd111@outlook.com
www.solumconsultantsltd.com

SOLUM CONSULTANTS LTD.
GEOTECHNICAL & MATERIAL TESTING LABORATORY

Hydraulic Conductivity Test (ASTM D5084- Method A)

Project Info: *243068 / West Raley Colony* *Reviewed by:* *S. F.*

Client: *Roseke Engineering Ltd.*

Solum Job No.: *18401250107(6)*

Sample Info: ***BH002*** ***1.0-4.0 m***

Test Parameters

Soil Type: Remoulded | Approx. Sat. Time (days): 9 | Test Fluids: tap water | Assumed Gs: 2.70

	Sample Information						Remoulding Information			
	Height (cm)	Diameter (cm)	MC (%)	mass (g)	Dry BD (kg/m^3)	Est. Sat. Degree (%)	OPT MC(%)	MAXDD (kg/m^3)	Remoulding Percentage	Target Density (kg/m^3)
Pre-Test Data	6.95	7.00	17.6	512.4	1630	72	18.4	1723	95	1637
Post-Test Data	6.98	7.02	25.1	545.0	1613	100				

Test Results

Elapsed Time (h)	Test Time (h)	Temp (deg. C)	Rt	P_{cell} (kPa)	P_{Head} (kPa)	P_{Tail} (kPa)	(In + Out)/2 (mL)	Gradient	Hydraulic Conductivity K_{20} (cm/sec)
112	10	16.9	1.081	250.0	230.1	200.0	3.49	44.2	6.17E-08
137	10	17.4	1.068	250.0	230.0	200.1	2.77	43.9	4.86E-08
153	10	17.3	1.070	250.1	230.0	200.0	2.12	44.0	3.72E-08
168	10	16.8	1.084	250.0	230.1	200.1	1.61	44.0	2.86E-08
181	10	16.9	1.081	250.1	230.2	200.2	1.60	44.0	2.84E-08

Avg. K_{20} (cm/sec) **2.8E-08** **Avg. K_{20} (m/sec)** **2.8E-10**

Remarks:

SOLUM CONSULTANTS LTD.
GEOTECHNICAL & MATERIAL TESTING LABORATORY

Hydraulic Conductivity Test (ASTM D5084- Method A)

Project Info:	*243068 / West Raley Colony*	*Reviewed by:*	*S. F.*
Client:	*Roseke Engineering Ltd.*		
Solum Job No.:	*18401250107(6)*		
Sample Info:	***BH003 1.0-4.0 m***		

Test Parameters

Soil Type: Remoulded | Approx. Sat. Time (days): 9 | Test Fluids: tap water | Assumed Gs: 2.70

	Sample Information						Remoulding Information			
	Height (cm)	Diameter (cm)	MC (%)	mass (g)	Dry BD (kg/m^3)	Est. Sat. Degree (%)	OPT MC(%)	MAXDD (kg/m^3)	Remoulding Percentage	Target Density (kg/m^3)
Pre-Test Data	7.44	7.00	15.1	578.3	1754	76	13.8	1853	95	1760
Post-Test Data	7.47	7.02	20.5	605.6	1738	100				

Test Results

Elapsed Time (h)	Test Time (h)	Temp (deg. C)	Rt	P_{cell} (kPa)	P_{Head} (kPa)	P_{Tail} (kPa)	(In + Out)/2 (mL)	Gradient	Hydraulic Conductivity K_{20} (cm/sec)
106	10	17.1	1.076	250.0	230.1	200.0	3.32	41.2	6.25E-08
123	10	17.7	1.059	250.1	230.1	200.1	2.54	41.1	4.73E-08
142	10	18.2	1.046	250.1	230.0	200.0	1.76	41.1	3.23E-08
159	10	18.4	1.041	250.1	230.1	200.1	1.16	41.1	2.12E-08
172	10	18.5	1.038	250.0	230.0	200.1	1.15	41.0	2.10E-08

Avg. K_{20} (cm/sec) **2.1E-08** | **Avg. K_{20} (m/sec)** **2.1E-10**

Remarks:

SOLUM™
CONSULTANTS LTD.
GEOTECHNICAL & MATERIAL
TESTING LABORATORY

STANDARD LABORATORY TERMS AND CONDITIONS

1.0 Description of Services to be Performed by Solum Consultants Ltd. (Solum)
Solum shall provide geotechnical and material laboratory testing services on samples in accordance with these terms and conditions and executed Laboratory Testing Request Forms. Solum shall perform its work in accordance with accepted laboratory standards, such as ASTM, CSA or client's specific specs, as well as accepted standard operating procedures. Solum reserves the right to modify methods as necessary based upon experience and/or current scientific literature. If the Client requests a manner of analysis that varies from standard operating or recommended procedures, the Client shall not hold Solum responsible for the results. Such variations of analysis will be noted on the reports. Solum reserves the right to subcontract laboratory testing if a particular test cannot be performed by Solum.

2.0 Reports, Confidentiality and Third Parties
Laboratory reports provided by Solum will be composed of a cover page, tables and figures if applicable. Reports will be e-mailed in PDF format to the individual(s) specified on the Laboratory Testing Request Forms. Laboratory reports may also be faxed or mailed to the Client upon request. Except as required by law, Solum shall not disclose testing results or reports to any party other than the Client, unless the Client, in writing, requests information to be provided to a third party. Solum shall abide by any additional confidentiality requirements requested by the Client provided that such requirements are provided to Solum at or before execution of the testing.
Information provided by Solum is intended for Client use only. Any use by a third party, of reports or documents authored by Solum, or any reliance on or decisions made by a third party based on the findings described in said documents, are the sole responsibility of such third parities, and Solum accepts no responsibility of damages suffered by any third party as a result of decisions made or actions conducted.

3.0 Laboratory Testing Request Form (Chain of Custody)
The laboratory testing request form must be completed by the Client and be accompanied with the samples. Other form of COC may be accepted; however, the condition of Solum COC is still applied. Testing will not commence until the laboratory testing request form has been completed. If requested by the Client, Solum shall provide a copy of the laboratory testing request form with the report.
No persons other than the designated representatives for each Laboratory Testing Request Form are authorized to act regarding changes to the testing request form. Any changes or amendments of the laboratory testing request form must be in writing and be completed by the originator.

4.0 Acceptance, Contamination and Disposal of Samples
Loss or damages to samples remains the responsibility of the Client until Solum representatives acceptance of samples by notation on the laboratory testing request form.
As to any samples that are suspected of containing hazardous substances, the Client will specify the suspected or known substance and level of contamination. This information is to be stated on the laboratory testing request form and be accompanied with the samples before testing can commence. Solum may refuse acceptance of samples if it determines they present a risk to health and safety.
Samples accepted by Solum shall remain the property and liability of the Client while in the custody of Solum. Solum will discard all non-contaminated samples after two weeks of submitting lab report or a month from the date of receiving the samples without additional retention period at a fixed disposal charge, or if requested by the Client, samples may be returned to the Client at no cost to Solum. If requested by client, Solum will store samples provided the client agrees to pay for the storage charge. Contaminated material may be returned/shipped to the Client at the Client's expense or Solum will discard samples with disposal rates varying for samples containing higher levels of contamination, refer to price list.
Soil samples requested to be stored will be stored inside the lab up to the expiration of storage period. Soil samples will be discarded upon the expiration date of the storage period unless client requests either extending storage period or return samples back to client at no cost to Solum.

5.0 Indemnification/Hold Harmless
Solum shall protect, indemnify and save harmless Client, and its directors, officers, employees, agents, representatives, invitees and subcontractors, and at Client's request, investigate and defend such entities form and against all claims, demands and causes of action, of every kind and character, without limitation, arising in favour of or made by third parties, on account of bodily injury, death or damage to or loss of their property resulting from any negligent act or wilful misconduct of Solum.
The Client shall protect, indemnify and save harmless Solum, and its directors, officers, employees, agents, representatives, invitees and subcontractors, and at Solum's request, investigate and defend such entities form and against all claims, demands and causes of action, of every kind and character, without limitation, arising in favour of or made by third parties, on account of bodily injury, death or damage to or loss of their property resulting from any negligent act or wilful misconduct of Client.

6.0 Limitation of Liability
The total liability of Solum or its staff whether based in contract or tort, will be limited to the lesser of the fees paid or actual damages incurred by the Client. Solum will not be responsible for any consequential or indirect damages even if caused by negligence of Solum. Solum will only be liable for damages resulting form negligence of Solum. All claims by the Client shall be deemed relinquished if not made within one year after the testing date. No warranty is either expressed or implied, or intended by any agreement or by furnishing oral or written reports or findings.

7.0 Termination of Testing Work Order
The Client may order work suspended or terminated upon seven days advance written notice. If work is suspended, Solum shall receive, upon resumption, an adjustment in the cost of services to compensate for additional costs incurred due to the interruption of services. Upon suspension or termination, Solum shall preserve samples provided that the Client agrees to pay the sample storage charge.

8.0 Pricing, Payments and Invoicing
Invoices will be based on most current Solum laboratory testing rates; rates may change without notice. Solum invoices shall be paid within thirty (30) days of receipt of the invoice. Amounts not paid when due shall bear interest at the rate of 18% per annum from the date due until the date of payment.

Moisture - Density Relationship Report

3614 18th Avenue North
Lethbridge AB T1H 5S7
Tel: 1-403-942-6170

TO: **West Raley Colony**
Township Road 42
Cardston County, AB

ATTENTION:
EMAIL:

ROSEKE PROJECT #: REL243-068

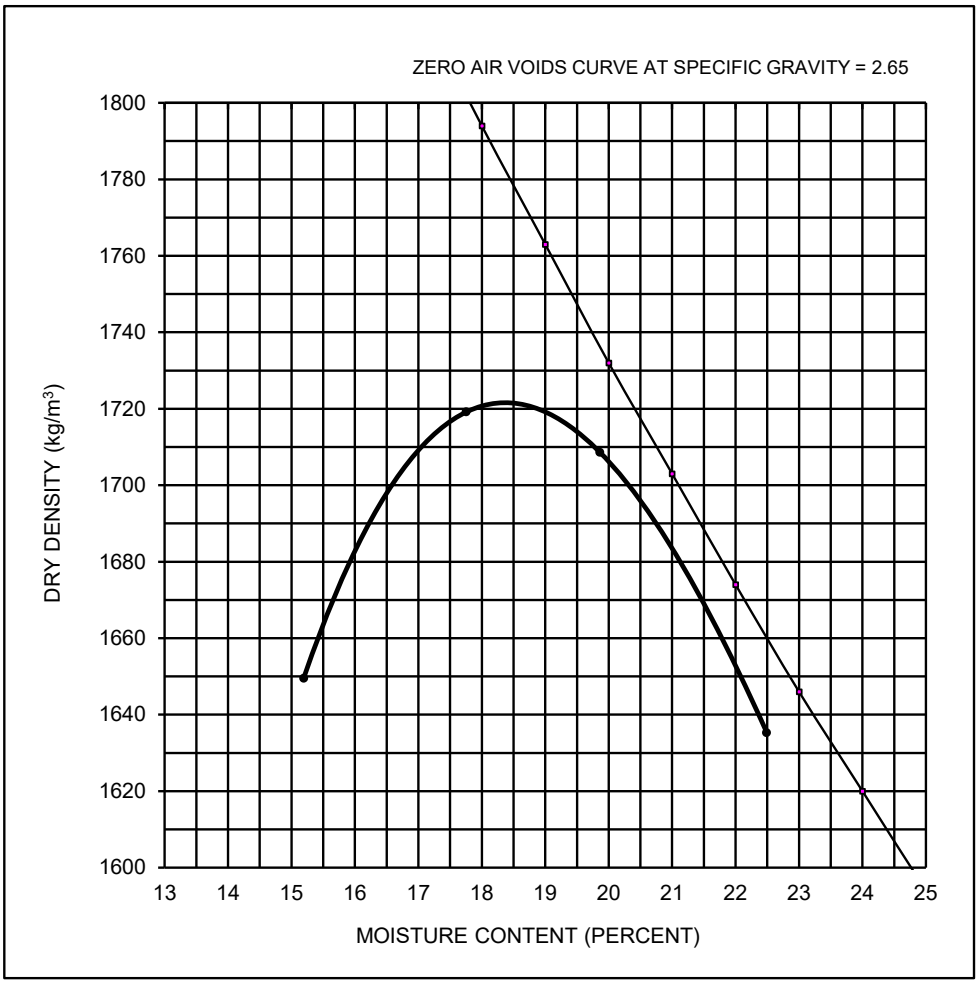
PROJECT: West Raley Colony - NRCB Assesment

COMPACTION STANDARD [X] ASTM D698 [ ] ASTM D1557 [ ] ASTM D558 **METHOD:** A

DRY DENSITY kg/m³	1650	1719	1709	1635			
MOISTURE CONTENT (%)	15.2	17.8	19.9	22.5			

MAXIMUM DRY DENSITY: 1723 kg/m³
OPTIMUM MOISTURE CONTENT: 18.4 %

SOURCE: BH002 - 0m to 4m composite sample



DATE SAMPLED: 15-Nov-24
SAMPLED BY: REL / CA
DATE RECEIVED: 6-Jan-25
SAMPLE NO.: 2

RAMMER TYPE
[ ] AUTO
[X] MANUAL

PREPARATION
[X] MOIST
[ ] DRY

PERCENT RETAINED
[E - 5] 4.75 mm SCREEN
[ ] 9.50 mm SCREEN
[ ] 19.0 mm SCREEN

SOIL DESCRIPTION:
Clay

Roseke Engineering Ltd.

Per: [redacted]
Christopher Allard, C.E.T.

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request.

Moisture - Density Relationship Report

ROSEKE ENGINEERING

3614 18th Avenue North
Lethbridge AB T1H 5S7
Tel: 1-403-942-6170

TO: **West Raley Colony**
Township Road 42
Cardston County, AB

ATTENTION:
EMAIL:

ROSEKE PROJECT #: REL243-068

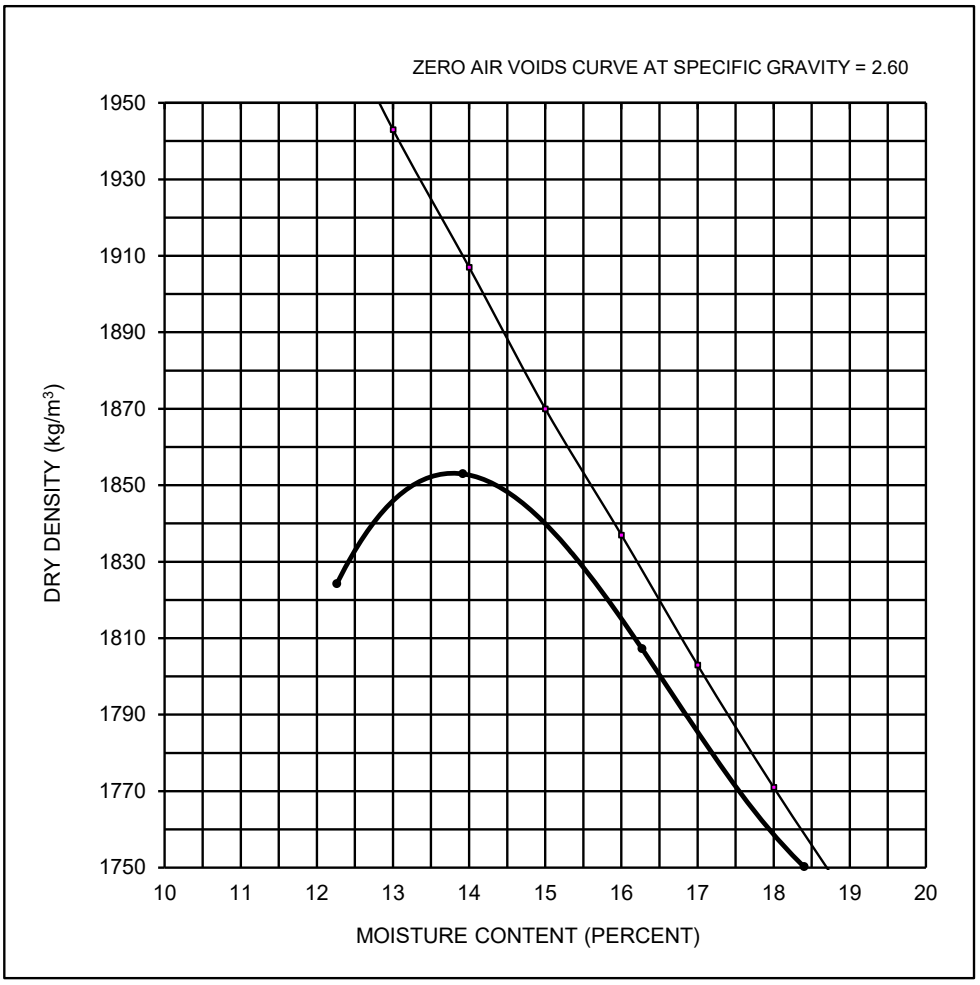
PROJECT: West Raley Colony - NRCB Assesment

COMPACTION STANDARD [X] ASTM D698 [ ] ASTM D1557 [ ] ASTM D558 **METHOD:** A

DRY DENSITY kg/m³	1824	1853	1807	1750			
MOISTURE CONTENT (%)	12.3	13.9	16.3	18.4			

MAXIMUM DRY DENSITY: 1853 kg/m³
OPTIMUM MOISTURE CONTENT: 13.8 %

SOURCE: BH003 - 0m to 4m composite sample



DATE SAMPLED: 15-Nov-24
SAMPLED BY: REL / CA
DATE RECEIVED: 6-Jan-25
SAMPLE NO.: 3

RAMMER TYPE
[ ] AUTO
[X] MANUAL

PREPARATION
[X] MOIST
[ ] DRY

PERCENT RETAINED
[E - 5] 4.75 mm SCREEN
[ ] 9.50 mm SCREEN
[ ] 19.0 mm SCREEN

SOIL DESCRIPTION:
Clay

Roseke Engineering Ltd.

Per: [redacted]
Christopher Allard, C.E.T.

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request.

Appendix D – GENERAL CONSTRUCTION GUIDELINES

Backfill Materials and Compaction

1.0 Definitions

"Landscape fill" is typically used in areas such as berms and grassed areas where settlement of the fill and noticeable surface subsidence can be tolerated. "Landscape fill" may comprise soils without regard to engineering quality.

"General engineered fill" is typically used in areas where a moderate potential for subgrade movement is tolerable, such as asphalt (i.e., flexible) pavement areas. "General engineered fill" should comprise clean, granular or clay soils.

"Select engineered fill" is typically used below slabs-on-grade or where high volumetric stability is desired, such as within the footprint of a building. "Select engineered fill" should comprise clean, well-graded granular soils or inorganic low to medium plastic clay soils.

"Structural engineered fill" is used for supporting structural loads in conjunction with shallow foundations. "Structural engineered fill" should comprise clean, well-graded granular soils.

"Lean-mix concrete" is typically used to protect a subgrade from weather effects including excessive drying or wetting. "Lean-mix concrete" can also be used to provide a stable working platform over weak subgrades. "Lean-mix concrete" should be low strength concrete having a minimum 28-day compressive strength of 3.5 MPa. Standard Proctor Density (SPD) as used herein means Standard Proctor Maximum Dry Density (ASTM Test Method D698). Optimum moisture content is defined in ASTM Test Method D698.

2.0 General Backfill and Compaction Recommendations

Exterior backfill adjacent to abutment walls, basement walls, grade beams, pile caps and above footings, and below highway, street, or parking lot pavement sections should comprise "general engineered fill" materials as defined above. Exterior backfill adjacent to footings, foundation walls, grade beams and pile caps and within 600 mm of final grade should comprise inorganic, cohesive "general engineered fill". Such backfill should provide a relatively impervious surficial zone to reduce seepage into the subsoil against the structure.

Backfill should not be placed against a foundation structure until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction. During compaction, careful observation of the foundation wall for deflection should be carried out continuously. Where deflections are apparent, the compactive effort should be reduced accordingly.

In order to reduce potential compaction induced stresses, only hand-held compaction equipment should be used in the compaction of fill within 1 m of retaining walls or basement walls. If compacted fill is to be placed on both sides of the wall, they should be filled together so that the level on either side is within 0.5 m of each other.

All lumps of materials should be broken down during placement. Backfill materials should not be placed in a frozen state, or placed on a frozen subgrade.

Where the maximum-sized particles in any backfill, material exceed 50 percent of the minimum dimension of the cross-section to be backfilled (e.g., lift thickness), such particles should be removed and placed at other more suitable locations on site or screened off prior to delivery to site.

Bonding should be provided between backfill lifts. For fine-grained materials, the previous lift should be scarified to the base of the desiccated layer, moisture-conditioned, and recompacted and bonded thoroughly to the succeeding lift. For granular materials, the surface of the previous lift should be scarified to about a 75 mm depth followed by proper moisture-conditioning and re-compaction.

3.0 COMPACTION AND MOISTURE CONDITIONING

"Landscape fill" material should be placed in compacted lifts not exceeding 300 mm and compacted to a density of not less than 90 percent of SPD unless a higher percentage is specified by the jurisdiction.

"General engineered fill" and "select engineered fill" materials should be placed in layers of 150 mm compacted thickness and should be compacted to not less than 98 percent of SPD. Note that the contract may specify higher compaction levels within 300 mm of the design elevation. Cohesive materials placed as "general engineered fill" or "select engineered fill" should be compacted at 0 to 2 percent above the optimum moisture content. Note that there are some silty soils which can become quite unstable when compacted above optimum moisture content.

Granular materials placed as "general engineered fill" or "select engineered fill" should be compacted at slightly below (0 to 2%) the optimum moisture content. "Structural engineered fill" material should be placed in compacted lifts not exceeding 150 mm in thickness and compacted to not less than 100 percent of SPD at slightly below (0 to 2%) the optimum moisture content.

4.0 "GENERAL ENGINEERED FILL"

Low to medium plastic clay is considered acceptable for use as "general engineered fill," assuming this material is inorganic and free of deleterious materials. Materials meeting the specifications for "select engineered fill" or "structural engineered fill" as described below would also be acceptable for use as "general engineered fill."

5.0 "SELECT ENGINEERED FILL"

Low to medium plastic clay with the following range of plasticity properties is generally considered suitable for use as "select engineered fill":

Liquid Limit	=	20 to 40%
Plastic Limit	=	10 to 20%
Plasticity Index	=	10 to 30%

Test results should be considered on a case-by-case basis.

Construction Excavations

Construction should be in accordance with good practice and comply with the requirements of the responsible regulatory agencies.

All excavations greater than 1.5m deep should be sloped or shored for worker protection.

Shallow excavations up to about 3m depth may use temporary sideslopes of 1H:1V. A flatter slope of 2H:1V should be used if groundwater is encountered. Localized sloughing can be expected from these slopes.

Deep excavations or trenches may require temporary support if space limitations or economic considerations preclude the use of sloped excavations.

For excavations greater than 3m depth, temporary support should be designed by a qualified geotechnical engineer. The design and proposed installation and construction procedures should be submitted to Roseke for review.

The construction of a temporary support system should be monitored. Detailed records should be taken of installation methods, materials, in situ conditions and the movement of the system. If anchors are used, they should be load tested. Roseke can provide further information on monitoring and testing procedures if required.

Attention should be paid to structures or buried service lines close to the excavation. For structures, a general guideline is that if a line projected down, at 45 degrees from the horizontal from the base of foundations of adjacent structures intersects the extent of the proposed excavation, these structures may require underpinning or special shoring techniques to avoid damaging earth movements. The need for any underpinning or special shoring techniques and the scope of monitoring required can be determined when details of the service ducts and vaults, foundation configuration of existing buildings and final design excavation levels are known.

No surface surcharges should be placed closer to the edge of the excavation than a distance equal to the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge.

Proof Rolling

Proof-rolling is a method of detecting soft areas in an 'as-excavated' subgrade for fill, pavement, floor or foundations or detecting non-uniformity of compacted embankment. The intent is to detect soft areas or areas of low shear strength not otherwise revealed by means of test holes, density testing, or visual examination of the site surface and to check that any fill placed or subgrade meets the necessary design strength requirements.

Proof-rolling should be observed by qualified geotechnical personnel.

Proof-rolling is generally accomplished by the use of a heavy (15 to 60 tonne) rubber-tired roller having 4 wheels abreast on independent axles with high contact wheel pressures (inflation pressures ranging from 550 kPa (80psi) up to 1030 kPa (150 psi).

A heavily loaded tandem axle gravel truck may be used in lieu of the equipment described in the paragraph above. The truck should be loaded to approximately 10 tonnes per axle and a minimum tire pressure of 550 kPa (80 psi). Ground speed - maximum 8 km/hr recommended 4 km/hr.

The recommended procedure is two complete coverages with the proof-rolling equipment in one direction and a second series of two coverages made at right angles to the first series; one 'coverage' means that every point of the proof-rolled surface has been subjected to the tire pressure of a loaded wheel. Less rigorous procedures may be acceptable under certain conditions subject to the approval of an engineer.

Any areas of soft, rutted or displaced materials detected should be either recompacted with additional fill or the existing material removed and replaced with general engineered fill, or properly moisture conditioned as necessary.

The surface of the grade under the action of the proof-roller should be observe, noting; visible deflection and rebound of the surface, formation of a crack pattern in the compacted surface or shear failure in the surface or granular soils as ridging between wheel tracks.

If any part of an area indicates significantly more distress than other parts, the cause should be investigated, by, for example, shallow auger holes.

In the case of granular subgrades, distress will generally consist of either compression due to insufficient compaction or shearing under the tires. In the first case, rolling should be continued until no further compression occurs. In the the second case, the tire pressure should be reduced to a point where the subgrade can carry the load without significant deflection and subsequently gradually increased to it specified pressure as the subgrade increases in shear strength under this compaction.