Part 2 — Technical Requirements

NRCB Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

NRCB USE ONLY	Application number	Legal land description
☑ Approval ☐ Registration ☐ Authorization ☐ Amendment	FA19003	NE 4-85-5-6

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 above, and I acknowledge that the information provided in this application is true to the best of my knowledge.

Sept 4 2019
Date of signing

Signature

Hines Creek Farms
Corporate name (if applicable)

Hines Creek Farms
Print name

GENERAL INFORMATION REQUIREMENTS

Proposed facilities. List all proposed confined feeding operation facilities and their measurements, including if it is an addition to a an existing facility (attach additional pages if needed)

Proposed manure collection areas & manure storage facilities	Dimensions (m) 30 M long 15 M wide
manure storage pad	30 m x 15 m
Broiler Barn office	6m x 19m
Pullet office	6m x 12m
See next page	

Existing facilities. List ALL existing confined feeding operation facilities and their measurements (use additional pages if needed)

Existing barns, manure collection areas & manure storage facility	Dimensions (m)	NRCB USE ONLY

NRCB USE ONLY Application for new CFO

Part 2 — Technical Requirements

NRCB Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

NRCB USE ONLY	Application number	Legal land description
☐ Approval ☐ Registration ☐ Authorization ☐ Amendment		

APPLICATION DISCLOSURE

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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 above, and I acknowledge that the information provided in this application is true to the best of my knowledge.

Date of signing ______________________ Signature ______________________

Corporate name (if applicable) ______________________ Print name ______________________

GENERAL INFORMATION REQUIREMENTS

Proposed facilities. List all proposed confined feeding operation facilities and their measurements, including if it is an addition to a an existing facility (attach additional pages if needed)

Proposed manure collection areas & manure storage facilities	Dimensions (m)
Layer Barn + manure storage	93m x 18m + 12m x 18
Pullet Barn + manure pad	54m x 12m + 12m x 12m
Broiler Barn	30 x 19
Multi Species	30 x 19
Office Egg grading	33 x 21

Existing facilities. List ALL existing confined feeding operation facilities and their measurements (use additional pages if needed)

Existing barns, manure collection areas & manure storage facility	Dimensions (m)	NRCB USE ONLY
none		

NRCB USE ONLY Application for new CFO

Part 2 — Technical Requirements

NRCB | Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

If a new facility is replacing an old facility, what will be done with the old facility and when? ☐ N/A

Proposed construction completion date: Fall 2023

Additional information:

Layer Barn fall 2020
Multi spices Fall 2021
Broilers Fall 2022
Pullet Fall 2023

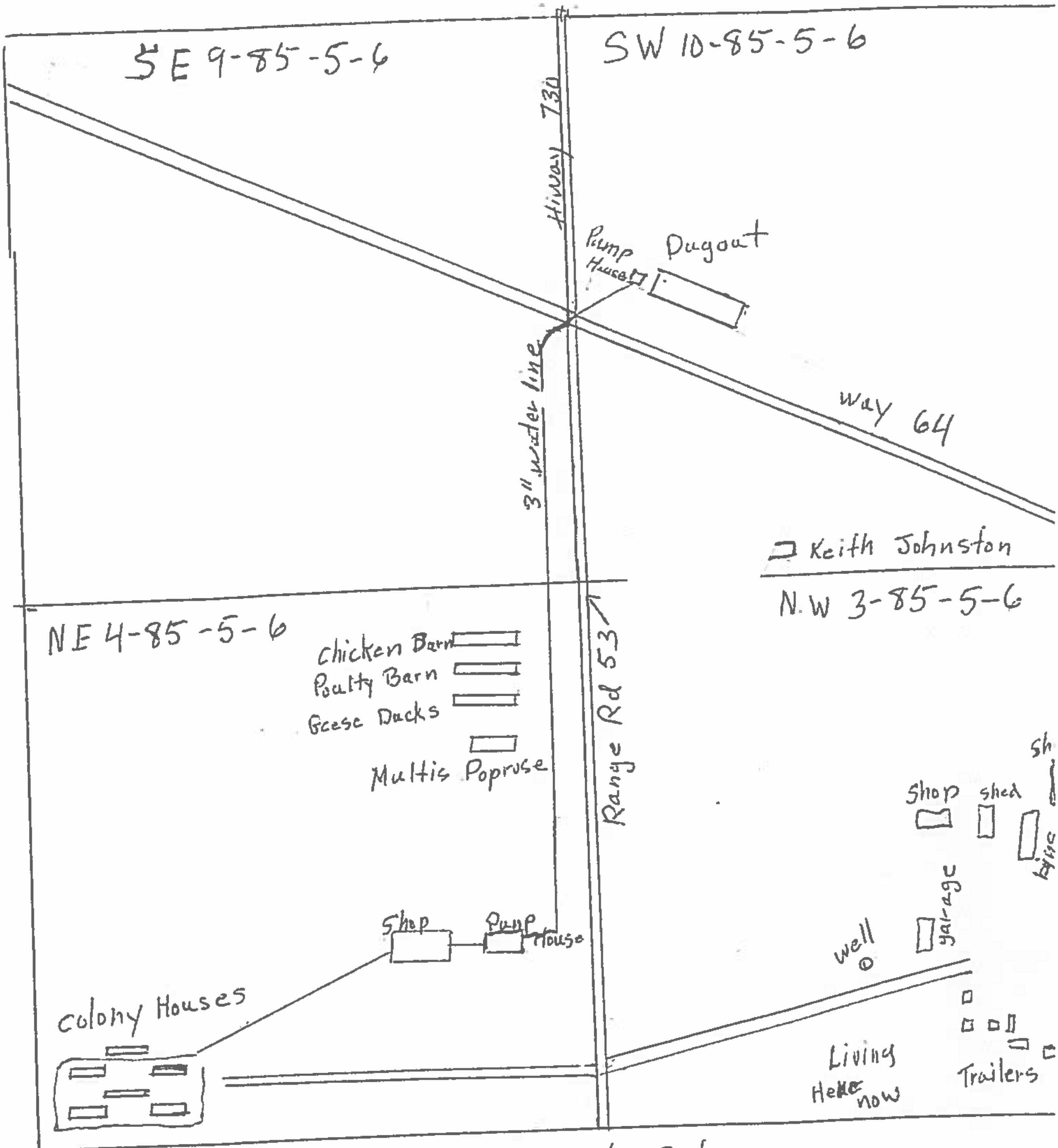
Livestock Numbers: (include all livestock)
Note: Livestock numbers in this table will be used when processing the application)

Livestock type/ category	Existing number	Change in number (if applicable)	Total
Layers	0	21000	
Pullets	0	22000	22000
Broilers	0	5000	
Duck	0	1000	
Geese	0	500	
Milk cows & dries	0	5	
and replacements			
Turkey	0	300	

Last updated: 08 Jan 18

Page 3 of 91

NRCB USE ONLY



Hines Creek Colony
1577912 Albeta Ltd.


64
730
Layer Barn
Pullet Barn
Multi Species Barn
Google

DECLARATION AND ACKNOWLEDGMENT OF APPLICANT CONCERNING *WATER ACT* LICENCE

Issued by Alberta Environment and Parks (AEP) for a confined feeding operation (CFO)

Date and sign (or check) one of the following four options

OPTION 1: Applying through the NRCB for both the AOPA permit and the *Water Act* licence

☐ I **DO** want my water licence application coupled to my AOPA permit application.

Signed this ____day of ________________, 20____. ____________________

Signature of Applicant or Agent

OPTION 2: Processing the AOPA permit and *Water Act* licence separately

1. I (we) acknowledge that the CFO will need a new water licence from AEP under the *Water Act* for the development or activity proposed in this AOPA application.
2. I (we) request that the NRCB process the AOPA application **independently of** AEP's processing of the CFO's application for a water licence.
3. In making this request, I (we) recognize that, if this AOPA application is granted by the NRCB, the NRCB's decision will not be considered by AEP as improving or enhancing the CFO's eligibility for a water licence under the *Water Act*.
4. I (we) acknowledge that any construction or actions to populate the CFO with livestock pursuant to an AOPA permit in the absence of a *Water Act* licence will **not** be relevant to AEP's consideration of whether to grant the *Water Act* licence application.
5. I (we) acknowledge that any such construction or livestock populating will be at the CFO's sole risk if the *Water Act* licence application is denied or if the operation of the CFO is otherwise deemed to be in violation of the *Water Act*. This risk includes being required to de-populate the CFO and/or to cease further construction, or to remove "works" or "undertakings" (as defined in the *Water Act*).
6. **CHECK IF RELEVANT** ☑ I (we) acknowledge that the CFO is located in the South Saskatchewan River Basin and that, pursuant to the *Bow, Oldman and South Saskatchewan River Basin Water Allocation Order* [Alta. Reg. 171/2007], this basin is currently closed to new surface water allocations.

Signed this 15 day of Aug, 2019. Michael Goos

Signature of Applicant or Agent

OPTION 3: Additional water licence not required

1. I (we) declare that the CFO will not need a new licence from AEP under the *Water Act* for the development or activity proposed in this AOPA application.

Signed this ____ day of ________________, 20____. ____________________

Signature of Applicant or Agent

OPTION 4: Uncertain if *Water Act* licence is needed: acknowledgement of risk (for existing CFOs only)

1. At this time, I (we) do not know whether a new water licence is needed from AEP under the *Water Act* for the development or activity proposed in this AOPA application.
2. If a new *Water Act* licence is needed, I (we) request that the NRCB process the AOPA application **independently of** AEP's processing of the CFO's application for a water licence.
3. In making this request, I (we) recognize that, if this AOPA application is granted by the NRCB, the NRCB's decision will not be considered by AEP as improving or enhancing the CFO's eligibility for a water licence under the *Water Act*.
4. I (we) acknowledge that any construction or actions to populate the CFO with additional livestock pursuant to an AOPA permit in the absence of a *Water Act* licence will **not** be relevant to AEP's consideration of whether to grant my *Water Act* licence application, if a new water licence is needed.
5. I (we) acknowledge that any such construction or livestock increase will be at the CFO's sole risk if the *Water Act* licence application is denied or if the operation of the CFO is otherwise deemed to be in violation of the *Water Act*. This risk includes being required to de-populate the CFO and/or to cease further construction, or to remove "works" or "undertakings" (as defined in the *Water Act*).
6. **CHECK IF RELEVANT** ☐ I (we) acknowledge that the CFO is located in the South Saskatchewan River Basin and that, pursuant to the *Bow, Oldman and South Saskatchewan River Basin Water Allocation Order* [Alta. Reg. 171/2007], this basin is currently closed to new surface water allocations.

Signed this ____ day of ________________, 20____. ____________________

Signature of Applicant or Agent

NRCB USE ONLY

*Not located in South Sask river basin.

Part 2 — Technical Requirements

NRCB | Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

GENERAL WATER INFORMATION – PROPOSED Use the proposed manure storage facility that is closest to a common body of water or water well			NRCB USE ONLY Comments	Meets regulations
Proposed facility name Hines Creek Farms				
Flood plain information What is the elevation of the floor of the lowest **proposed** manure storage or collection facility above the 1:25 year flood plain or the highest known flood level?	15 (m)	☑ Estimated ☐ From records	Not in known flood plain	☐ YES ☐ NO ☐ YES with exemption
Springs, wells, and surface water information a. How many springs are within 100 m of **proposed** manure storage facilities or manure collection areas?		None	Confirmed, none during site visits.	☑ YES ☐ NO ☐ YES with exemption
b. How many water wells are within 100 m of **proposed** manure storage facilities or manure collection areas?		1	ID 2090138 not within 100m	☑ YES ☐ NO ☐ YES with exemption
c. What is the shortest distance from a **proposed** manure collection or storage facility to a surface water body? (ie, lake, creek, slough, seasonal, etc.)		100 m	30 m slough north*	☑ YES ☐ NO ☐ YES with exemption
Groundwater information a. What is the depth to bedrock?	97.54 (m)	☐ Estimated ☐ Measured ☑ Drilling reports	N/A	
b. What is the depth to the water table?	75 (m)	☑ Estimated ☐ Measured ☐ Drilling reports	No signs of water table	☑ YES ☐ NO ☐ YES with exemption
c. What is the shallowest depth to the uppermost groundwater resource?	115 (m)	☐ Estimated ☐ Measured ☑ Drilling reports	115.82 m gray hard shale	☑ YES ☐ NO ☐ YES with exemption

Additional information: (attach borehole logs and records, as required)

*Few sloughes on quarter section North slough ~ 30m north of manure pad.
Not a common body of water.
Nearest common body of water is ~587 m NW on LLD SW 9-85-5 W6M
Montagneuse River ~1500m

Alberta

Water Well Drilling Report

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

View in Imperial | Export to Excel

GIC Well ID 2090138
GoA Well Tag No.
Drilling Company Well ID
Date Report Received 2012/10/23

GOWN ID

Well Identification and Location

Measurement in Metric

Owner Name	Address	Town	Province	Country	Postal Code
HINES CREEK FARMS	P.O. BOX 389	HINES CREEK	ALBERTA	CANADA	T0H 2A0

Location	1/4 or LSD	SEC	TWP	RGE	W of MER	Lot	Block	Plan	Additional Description
	NW	3	85	5	6				

Measured from Boundary of
m from
m from

GPS Coordinates in Decimal Degrees (NAD 83)
Latitude 56.345546 Longitude -118.706008
How Location Obtained
Not Verified

Elevation m
How Elevation Obtained
Not Obtained

Drilling Information

Method of Drilling
Rotary - Air

Proposed Well Use
Unknown

Type of Work
New Well

Formation Log

Measurement in Metric

Depth from ground level (m)	Water Bearing	Lithology Description
24.38		Dark Gray Clay
30.48		Dark Gray See Comments Clay
36.58		Dark Gray Clay
73.15		Clay & Silt
97.54		Gray See Comments Clay
100.58		Gray Hard Sandstone
102.11		Gray Medium Grained Sandstone
103.63		Gray Soft Sandstone
109.73		Brown Hard Siltstone
111.25		Gray Hard Siltstone
115.82		Brown Sandstone
134.11		Dark Gray Hard Shale
137.16		Dark Gray See Comments Shale
149.35	Yes	Sand
152.40		Black Shale

Yield Test Summary

Measurement in Metric

Recommended Pump Rate 45.46 L/min

Test Date	Water Removal Rate (L/min)	Static Water Level (m)
2011/08/15	90.92	109.73

Well Completion

Measurement in Metric

Total Depth Drilled	Finished Well Depth	Start Date	End Date
152.40 m	152.40 m	2011/08/15	2011/08/15

Borehole

Diameter (cm)	From (m)	To (m)
15.24	0.00	152.40

Surface Casing (if applicable)
Steel
Size OD : 16.84 cm
Wall Thickness : 0.478 cm
Bottom at : 100.58 m

Well Casing/Liner
Steel
Size OD : 14.12 cm
Wall Thickness : 0.478 cm
Top at : -0.91 m
Bottom at : 140.21 m

Perforations

From (m)	To (m)	Diameter or Slot Width (cm)	Slot Length (cm)	Hole or Slot Interval(cm)
138.68	140.21	0.000		0.00

Perforated by Other

Annular Seal
Placed from m to m
Amount

Other Seals

Type	At (m)
Driven	100.58

Screen Type
Size OD : cm

From (m)	To (m)	Slot Size (cm)

Attachment
Top Fittings Bottom Fittings

Pack
Type Grain Size
Amount

Contractor Certification

Name of Journeyman responsible for drilling/construction of well
SIMON WOLFORD

Certification No
1109E

Company Name
CARBON MOUNTAIN DRILLING & WATER SERVICES LTD.

Copy of Well report provided to owner Date approval holder signed

Printed on 9/6/2019 10:16:38 AM

Alberta

Water Well Drilling Report

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

View in Imperial | Export to Excel

GIC Well ID 2090138
GoA Well Tag No.
Drilling Company Well ID
Date Report Received 2012/10/23

GOWN ID

Well Identification and Location

Measurement in Metric

Owner Name	Address	Town	Province	Country	Postal Code
HINES CREEK FARMS	P.O. BOX 389	HINES CREEK	ALBERTA	CANADA	T0H 2A0

Location	1/4 or LSD	SEC	TWP	RGE	W of MER	Lot	Block	Plan	Additional Description
	NW	3	85	5	6				

Measured from Boundary of
m from
m from

GPS Coordinates in Decimal Degrees (NAD 83)
Latitude 56.345546 Longitude -118.706008
How Location Obtained
Not Verified

Elevation m
How Elevation Obtained
Not Obtained

Additional Information

Measurement in Metric

Distance From Top of Casing to Ground Level 91.44 cm
Is Artesian Flow
Rate L/min
Is Flow Control Installed
Describe

Recommended Pump Rate 45.46 L/min
Recommended Pump Intake Depth (From TOC) 128.02 m
Pump Installed Yes
Type Unknown
Depth 128.02 m
Make
H.P. Other
Model (Output Rating) 10 GPM - 2 HP

Did you Encounter Saline Water (>4000 ppm TDS) Depth m
Gas Depth m
Well Disinfected Upon Completion
Geophysical Log Taken
Submitted to ESRD
Sample Collected for Potability
Submitted to ESRD

Additional Comments on Well

LITH: 80' - 100' ALSO LENSES OF SAND AND GRAVEL; 240' - 320' DENSE CLAY; 440' - 450' INTERBEDDED LAYERS OF BLACK GREY SHALE AND BROWN SANDSTONE. RECOMMENDED PUMP RATE: 10 TO 12 GPM

Yield Test

Taken From Top of Casing — Measurement in Metric

Test Date	Start Time	Static Water Level
2011/08/15	11:00 AM	109.73 m

Method of Water Removal

Type Air
Removal Rate 90.92 L/min
Depth Withdrawn From 152.40 m

If water removal period was < 2 hours, explain why

Depth to water level

Pumping (m)	Elapsed Time Minutes:Sec	Recovery (m)
109.73	0:00	152.40
	5:00	137.77
	6:00	131.98
	7:00	126.49
	8:00	119.18
	9:00	115.52
	20:00	112.47
	30:00	111.86
	105:00	109.12

Water Diverted for Drilling

Water Source	Amount Taken	Diversion Date & Time
	L	

Contractor Certification

Name of Journeyman responsible for drilling/construction of well
SIMON WOLFORD

Certification No
1109E

Company Name
CARBON MOUNTAIN DRILLING & WATER SERVICES LTD.

Copy of Well report provided to owner

Date approval holder signed
2011/08/1?

Printed on 9/6/2019 10:16:36 AM

WELL INFORMATION:

Well IDs: ID 2090138 ______________________ ______________________ ______________________

______________________ ______________________ ______________________

Surface water related concerns from directly affected parties or referral agencies: ☐ YES ☑ NO

Ground water related concerns from directly affected parties or referral agencies: ☐ YES ☑ NO

Water Wells

If applicable, exemption for 100 m distance requirements applied: N/A ☐ YES ☐ NO Condition required: ☐ YES ☐ NO

Surface Water

If applicable, exemption for 30 m distance requirements applied: N/A ☐ YES ☐ NO Condition required: ☐ YES ☐ NO

ERST for **proposed** facilities

Facility	Groundwater score	Surface water score	File Number
Layer barn with manure pad	Low	Low	FA19003
Pullet barn with manure pad	Low	Low	FA19003
Broiler barn	Low	Low	FA19003
Multi-species barn	Low	Low	FA19003
Solid manure storage pad	Low	Low	FA19003

ERST for **existing** facilities

Facility	Groundwater score	Surface water score	File Number
N/A			

DISTANCE OF ANY MANURE STORAGE FACILITY (EXISTING OR PROPOSED) TO NEIGHBOURING RESIDENCES

	Name	Legal Land Description	Distance (m)	Zoning (LUB) Category	MDS Cat (1-4)	Distance (m)	Meets Regulations
1	Kieth Johnson	SW 10-85-5-6	1000 M	AG	Cat 1	246 m	Yes*
2	Gary Hoover	NE 33-84 5-6	1600 M	AG	Cat 1	1456 m	Yes
3	Rick Millar	SW 9-85-5-6	1650 M	AG	Cat 1	1403 m	Yes

Methods used/margins of error to determine distance:

Additional Information: * Mr. Johnson has provided the applicant with an MDS waiver.

NRCB USE ONLY

Methods used to determine distance (if applicable): Google earth

Margin of error (if applicable): N/A

Requirements: Category 1: 315m Category 2: 421m Category 3: 526m Category 4: 841m

Technology factor: ☐ YES ☑ NO

Expansion factor: ☐ YES ☑ NO

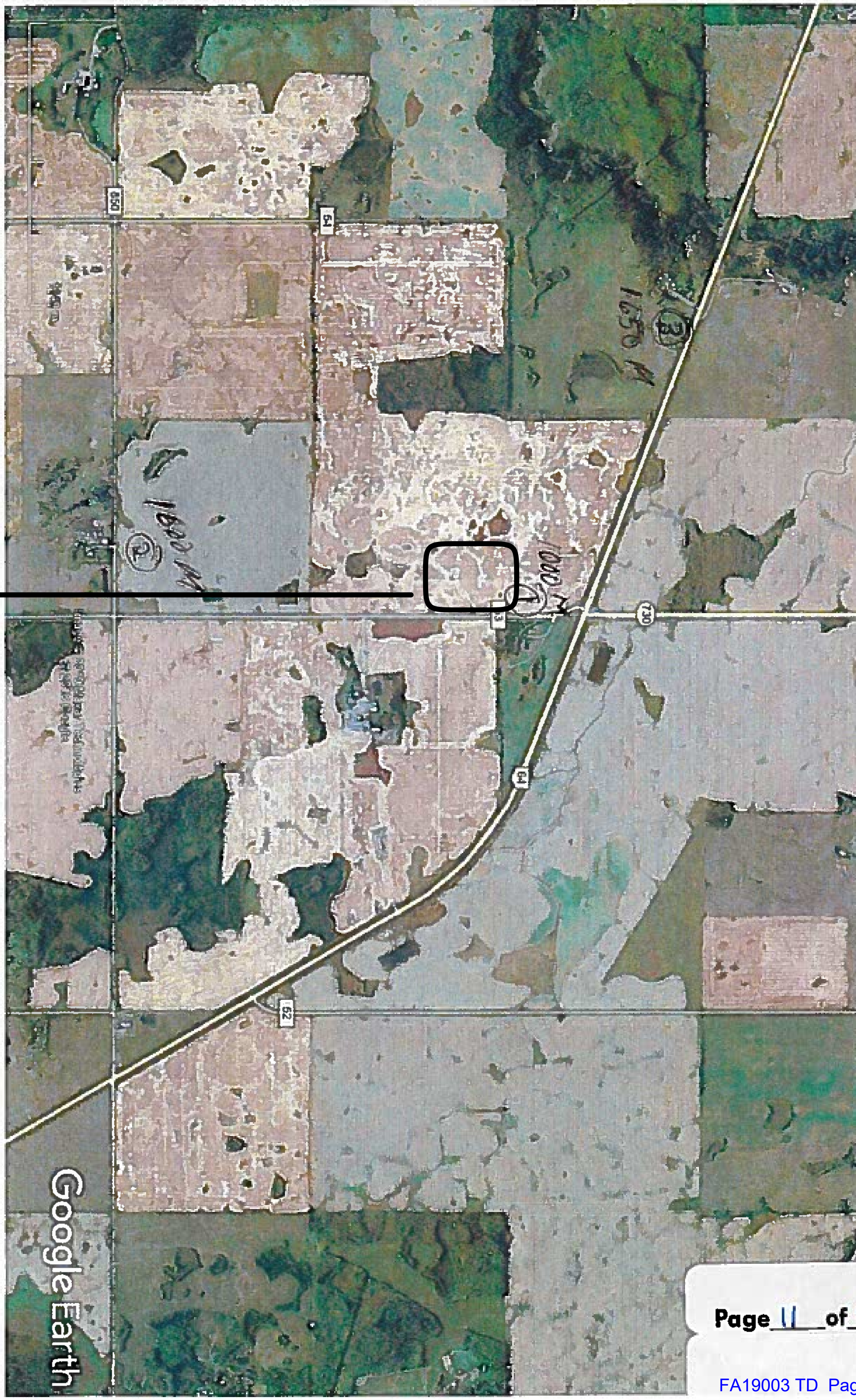
Waivers required: ☑ YES ☐ NO # 1

Waivers attached: ☑ Waivers in file: ☑

MDS related concerns from directly affected parties or referral agencies: ☑ YES ☐ NO

Comments: Doesn't meet the MDP setback of 3.2 km to residences

Proposed
CFO



Declaration of Permit Applicant Regarding MDS Waiver

NRCB application number FA19003

Applicant information

Operator/operation name: Hincs Creek Farms

Address: Box 389

Postal code: T0H-2A0 NE 04-85-05 W6m

Legal land location of proposed confined feeding operation (CFO development):

I have requested the residence owner(s) named below to waive the required minimum distance separation (MDS) to their residence for the *Agricultural Operation Practices Act* (AOPA) permit application identified above. In making this request, I have provided the owner(s) with an opportunity to review my permit application and a copy of the NRCB publication "Minimum Distance Separation (MDS) Waivers." I have also explained:

- The MDS requirement set out in section 3 of the Standards and Administration Regulation of AOPA. I have advised the owner(s) that section 3(6)(a) of the Standards and Administration Regulation allows this requirement to be waived by the owners of residences, if they agree in writing to grant a waiver;
- That my proposed development does not meet the required MDS to the owner's residence; and,
- That this waiver applies only to this application as described. An increase in livestock capacity, change to the site plan or change to a facility that would increase the MDS would require a new waiver.

Following is a summary of the proposed development:

- ✓ The current scope of my confined feeding operation (CFO), including the type, number, and category of livestock, if any, is:

  Layers 21,000 Pullets 22,000 Broilers 5000 Ducks 1000
  Geese 500 milk cows 5 Turkey 300 4 Barns manure pad

- My application for a new AOPA permit proposes the following changes to the existing livestock capacity at my CFO:

- The proposed new CFO facility(ies), or changes to the existing CFO facilities, including manure storage, manure storage volume and any other pertinent details, if any, are (attach a site layout plan if available):

Permit applicant: Michael [signature]
Signature

Date: Sept 19-19

Residence owner(s) to initial: [initials]

Minimum Distance Separation (MDS) Waiver

Residence owner information

Names(s) on title: KEITH N. JOHNSON

Address: BOX 471 HINES CREEK.

Postal code: T0H. 2A0

Legal land location: SW10 85-6-6

I am/we are the legal landowner(s) of a residence located at the above noted address. I/we have read the NRCB publication "Minimum Distance Separation (MDS) Waivers" and the above declaration of the applicant, and discussed the nature of application number_______________with the applicant. I/we understand that:

- The application **does not** meet the MDS requirement to my/our residence, under the *Agricultural Operation Practices Act* (AOPA);
- **I/we are not obligated to waive the MDS requirement to our residence;**
- If I/we choose to waive the MDS requirement, I/we can cancel the waiver, by providing written notice of the cancellation to the Natural Resources Conservation Board (NRCB), at any time prior to the permit decision being issued by the NRCB;
- This waiver is a public document.

Having considered my/our rights, I/we hereby waive the MDS requirement to my/our residence, with respect to application number_______________.

Keith N Johnson

Signatures of all landowners on title

KEITH N. JOHNSON

Printed names of all landowners on title

Date: Sept 19-19

FOR NRCB USE ONLY:
Residence owner contact information
(Please note that telephone numbers and email addresses are not publicly released)

Telephone: **Email:**

LAND BASE FOR MANURE AND COMPOST APPLICATION (for approvals and registrations only)

Name of landowner(s)*	Legal Land Description	Area ** (usable hectares)	Soil Zone	NRCB USE ONLY Area unsuitable:
Hines Creek Farms	NW 26-84-5 W6	138 Acer	GW	
Hines Creek Farms	SE 26-84-5-W6	150 Acers		
Hines Creek Farms	NE 3-85-5-W6	160 Acers		
Hines Creek Farms	NE 6-85-5-W6	134 Acers		
Hines Creek Farms	NW 6-85-5-W6	130 Acers		
	TOTAL	712 Acers		

*If you are not the registered land owner, please attach copies of land use agreements signed by all landowners.

** Available manure spreading area (do not include required setback areas from residences, common bodies of water, water wells, etc.) (to convert from acres to hectares divide acres by 2.47)

Additional information: (attach copies of all signed land use agreements)

See next page for additional spreading lands.

NRCB USE ONLY

Land base required: see next page

Applicant has sufficient landbase available.

Land base listed: ____________

Area not suitable: ____________

Available area ____________

Requirement Met: ☑ YES ☐ NO

Land spreading agreements required: ☐ YES ☑ NO If yes, Agreements in file: ☐ Agreements attached: ☐

Manure Management Plan: ☐ YES ☑ NO Plan attached: ☐ Plan in file: ☐

Part 2 — Technical Requirements

NRCB | Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

LAND BASE FOR MANURE AND COMPOST APPLICATION (for approvals and registrations only)

Name of landowner(s)*	Legal Land Description	Area ** (usable hectares)	Soil Zone	NRCB USE ONLY Area unsuitable:
Hines Creek Colony	NE 9-85-5-6	297 acres	5W	n/a
Hines Creek Colony	SW 10 85-5-6	114 acres		n/a
Hines Creek Colony	NW 10 85-5-6	149 acres		n/a
Hines Creek Colony	SW 3-85-5-6	150 acres		n/a
Hines Creek Colony	SE 3-85-5-6	160 acres		n/a
	TOTAL	1170		

*If you are **not** the registered land owner, please attach copies of land use agreements signed by all landowners.

** Available manure spreading area (do not include required setback areas from residences, common bodies of water, water wells, etc.) (to convert from acres to hectares divide acres by 2.47)

Additional Information: (attach copies of all signed land use agreements)

NRCB USE ONLY

Land base required: 120.3ha(297.3ac)

Land base listed: 1170ac

Area not suitable: n/a

Available area: Applicant has sufficient landbase available

Requirement Met: ☑ YES ☐ NO

Land spreading agreements required: ☐ YES ☑ NO If yes, Agreements in file: ☐ Agreements attached: ☐

Manure Management Plan: ☐ YES ☑ NO Plan attached: ☐ Plan in file: ☐

NRCB Natural Resources Conservation Board

PLANS

Submitted and attached construction plans ☑ YES ☐ NO

Submitted aerial photos ☑ YES ☐ NO

Submitted photos ☐ YES ☑ NO

GRANDFATHERING:

N/A application for new CFO

On this application: ☐ Yes ☐ No

Comments:

On a previous application/decision: ☐ Yes ☐ No If yes, list application/decision number ________________________

Comments:

DEEMING CAPACITY:

☐ Yes ☐ No

Comments:

ALL SIGNATURES IN FILE: ☑ Yes ☐ No

DATES OF APPROVAL OFFICER SITE VISITS:

January 21, 2019	
August 15, 2019	
September 17, 2019	

CORRESPONDENCE WITH MUNICIPALITIES AND REFERRAL AGENCIES:

Date deeming letters sent ___October 9, 2019___

Municipality: ___Clear Hills County___

☑ Letter sent ☑ Response received ☑ written/email ☐ verbal ☐ no comments received

Alberta Health Services:

☑ 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: ____

☐ Letter sent ☐ Response received ☐ written/email ☐ verbal ☐ no comments received

Other: ____

☐ Letter sent ☐ Response received ☐ written/email ☐ verbal ☐ no comments received

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner

*(complete a copy of this section for **EACH** barn, feedlot and storage facility for solid manure, composting materials or compost with a concrete liner)*

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

1. Layer Barn
2. Layer Pad

Manure storage capacity

	Length (m)	Width (m)	Estimated storage capacity (m^3)	Depth below grade to the bottom of the liner (m)
1.	9.3	18		0
2.	12	18		0

NRCB USE ONLY

Depth to water table: >5m — Requirements met: ☑ YES ☐ NO

Depth to UGR: 115.82 m — Requirements met: ☑ YES ☐ NO

ERST completed: ☑ YES ☐ NO

Groundwater risk level: Low — Surface Water risk level: Low

UGR: Uppermost Groundwater Resource as defined under AOPA's *Standards and Administration Regulation*.

Surface water control systems

☑ Under roof: Surface water will be controlled by the walls and roof of the building and by the finished landscaping.

☐ Outdoor: Describe the run-on and runoff control system proposed for feedlots and outdoor manure storage facilities

NRCB USE ONLY

Requirements met: ☑ YES ☐ NO — Details/comments:

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner (cont.)

Concrete liner details

Concrete thickness	Provide details: 5 inches
Concrete strength	Provide details: 25 mpa
Method of sulphate protection	Provide details: Type 50 or similar
Concrete reinforcement size and spacing	Provide details: 12 inch O/C

Additional information:

NRCB USE ONLY

Technical guideline requirements met: ☑ YES ☐ NO

Construction plans approved by professional engineer: ☐ YES ☑ NO Condition required: ☑ YES ☐ NO

Comments:

Applicant to provide concrete documentation proving the type and strength.

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner

(complete a copy of this section for EACH barn, feedlot and storage facility for solid manure, composting materials or compost with a concrete liner)

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

1. Pullet Barn
2. manure storage pad

Manure storage capacity

	Length (m)	Width (m)	Estimated storage capacity (m^3)	Depth below grade to the bottom of the liner (m)
1.	54	12		0
2.	12	12		0

NRCB USE ONLY

Depth to water table: >5m — Requirements met: ☑ YES ☐ NO

Depth to UGR: 115.82 m — Requirements met: ☑ YES ☐ NO

ERST completed: ☑ YES ☐ NO

Groundwater risk level: Low — Surface Water risk level: Low

UGR: Uppermost Groundwater Resource as defined under AOPA's *Standards and Administration Regulation*.

Surface water control systems

☑ Under roof: Surface water will be controlled by the walls and roof of the building and by the finished landscaping.

☑ Outdoor: Describe the run-on and runoff control system proposed for feedlots and outdoor manure storage facilities

Pony wall on manure storage

NRCB USE ONLY

Requirements met: ☑ YES ☐ NO — Details/comments:

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner (cont.)

Concrete liner details

Concrete thickness 5inches	Provide details:
Concrete strength 25mpa	Provide details: 30 mpa for pad
Method of sulphate protection Type 50	Provide details:
Concrete reinforcement size and spacing 12inch o/c	Provide details:

Additional information:

NRCB USE ONLY

Technical guideline requirements met: ☑ YES ☐ NO

Construction plans approved by professional engineer: ☐ YES ☑ NO Condition required: ☑ YES ☐ NO

Comments:

Applicant to provide concrete documentation proving the type and strength.

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Naturally occurring protective layer

(complete a copy of this section for ***EACH*** *barn, feedlot and storage facility for solid manure, composting materials or compost with a naturally occurring protective layer for the liner)*

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

AO comment: Pad in field behind proposed barns

1. Manure storage **2.** ____________________

Manure storage capacity

	Length (m)	Width (m)	Estimated storage capacity (m^3)	Depth below grade of the top protective layer surface (m)
1.	30	15		0
2.				

NRCB USE ONLY

Depth to water table: >5m — Requirements met: ☑ YES ☐ NO

Depth to UGR: 115.82m — Requirements met: ☑ YES ☐ NO

ERST completed: ☑ YES ☐ NO

Groundwater risk level: Low — Surface Water risk level: Low

UGR: Uppermost Groundwater Resource as defined under AOPA's *Standards and Administration Regulation*.

Surface water control systems

☐ Under roof: Surface water will be controlled by the walls and roof of the building and by the finished landscaping.

☑ Outdoor: Describe the run-on and runoff control system proposed for feedlots and outdoor manure storage facilities:

Dead man Block on 3 sides to control runoff

NRCB USE ONLY

Requirements met: ☑ YES ☐ NO — Details/comments:

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Naturally occurring protective layer (cont.)

Naturally occurring protective layer details

a. Naturally occurring protective layer	Thickness of naturally occurring protective layer 15 (m)	Provide details:	
b. Soil texture	3.3 % sand	24.8 % silt	72 % clay
c. Hydraulic conductivity - naturally occurring protective layer	Material tested	Hydraulic conductivity (cm/s)	Describe test standard used
	Borehole: 19-07 Depth: 8 (m)	3.8 x10-9	D5084

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

See report

NRCB USE ONLY

Protective layer specification (e.g. sand lenses; layering uniform or irregular; number and location of boreholes).
Comments:

Protective layer requirements met: ☑ YES ☐ NO   Condition required: ☑ YES ☐ NO
Comment:

Part 2 — Technical Requirements

NRCB | Natural Resources Conservation Board

Application under the *Agricultural Operation Practices Act* for a confined feeding operation, manure collection area and/or manure storage facility(ies)

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner

*(complete a copy of this section for **EACH** barn, feedlot and storage facility for solid manure, composting materials or compost with a concrete liner)*

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

1. Multi Spices 2. Broiler Barn

Manure storage capacity

	Length (m)	Width (m)	Estimated storage capacity (m^3)	Depth below grade to the bottom of the liner (m)
1.	30	19	6	0
2.	30	19		0

NRCB USE ONLY

Depth to water table: >5m Requirements met: ☑ YES ☐ NO

Depth to UGR: 115.82m Requirements met: ☑ YES ☐ NO

ERST completed: ☑ YES ☐ NO

Groundwater risk level: Low Surface Water risk level: Low

UGR: Uppermost Groundwater Resource as defined under AOPA's *Standards and Administration Regulation.*

Surface water control systems

☑ Under roof: Surface water will be controlled by the walls and roof of the building and by the finished landscaping.

☐ Outdoor: Describe the run-on and runoff control system proposed for feedlots and outdoor manure storage facilities

NRCB USE ONLY

Requirements met: ☑ YES ☐ NO Details/comments:

SOLID MANURE, COMPOST & COMPOSTING MATERIALS: Barns, feedlots & storage facilities - Concrete liner (cont.)

Concrete liner details

Concrete thickness	Provide details: 5 inch
Concrete strength	Provide details: 25 mpa
Method of sulphate protection	Provide details: Type 50 or similar
Concrete reinforcement size and spacing	Provide details: 12 inch O/C

Additional information:

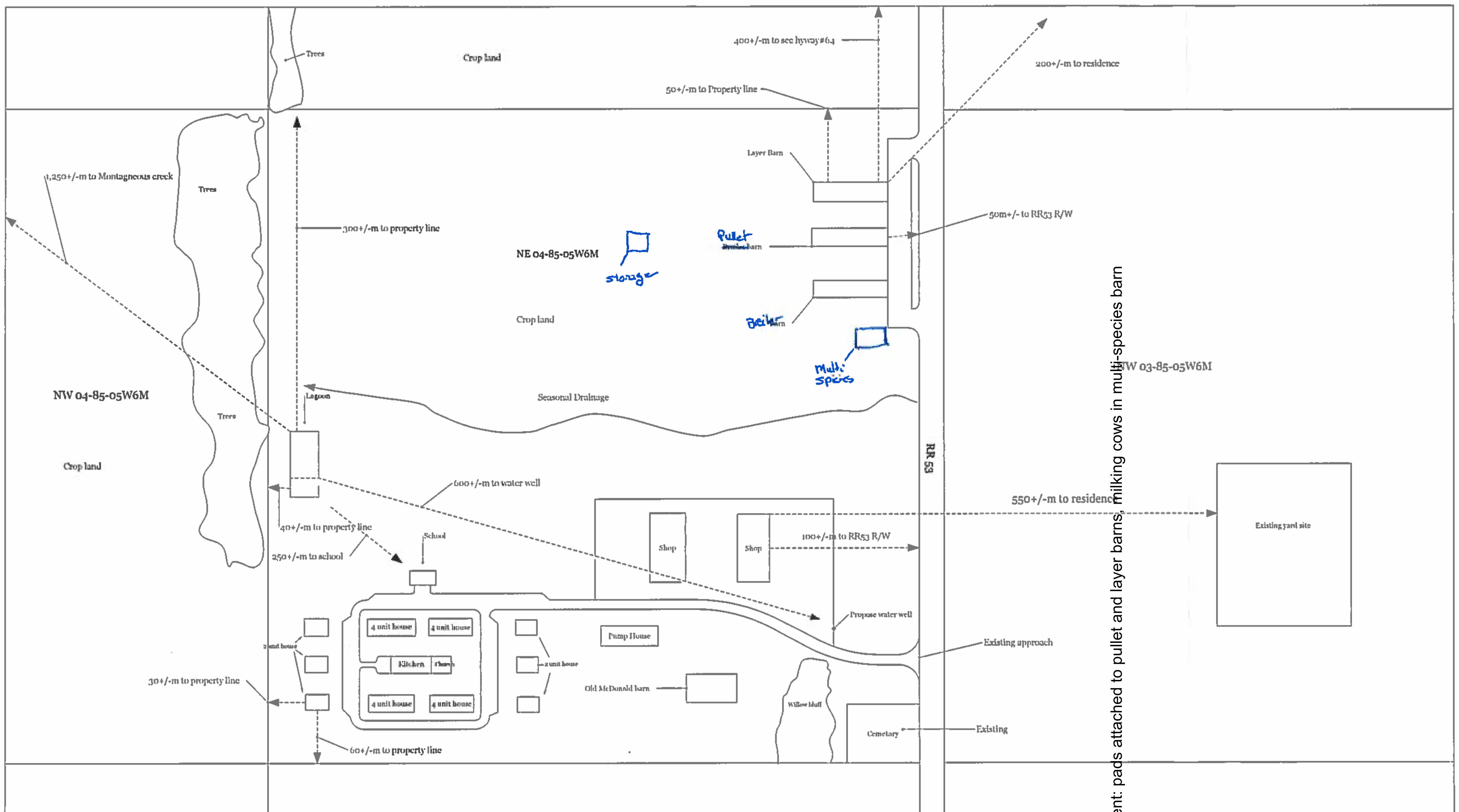
NRCB USE ONLY

Technical guideline requirements met: ☑ YES ☐ NO

Construction plans approved by professional engineer: ☐ YES ☑ NO Condition required: ☑ YES ☐ NO

Comments:

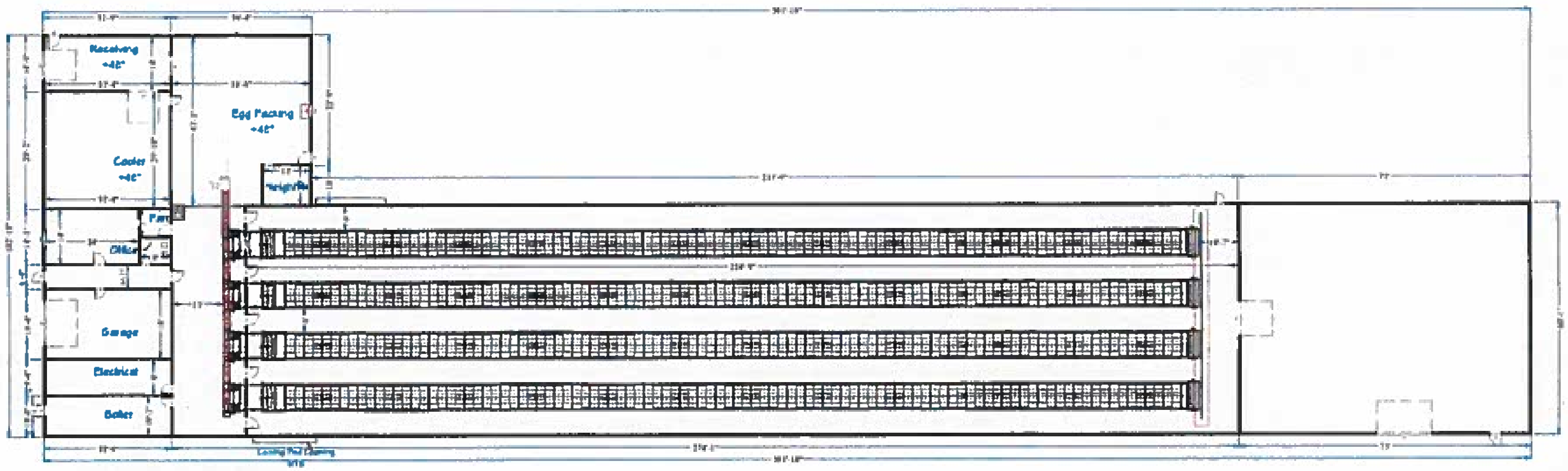
Applicant to provide concrete documentation proving the type and strength.

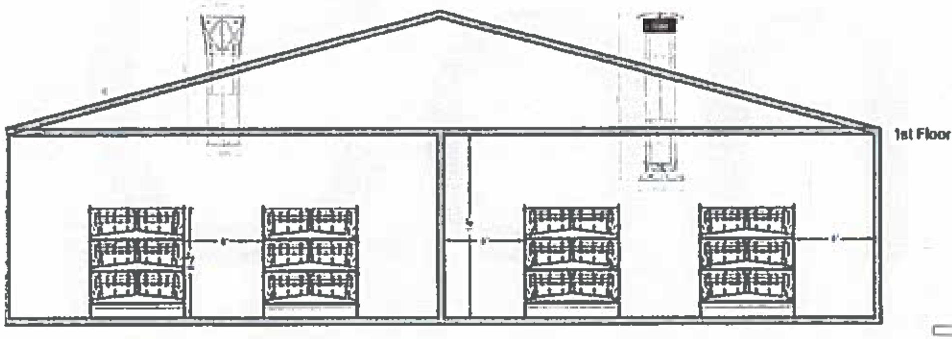


AO comment: pads attached to pullet and layer barns, milking cows in multi-species barn

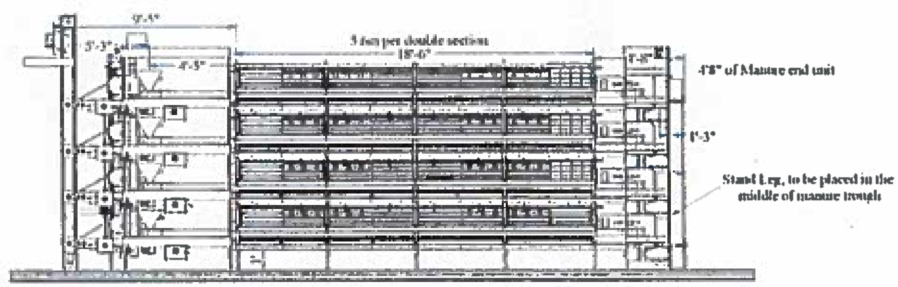
Hines Creek Colony Yard Layout	**Murk Construction Services** Design, Survey, Construct **Hines Creek Colony**	11/07/18 — Yard site location change. Not to scale. distances are estimated.

01
A





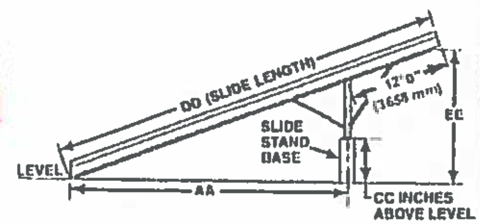
4 Tier system will be 2.5ft higher than 3 tier system.
Dacs Corona System requires 1.5m from top of cage to ceiling, minimum.



Hines Creek Colony
KPS Comfort
4 Rows, 3 Tiers, 25 Sections
20,400 Birds

Kaiser Poultry Systems

DD Slide Length		AA Dim.		CC Dim.		EE Dim.	
ft.	m	ft.	m	ft.	mm	ft.	m
28'	8.534	20' 4"	6.198	49-1/2"	1257	12' 5"	3.785
30'	9.144	16' 2"	4.928	23-1/2"	597	13' 2"	4.013
32'	9.754	17' 11"	5.461	35"	889	14' 2"	4.318
34'	10.363	19' 8-1/2"	6.007	46"	1168	15' 1"	4.597
36'	10.973	21' 6-1/2"	6.566	56"	1422	15' 11"	4.851
38'	11.582	23' 4"	7.112	67"	1702	16' 10"	5.131
40'	12.192	25' 1"	7.645	78"	1981	17' 9"	5.410



Layer

NO.	DESCRIPTION	BY	DATE
1	Version 2	BOK	15/08/19
2	Version 3	BOK	[illegible]
3			

SHEET TITLE: Layer Barn

PROJECT DESCRIPTION: Hines Creek

DRAWINGS PROVIDED BY: Kaiser Ag

DATE: 15/08/2019

SCALE: 1/4"-5'

SHEET: A-1

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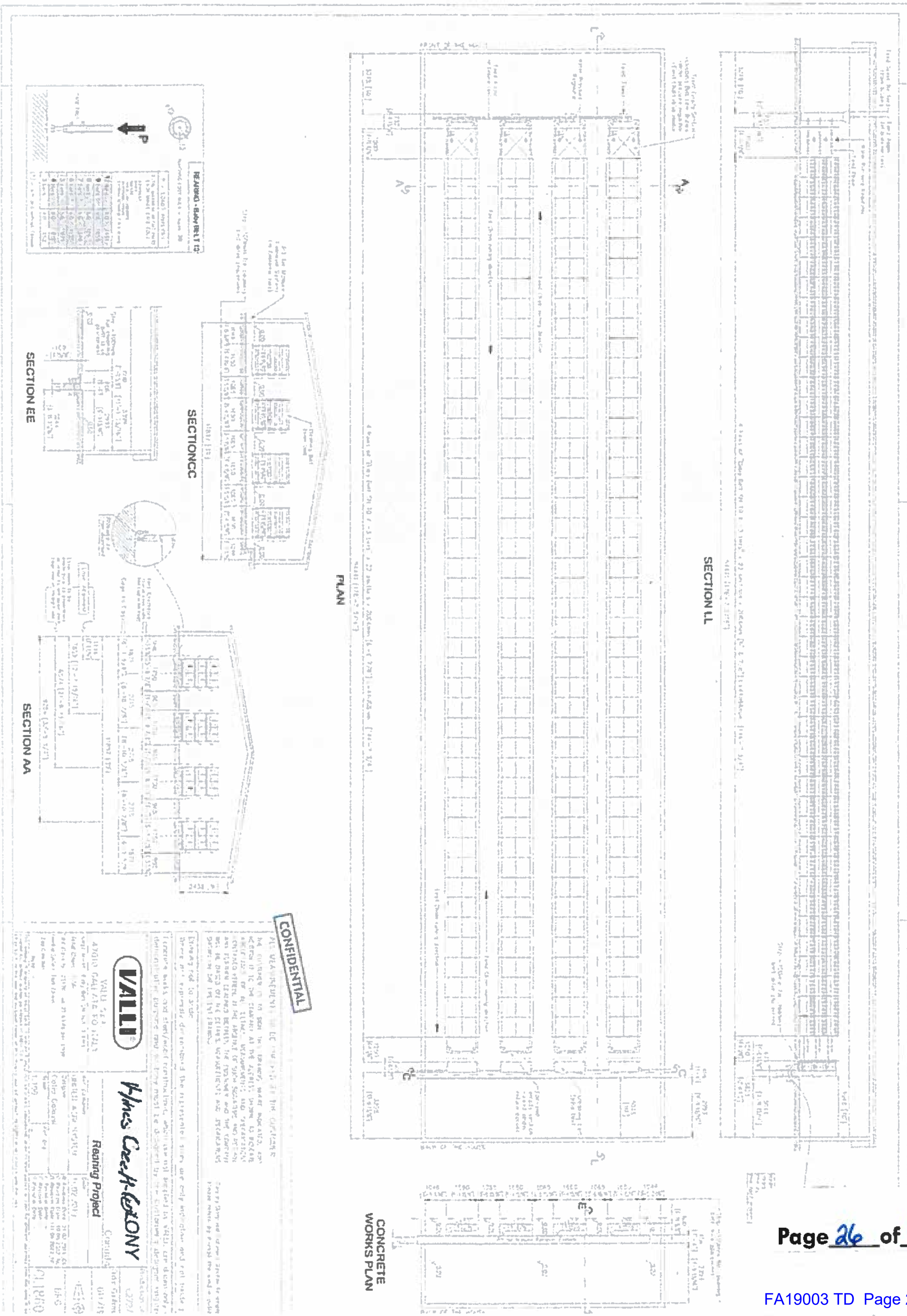
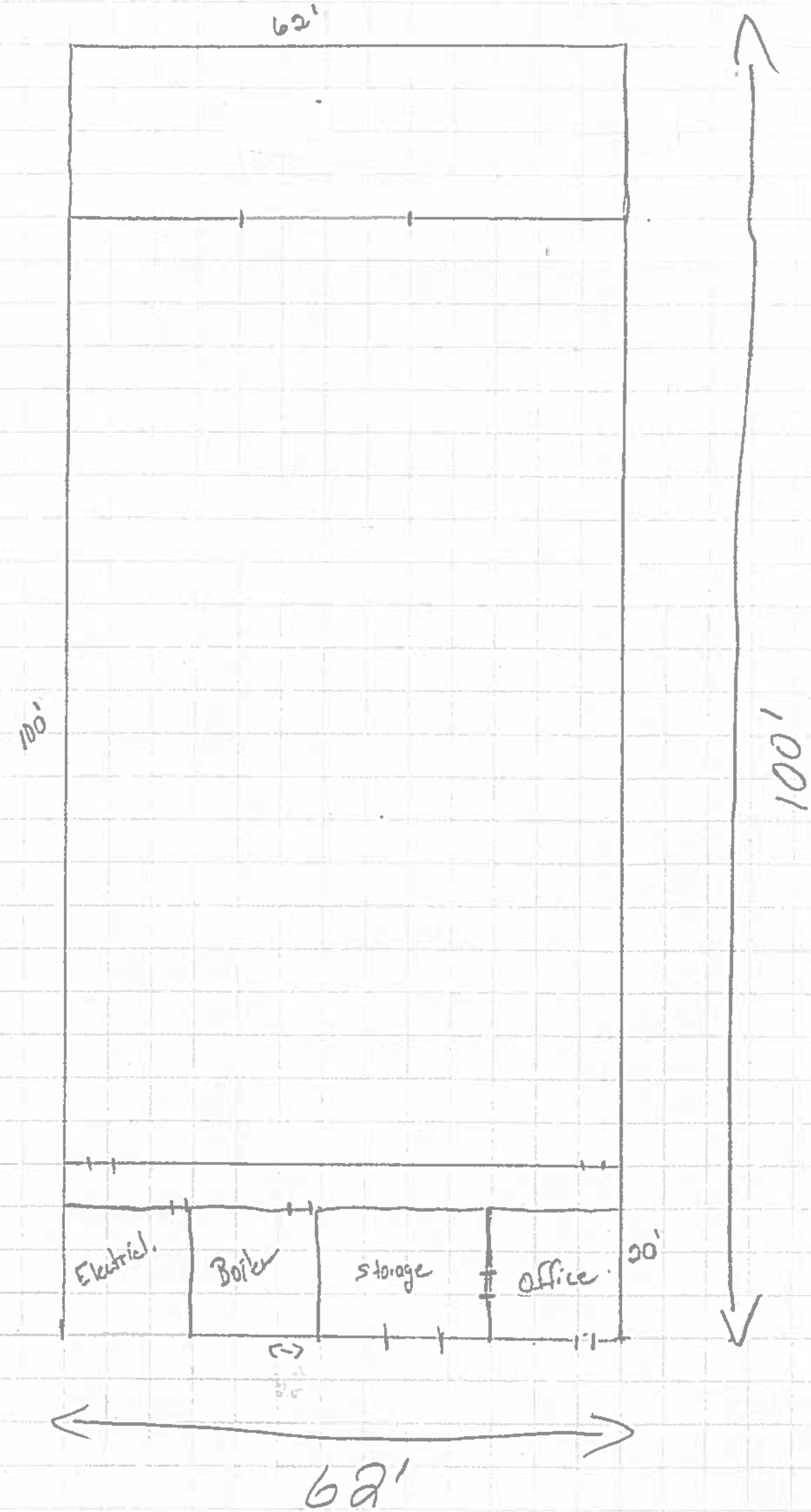

SECTION LL
PLAN
SECTIONCC
SECTION EE
SECTION AA
CONCRETE WORKS PLAN
CONFIDENTIAL
VALLI
Rearing Project

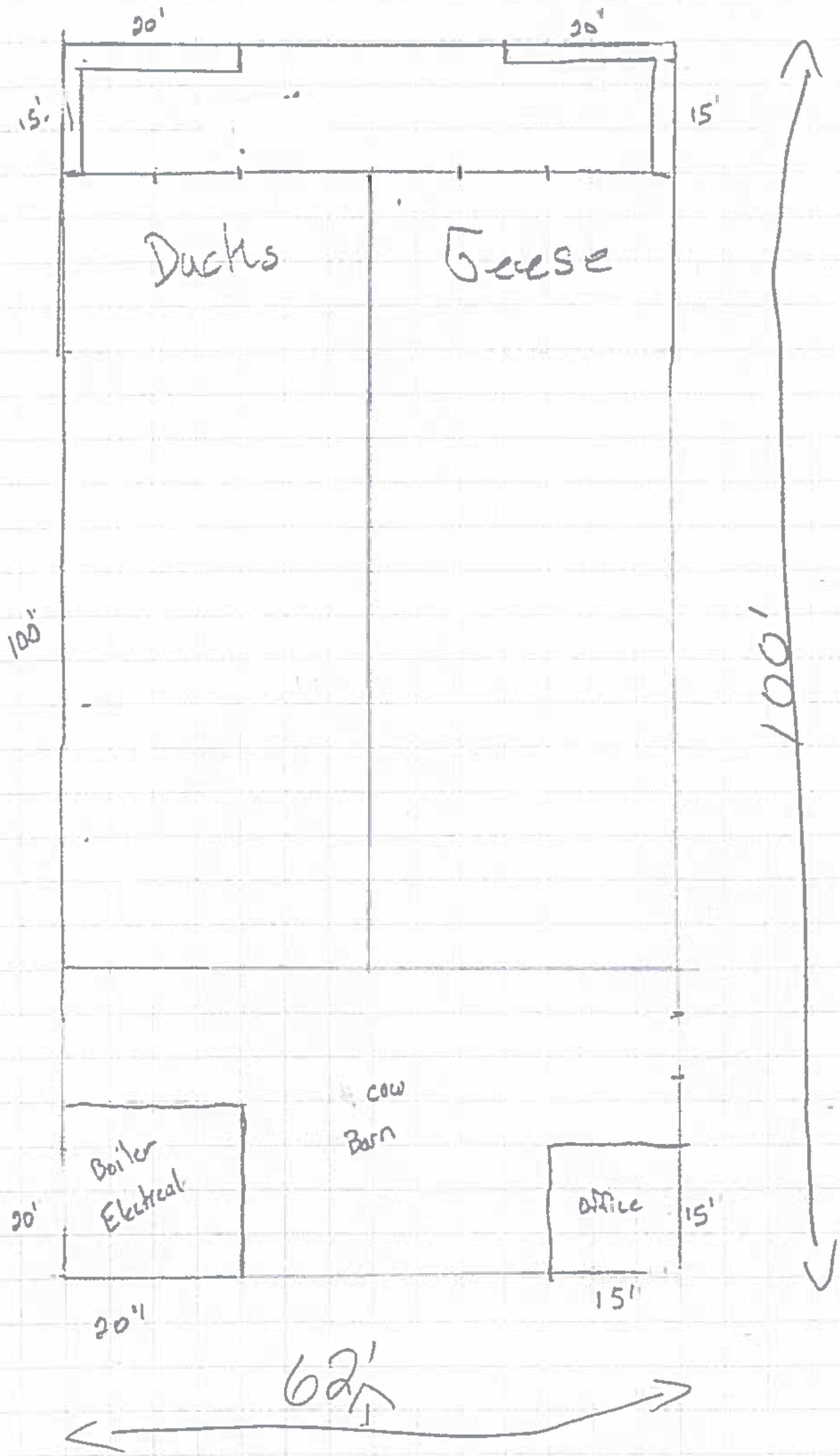
Pallet

Pullet Barn.

Broiler Barn



Multi-Species Barn



GEOTECHNICAL INVESTIGATION REPORT

PROPOSED HINES CREEK COLONY
NE-4-85-5-W6M, CLEAR HILLS COUNTY
NEAR HINES CREEK, ALBERTA

PREPARED FOR

HINES CREEK FARMS

PROPOSED HINES CREEK COLONY

PREPARED BY

PARKLAND GEOTECHNICAL LTD.

GRANDE PRAIRIE, ALBERTA

ParklandGEO

PROJECT No.: GP4287

DATE: AUGUST 2, 2019

Geotechnical, Environmental and Materials Engineering

Red Deer · Sherwood Park · Grande Prairie · Calgary · Fort McMurray
Peace River · Medicine Hat · Lethbridge · Estevan

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Figure 4 SPT vs Elevation
Site Photographs

APPENDICES

Appendix A Borehole Logs
Explanation Sheets
Appendix B Laboratory Results
Limitations General Terms, Conditions and Limitations

1.0 INTRODUCTION

Hines Creek Farms (Owner) is proposing to construct a new colony near Hines Creek, Alberta. Parkland Geotechnical Ltd. (ParklandGEO) was commissioned to carry out a geotechnical investigation on the property to provide construction recommendations for the proposed development. This report summarizes the results of field and laboratory testing programs and presents geotechnical recommendations for foundations, sewage treatment, manure storage design and general site development.

1.1 SCOPE OF WORK

The proposed scope of work for this project was outlined to Mr. Murray Kwasny of Murk Construction on behalf of the Owner in proposal PRO-GP19-039 dated March 4, 2019. Authorization to proceed was provided by Mike Gross of Hines Creek Farms by signing and returning a copy of the professional services agreement on March 6, 2019.

1.2 PREVIOUS INVESTIGATIONS

ParklandGEO is not aware of any previous geotechnical investigations having been conducted on this property.

2.0 SITE & PROJECT DESCRIPTION

The subject property is located within NE-04-85-05-W6M, approximately 14 km northwest of Hines Creek, Alberta, as shown on the Area Plan, Figure 1. An Aerial Plan for the proposed development site is shown in Figure 2. At the time of the investigation, the site was snow covered. Access to the site was provided by Range Road 53 and the access road to an existing farm yard from the west of the site. The topography of the site was relatively flat with general drainage from east to west. Surrounding land use consisted of agricultural fields in all directions and an existing farm yard to with agricultural structures to the east. Site photographs taken during the field investigation are appended.

The proposed developments occupy the whole quarter section and are expected to contain a barn area near the northeast corner of the site, housing areas to the southwest, shop areas to the southeast, a sewage lagoon near the west section of the site, and a dry sewage storage cell near the north section of the site. The foundation loads are expected to be light to moderate. Traffic loads are expected to be light to moderate. A site plan illustrating the proposed site layout and borehole locations is provided on Figure 3.

3.0 FIELD AND LABORATORY PROGRAMS

On March 15 and 16, 2019, ten boreholes were drilled to depths ranging from 3.5 to 15.0 m at the site. The borehole locations are shown on Figure 3. The boreholes were drilled with a track mounted, continuous flight, 150 mm diameter solid stem auger operated by Frontier Enviro Drilling Ltd. Supervision of the drilling, soil sampling and logging of the various soil strata was performed by Mr. Steven Kwan, E.I.T. of ParklandGEO. The detailed borehole logs are provided in Appendix A. The following is a brief description of the field and laboratory programs completed for this site:

1. All samples from the boreholes were examined in the field and classified using the Modified Unified Soil Classification System.

2. Disturbed samples for moisture content were obtained at depths intervals of 1.0 m in all boreholes. Standard penetration tests were performed at depth intervals of 1.5 m where possible, in all boreholes.

3. A 50 mm monitoring well was installed in Borehole 19-06 to a depth of 15.5 m. Hand slotted, 25 mm diameter PVC standpipes were installed in Boreholes 19-03, 19-07 and 19-09. The groundwater conditions were noted during drilling, upon completion and again on April 4, 2019, about 19 days after drilling.

4. The borehole locations and elevations were surveyed by ParklandGEO personnel by using a handheld Trimble Geo 7X. The survey was performed referencing to a geodetic datum (accurate to within 10 cm).

5. All soil samples were returned to ParklandGEO's Grande Prairie laboratory for selected testing to determine the soil properties. The laboratory program consisted of moisture contents, Atterberg Limits, Particle Size Analysis (Hydrometer Test) and Permeability (Triaxial Hydraulic Conductivity). Select samples were sent to AGAT Laboratories in Grande Prairie to test for water soluble sulphate concentrations. The results of all laboratory testing are shown on the borehole logs and results are included in Appendix B.

4.0 SUBSURFACE CONDITIONS

The general soil profile consisted of topsoil overlying clay till. Detailed descriptions of the soil conditions encountered are provided on the borehole and test pit logs in Appendix A along with the definitions of the terminology and symbols used on the logs. The following is a brief description of the soil types encountered.

4.1 TOPSOIL

Topsoil up to approximately 800 mm in thickness was found at the surface in all boreholes. The topsoil was organic, contained little peat, roots and organic inclusions and was damp. The topsoil was considered to be low plastic, loose, weak and compressible under load. The topsoil thickness may vary between borehole locations.

4.2 CLAY TILL

Clay till was encountered beneath the topsoil in all boreholes and extended beyond the maximum drilled depth of 15.5 m (elevation 661.5 m). The till was a variable mixture of clay and silt with little sand and trace gravel with rust inclusions. The clay till was medium to high plastic with Liquid Limits (LL) ranging from 44 to 67 percent. Based on the results of seven grain size analyses, the average soil texture was 44 percent clay, 36 percent silt, 19 percent sand and less than 1 percent gravel. Although not encountered during the investigation, the local till is known to contain large boulders and water bearing sand lenses. Standard Penetration Tests (SPT) in the clay till ranged from 8 to 30 blows for 300 mm of penetration indicating the clay till was of a stiff to very stiff consistency. The moisture content of the clay till was about 15 to 36 percent which is considered near or above the estimated Optimum Moisture Content (OMC).

4.3 ROUTINE LABORATORY TESTING

TABLE 1: SUMMARY OF LABORATORY TEST RESULTS

Borehole No.	Depth (m)	Grain Size Distribution (%)				Plasticity (%)			Soil Type*
		Clay	Silt	Sand	Gravel	LL	PL	PI	
19-01	3.0	45.5	40.3	13.2	1.0	56	15	41	CH
19-04	1.5	50.3	35.5	14.1	0.1	54	17	37	CH
19-05	4.5	39.7	34.4	22.1	3.7	45	18	27	CI
19-05	6.0	39.2	36.2	24.2	0.4	44	15	29	CI
19-06	3.0	42.3	36.6	19.8	1.2	47	14	33	CI
19-06	4.5	42.6	36.3	20.8	0.3	47	15	32	CI
19-07	1.5	72.0	24.8	3.3	0.0	67	19	48	CH

* Modified Unified Soil Classification System

4.4 SOIL SULPHATES

Soil samples at various depths from Boreholes 19-01, 19-03 and 19-07 were tested for sulphate concentrations. Results showed water soluble sulphate concentrations between 0.03 and 0.38 percent. The concentrations of sulphates are expressed as a percentage of the dry mass of soil. The concentration of water soluble sulphates at this site range is indicative of an S-2 or Severe classification as per CAN/CSA-A23.1-14 standards. Concrete recommendations are provided in Section 5.9.

4.5 GROUNDWATER

4.5.1 Groundwater Measurements

Groundwater was not encountered during drilling or upon completion in any of the boreholes. On April 4, 2019, about 19 days after drilling, the groundwater levels were measured again but the boreholes were once again dry. The observed groundwater conditions suggest a relatively deep groundwater table and low permeable soil which restricts groundwater infiltration and movement. This is considered typical for the area.

Groundwater elevations are expected to fluctuate on a seasonal basis and will be highest after periods of prolonged heavy precipitation or snow melt. Seasonally high groundwater levels will decrease during dry periods as the groundwater infiltrates. Due to the high plastic soils, groundwater infiltration may be slowed and perch conditions may be present in sand lenses within the till during periods of higher precipitation. Groundwater seepage is not expected for deep excavations at this site.

4.5.2 Hydraulic Conductivity

TABLE 2: HYDRAULIC CONDUCTIVITY TEST RESULTS

Borehole	Sample No.	Sample Depth (m)	Elevation (m)	Hydraulic Conductivity (cm/sec)	Soil Type	Comments
19-05	5U1	4.5	672.8	3.8×10^{-9}	Clay Till	Lab Test

The triaxial hydraulic conductivity tests undertaken on undisturbed samples from Borehole 19-05 at 4.5 m indicate a hydraulic conductivity of 3.8×10^{-9} cm/s.

4.5.3 Groundwater Flow and Velocity

Based on the deep groundwater table and very low permeable soils at this site, accurate monitoring of groundwater flow and velocity were not possible. The vertical gradient of groundwater is considered to be downward with little to no lateral movement. Based on the very low permeability of the subgrade soils, vertical and horizontal movement of groundwater at this site is expected to be very slow and restricted.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 GEOTECHNICAL EVALUATION

The proposed new colony is located at NE-04-85-05-W6M and will include a dry manure storage cell in the north area of the property, a sewage lagoon near the west area, shops near the southeast corner, barns near the northeast corner and housing areas near the southwest corner. The foundations for the houses are expected to be lightly loaded conventional footings. Traffic loads are expected to be light to moderate for the proposed local roads. It is understood that the client's preference is that access roads will have graveled surfacing.

The general topography of the site is relatively flat. In general, the conventional residential foundation conditions at the site are considered to be moderately suitable for the proposed development due to the near surface high plastic soils. The stiff to very stiff clay will provide good bearing conditions for conventional footings. The site soil conditions were considered fair to the proposed shop and barn areas due to the presence of surficial high plastic soils. The observed groundwater conditions suggest a relatively deep groundwater table. The main geotechnical issues regarding site development are:

1. Surficial deposits of high plastic clays are present at this site. These soils are considered to be swelling soils which exhibit volume changes, such as swelling and shrinkage with changes in moisture content. These types of clays can create issues for shallow footing foundations and slabs on grade. Issues associated with these soils and recommendations to mitigate these issues are presented in Section 5.2.

2. The fine grained soils on this site are low permeable and well suited for lagoons and dry manure storage. Berm slope stability and erosion protection will be the main design issues for the lagoon.

3. The subgrade consists of fine grained soils which are expected to provide a low level of subgrade support for pavements. Like all fine grained soils, clay subgrades may be subject to softening or rutting if the exposed subgrade is allowed to get wet during construction. Therefore, weather will play a roll in site development.

4. The disturbance of the subgrade in utility trench areas may result in some lowering of the subgrade support along with consolidation settlement of the backfill for the first few years after placement. This can be reduced by providing good levels of compaction and moisture control during operations.

5. Based on the 1 in 25 years return period winter, the depth of frost penetration in the Hines Creek area is approximately 2.7 m for clay and clay till.

6. The foundation conditions are considered to be suitable for several pile options including bored cast-in-place (CIP) concrete piles and steel screw piles. The site is considered marginally suitable for footing foundations for commercial developments due to the presence of high plastic swelling soils. Recommendations are included for bored CIP concrete piles, screw piles and footings. Other options can be provided upon request.

5.2 SWELLING CLAY ISSUES

Near surface high plastic swelling clay till are present at this site which is typical for many areas in and around the Peace Region. High plastic soils exhibit volume changes such as swelling and shrinkage with changes in soil moisture content. Swelling potential decreases at higher soil moisture contents in the order of 35 percent or greater. The high plastic soils observed at this site have soil moisture contents ranging from 15 to 36 percent. The typical problem with swelling soils is that they are exposed and allowed to dry out during construction and then once a shallow footing, slab or pavement is placed over the soil the evapo-transpiration conditions change and the soil gains moisture. Since structural features are placed after shrinkage, the effects of swelling are magnified when the soil re-establishes a new soil - moisture equilibrium. Swelling pressures in excess of 150 kPa are considered possible at this site, which is well in excess of typical house footing and slab loads. The swelling problems are magnified by the variation of plasticity in the subgrade, which might lead to non uniform swelling and harmful differential heave. The following construction practices can be undertaken and reduce potential problems with heaving and shrinking:

1. If practical, higher plastic soils could be removed, replaced or mixed with a suitable low to medium plastic or granular material. However, this option may not be practical for this development. The native medium plastic clay till would provide a better bearing surface for the foundation than the native high plastic clay till where the option is possible. If the foundation bearing surface is in high plastic clay till it is recommended to place a mud slab, compacted gravel or self-compacting gravel on the bearing surface. Geotextile should be used between the clay subgrade and the gravel fill.

2. Lightly loaded residential structures are not well suited for swelling clays where bearing pressures may be less than potential heave pressures due to swelling. Swelling pressures and heave potential are reduced when soil moisture contents approach 35 percent. Soils drier than this will be subject to higher swelling. It is crucial not to allow exposed subgrade soils to dry during construction through the use of protective layer such as mud slabs; or the subgrade can be saturated by flooding or injection prior to placement of the gravel base and slab. The soil adjacent to the footing should not be allowed to dry after the concrete is poured.

3. Interior non-load bearing walls need to be designed to accommodate potential vertical movement of the slab. The use of pad footings with adjustable posts is recommended over interior bearing walls.

4. Exterior drainage around the building perimeters is important to minimize the potential for infiltration into subgrade soils. Roof and other drains should discharge into storm sewers. If this is not possible, roof drains should discharge well clear of the buildings. The use of paving stones adjacent to buildings is also not recommended unless special design considerations are used to promote the drainage of water away from buildings. Pavement areas around the buildings should be kept high, especially in gravel surfaced areas. The surface of the top of the subgrade should mirror the surface grades and shed infiltration water away.

5. Landscaping should be designed to minimize the need for watering adjacent to the proposed buildings. Planting trees and larger shrubs within 1 to 3 m of the buildings should be avoided, because root systems can take moisture from subgrade soils and lead to possible subgrade shrinkage and settlement.

These steps can be taken to reduce the detrimental effects of swelling clays on foundations and slabs. Due to the nature of these soils however, there is no procedure that can be followed that can totally eliminate the risk.

5.3 SITE PREPARATION

It is expected that stripping and grading will be required for the proposed development. Topsoil and organic material should be stripped before excavation takes place. It is expected that topsoil will be stockpiled for re-use for later landscaping. Care should be taken to minimize cross contamination of organic and non organic soils. If soft spots are encountered in near surface soils, sub-cut excavation and replacement of soils may be required. The depth of any sub-cut excavation should be sufficient to remove soft material or to bridge over the material to give proper support to construction traffic. Following removal of any undesirable soils, all exposed subgrade soils should be scarified to a minimum depth of 150 mm, moisture adjusted and compacted to a minimum of 97 percent of Standard Proctor Maximum Dry Density (SPMDD) in pavement and building areas. In building areas the clay surface should be moisture adjusted to a moisture content 2 to 4 percent above OMC.

Fill required to bring the site up to grade should be low to medium plastic clay. The native surficial clay is high plastic which is marginally suitable for use as engineered fill. High plastic clay may be selectively used or should be mixed with lower plastic clays to reduce swelling potential. High plastic clay should be placed well wet of OMC.

The engineered fill placed during site grading at this site should be compacted to at least 95 percent of SPMDD. Uniformity of compaction is most important. The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. It is recommended that a maximum lift thickness of 200 mm for granular fill and 150 mm for clay fill be utilized. Granular fill is best compacted with large smooth drum vibratory rollers. Clay fill is best compacted with large vibratory "padfoot" or "sheepsfoot" rollers. In areas which require higher compaction, it is recommended that granular fill be placed at moisture contents zero to 2 percent below OMC and that clay fill be placed at moisture contents about 0 to 2 percent above OMC. This will help reduce compaction effort and potential risk of subgrade disturbance needed to achieve maximum density.

Subsequent to site grading, special consideration must be given to deep fill areas below proposed residential lots where the depth of fill is greater than 1.0 m below final grade. Engineered clay fill placed more than 1.0 m deep or below structures should be uniformly compacted to at least 100 percent of SPMDD at a moisture content within 2 percent of OMC. The control of moisture content is considered to be important for high plastic clays, because future wetting of these fill soils may cause significant swelling. This swelling could occur long after original construction depending on changes in the groundwater regime due to development (ie. lawn watering, servicing, etc.) and on normal seasonal conditions. If these density levels cannot be achieved using common fill during site grading, the footing bearing surfaces should be sub-cut and underlain with select granular fills compacted to at least 98 percent. The depth of sub-cut should be determined at the time of construction and will depend on factors such as; age of fill, initial compaction, depth of fill, water table, footing configuration and loads. To reduce settlement potential and compaction effort needed to achieve maximum density, it is recommended that granular fill be placed at moisture contents zero to 2 percent below OMC.

If subgrade conditions are soft, a thicker initial lift may be required to form a working base for subsequent construction. This condition is best addressed in the field at the time of construction. If subgrade conditions warrant the use of subgrade improvement gravel, it is possible, for lower lifts, to use less expensive select coarse gravel with a maximum aggregate size of 150 mm.

5.4 UNDERGROUND SERVICES

5.4.1 Buried Service Excavation

The proposed servicing for the site will include either well supply or a common water system fed by underground service lines. It is expected that typical services may be installed to depths of up to 4.0 m below the finished grade depending on changes in local topography. Excavations are not expected to extend below the groundwater table, but perched groundwater may be encountered seasonally within the low permeable clay. Conventional trenched excavations with back sloped walls and/or moving shields are considered to be feasible.

Excavations should be carried out in accordance with Alberta Occupational Health and Safety Regulations. The stability of excavated trench walls decreases with time and, therefore, service construction should be directed at minimizing the length of time service trenches are left open. The side-slopes of conventional unsupported trench excavations are dependent on the local soil conditions. In general, for excavations deeper than 1.5 m, it is recommended that side-slopes for short term excavations should be cut back to 1H:1V or flatter. If seepage zones or saturated soils are encountered, the excavation may require flatter side-slopes. If required side-slopes cannot be provided, the use of temporary shoring is recommended in the working area of the trench.

The degree of stability of a steeply cut excavated trench wall decreases directly with time and, therefore, construction should be directed at minimizing the length of time service trenches remain open. Preliminary groundwater measurements indicated that trenches are not expected to go below the groundwater table. This may change if perched groundwater is encountered due to seasonal weather changes, in which case de-watering of excavated slopes may be necessary for trenches. The stiff clay soils at this site may not be subject to boiling, but disturbance from excavation may cause loss of strength and subgrade support.

Surface grading should be undertaken so that surface water is not allowed to pond adjacent to service trenches. Surcharge loads, including excavation spoil, should be kept back from the crest of the excavation a minimum distance equal to the excavation depth. Monitoring and maintenance of the slopes should be carried out on a regular basis.

Installation of underground services and utilities requires an observational approach be adopted which should combine past experience, contractor's experience and geotechnical input. It would be desirable for the selected excavation contractor(s) to be experienced in similar soil conditions and/or excavate test pits in advance of construction to familiarize field personnel with subsurface conditions. Quality workmanship is essential.

5.4.2 Frost Protection For Buried Facilities

Based on the 1 in 25 years return period winter, the depth of frost penetration in the Hines Creek area is approximately 2.7 m for clay with an average moisture content of 30 percent. Therefore, the recommended minimum buried depth for water lines and sewers is 3.1 m.

5.4.3 Pipe Bedding

Minor deflections of the trench bedding are expected. Underground utility pipes should be of a type which will maintain watertight joints (i.e. rubber gasket) after minor shifting has occurred. Bedding requirements are a function of the class of pipe and trench configuration, as well as site specific geotechnical considerations. In general, granular pipe bedding should be relatively well graded sand or sand gravel mixture which can be readily compacted around the pipe to achieve a high frictional strength. Bedding soils must have an appropriate gradation so that migration of natural soils into the granular system is minimized. Uniform or gap-graded sands and gravels should not be used as bedding materials unless adequate provision is made to surround such soils with a filter fabric or graded granular filter compatible with the existing subsoils.

In the event of significant groundwater seepage or wet base conditions, additional measures may be required. Typically these measures include placement of a working mat of free draining gravel and filter cloth after lowering of the water table and removal of disturbed soils. This layer of gravel is intended to be a safe working base and the thickness required will be based on keeping groundwater below the working surface. The function of the geotextile in pipe bedding applications is to act as a separation barrier between the coarse bedding materials and the native fine grained soils, therefore it needs to be strong enough to withstand construction activity.

5.4.4 Trench Backfill

Soil used for trench backfill should be free of frozen soil, organics, and any other undesirable materials. Fill required to bring the site up to grade should be low to medium plastic clay or well graded select granular material such as sand or gravel. The native surficial clay is high plastic which is marginally suitable for use as engineered fill. If high plastic clay is used it should be placed well wet of OMC.

To minimize fill settlement under self-weight, it is recommended to use soil with a moisture content within 5 percent of OMC. When excavated soils are excessively wet, the material should be dried or blended prior to use as trench backfill. Suitable replacement soils would include local or imported sand borrow materials with an appropriate moisture content relative to OMC. In areas where this is not possible, the actual placement conditions (ie. moisture content and field density) should be assessed to determine appropriate corrective actions for proposed surface development.

Lift thicknesses for backfill should be governed by the ability of the selected compaction to achieve specified density throughout the entire lift. Uniformity is of most importance. The nominal lift thickness for select granular fill is 200 mm. Clay backfill should be placed in thin lifts with a nominal compacted thickness of 150 mm. This is especially important when backfilling very stiff clay soils. The backfill should be uniformly compacted to a minimum of 97 percent of SPMDD. For road areas, the backfill should be compacted throughout the depth of the fill to a minimum 97 percent of SPMDD.

Some settlement of the compacted backfill in trenches under self-weight is expected to occur. The magnitude and rate of settlement would be dependent on the backfill soil type, the moisture condition of the backfill at the time of placement, the depth of the service trench, drainage conditions and the initial density achieved during compaction. Density monitoring of backfill placement is recommended to encourage better attention to quality workmanship in placement.

Fill materials with variable moisture contents recompacted as trench backfill would not be expected to provide uniform roadway subgrades for the support of pavement sections. If trench settlement in road areas is a concern, it is suggested to consider a deep subgrade preparation of the upper 0.5 to 1.0 m of the subgrade to help make the subgrade more uniform.

To minimize the effects of potential settlements on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible, subsequent to completion of trench backfilling. A minimum of at least one season and freeze - thaw cycle is recommended for staging of final pavement.

5.5 ALBERTA BUILDING CODE

In accordance with the 2014 version of the Alberta Building Code (ABC), the use of Limit States Design (LSD) is required for the design of buildings and their structural components including foundations. The limit states of LSD design are classified into two groups; the Ultimate Limit States (ULS) and the Serviceability Limit States (SLS). The ULS design requirements in the ABC reference the Structural Commentaries in the User Guide of the National Building Code of Canada (NBCC).

5.5.1 Ultimate Limit States - ULS

The ULS case is primarily concerned with safety and the levels of load and resistance at the point of collapse or structural failure. The geotechnical value for this case is the ultimate resistance. For foundation design this ultimate resistance value is reduced using a Geotechnical Resistance Factor (GRF) which is based on the reliability index of the geotechnical data used to determine the ultimate resistance for the foundation loading case.

As per the NBCC the following GRF values should be used for foundation design:

TABLE 3: LSD GEOTECHNICAL RESISTANCE FACTORS*

GEOTECHNICAL CASE	Resistance Factors
DEEP FOUNDATIONS (PILES)	
Vertical resistance by semi-empirical analysis and in-situ test data	0.4
Vertical resistance from analysis of dynamic monitoring results	0.5
Vertical resistance from analysis of static load test results	0.6
Uplift resistance by semi-empirical analysis and in-situ test data	0.3
Uplift resistance from analysis of static load test results	0.4
SHALLOW FOUNDATIONS (FOOTINGS)	
Vertical resistance by semi-empirical analysis and in-situ test data	0.5

* NBCC - Users Guide - Structural Commentaries (Part 4 of Division B) - Commentary K -Foundations.

5.5.2 Serviceability Limit States - SLS

The SLS occurs when the foundation loads cause movements or vibrations that are greater than the structure can tolerate before the intended use of the structure is restricted or hindered. The SLS case is addressed by determining the maximum available resistance to keep the foundation deformation within tolerable limits under service loads (ie. settlement, lateral deflection, etc.). Typically, the foundation loads, configurations and serviceability tolerances have to be known to properly determine geotechnical SLS resistance values. In some cases, such as small footings, basic assumptions can be used to provide preliminary SLS resistance values under specific stated conditions.

For axial loading conditions the SLS resistance is addressed by determining the limiting load to deep foundation settlements within tolerable limits. Tolerable total and differential settlement should be verified by the structural engineer, but for normal buildings the tolerable limit of total settlement for foundations is typically about 25 mm. For the pile sizes expected on this project, less than 25 mm of settlement is expected to be required to mobilize the ultimate resistance. As a result, the serviceability limit states are not expected to govern pile foundation design unless very strict settlement tolerances are required (ie. less than 10 to 15 mm of settlement). The settlement potential of the proposed foundation should be checked once foundation design and loading conditions are finalized.

5.5.3 Seismic Considerations

The National Building Code of Canada (2015) requires buildings to be designed to resist a minimum earthquake force. The formula for obtaining minimum earthquake force is dependent of several factors including the Foundation Factor (F) which should be determined using a Site Class of C for this site (Table 4.1.8.4.A). The subgrade soil include stiff clay with a shear strength of at least 100 kPa within 0.4 m of grade.

5.6 RESIDENTIAL FOUNDATIONS

5.6.1 Footings

Standard house basement foundations using strip and spread footings will generally be acceptable at this site. Footings based on native clay till soils or thin engineered gravel fill uniformly compacted to at least 100 percent SPMDD may be designed based on a maximum allowable bearing pressure of 150 and 175 kPa for strip and spread footings respectively, placed on undisturbed inorganic soil (clay or clay till) free from loosened material. If gravel fill is used, non-woven geotextiles should be used between the clay subgrade and the gravel layer. The design and construction of foundations should conform to the Alberta Building Code provision for residential structures. In general, excavations should be protected against surface water runoff and ingress of groundwater.

Footing bases should not be allowed to dry out excessively or freeze during construction; and the bearing soil should be protected against freezing during and after construction. In areas with high plastic clay soils, the bearing surface should be protected by a mud slab. While adhering to minimum footing width set by Alberta Building Code, footings should not be oversized to reduce bearing pressure because it may result in extra heave.

5.6.2 Basement Subdrainage System

A permanent subdrainage system (weeping tile drain) is recommended around the outside perimeter of basements. The weeping drain should be surrounded with granular material to prevent the fine grained native soil from being washed into the drain. The granular filter may consist of free draining crushed rock or washed rock placed around the perforated drain pipe and wrapped with a coarse concrete sand or suitable geotextile. A sump pit with pump should be the end point of the system to remove water away from the foundation perimeter.

Infiltration flows into most weeping tile drains are expected to be low to moderate because the native soil, particularly the clay, is relatively impermeable. The largest flows will occur during periods of heavy precipitation and spring runoff. Groundwater infiltration flows can be significantly increased by poor site drainage around houses, improperly directed roof leaders and poorly graded or compacted backfill.

5.6.3 Basement Excavation

Basement excavations in the native clay and clay till soils are not expected to be able to stand near vertical for long periods of time. For excavations deeper than 1.5 m, side slopes should be cut back to 1H:1V. If space does not permit the slopes to be cut back, some form of temporary shoring must be installed to protect workers in the excavation.

The latest edition of the Occupational Health and Safety Code should be followed. All temporary surcharge loads should be kept back from the excavated faces by at least a distance equivalent to the depth of the excavation. All vehicles delivering materials to the site should be kept back from excavated faces a distance equivalent to the depth or 1.0 m, whichever is greater.

For proposed basements excavated during wet weather or with elevations close to the groundwater table elevation, construction traffic from tractor dozer type equipment could cause the disturbance of the subgrade resulting in a significant weakening of the subgrade. In this case, excavation is best carried out with backhoe or "Gradall" equipment.

5.6.4 Backfill For Houses

Backfill soils are capable of exerting significant horizontal pressures onto a basement wall. It is recommended that backfilling be delayed until the concrete has gained enough strength to support the horizontal loads. The top and bottom of the wall should be braced prior to backfilling. Therefore, it is recommended to place the basement floor slab and floor joists prior to backfilling around walls. Backfill should be brought up evenly around the building perimeter to minimize differential horizontal pressures on the basement walls.

Rather than heavily compacting the backfill around the basements, it is recommended to nominally compact the backfill (90 - 95 percent of SPMDD) recognizing that settlement of the backfill will occur, particularly after the first freeze/thaw and moisture infiltration cycle. Backfill around basement walls should be sloped to shed water away from the structure with a recommended slope of at least 3 percent. The slope of the backfill should be checked periodically to maintain the slope of the ground surface away from the wall. Roof leaders from houses and garages may be discharged onto the ground surface well clear of the foundation walls to help reduce wet weather infiltration of water into the subdrainage weeping tile system.

5.7 PILE FOUNDATIONS

5.7.1 Bored CIP Concrete Piles - ULS Design

The soil conditions for this site are suitable for bored CIP concrete piles. Either straight-shaft or belled end-bearing piles could be considered. Bored CIP concrete piles may be designed based on the ultimate skin friction or end-bearing resistance provided in the following table.

TABLE 4: BORED CIP CONCRETE PILES - ULTIMATE RESISTANCE

Soil Type	Depth (mbg)	Elevation (m)	Ultimate		Factored ULS ($\varphi = 0.4$)	
			Skin Friction	End Bearing	Skin Friction	End Bearing
Frost Zone	0 - 1.5	-	0	-	0	-
Upper Clay Till	1.5 - 8.0	Above 666.0	50	-	20	-
Lower Clay Till	> 8.0	Below 666.0	60	1080	24	430

The factored ULS resistance in this table are calculated by multiplying the ultimate value using a geotechnical resistance factor (GRF) of 0.4. The upper 1.5 m of pile shaft for a heated structure and 2.5 m for an unheated structure, or the length of pile shaft in new fill, whichever is greater, should be assumed to carry no load. For belled piles, care must be taken to provide a bearing surface at the base of the pile free from all loose and disturbed soil. It should be noted that pile bells must be formed within the self supporting clay soils.

Additional recommendations for CIP concrete piles are as follows:

1. To resist uplift forces created by frost action, the minimum depth of straight shaft piles for heated structures should be 6.0 m below final grade. If this embedment requirement cannot be met, the piles should be belled to provide the necessary protection against frost uplift. Belled piles should have a minimum depth of 4.5 m.

2. Steel casing should be available on site during construction and should be used to prevent sloughing and groundwater seepage into the drill-hole, if required.

3. Pile excavations should be filled with concrete within 2 hours of completing the pile excavation.

4. A minimum shaft diameter of 400 mm is recommended for CIP concrete piles. The minimum centre to centre spacing of straight shaft piles should be 3 pile diameters unless group reduction factors are applied. The minimum spacing of belled piles should be sufficient to provide at least 0.5 m of separation between the edges of adjacent bells founded at similar elevations.

5. If belled piles are used:

   - a bell to shaft ratio up to 3:1 would be acceptable, as long as the angle on the roof of the bell is 45° or steeper, to ensure that the load being transferred from the shaft to the bell is properly spread over the entire area of the bell.

   - the minimum distance from the underside of any sand layer to the roof of the bell should be 1.5 m.

   - to avoid potential settlement in loose soils remaining after shaft is drilled, the base of the bell should be sub-cut by the belling tool at least 50 mm below the final depth achieved by the auger used to drill the shaft.

   - bells should not be placed within sand lenses or sand/gravel layers (if encountered).

6. Steel reinforcement should extend the full length of the pile for belled piles and at least 6 m for friction piles.

7. All pile installations should be inspected by a qualified geotechnical engineer or technician to verify that design criteria are met or exceeded.

5.7.2 Steel Screw Piles - ULS Design

Steel screw piles are considered a feasible foundation option at this site. The design and installation of screw piles is often undertaken by specialty contractors based on service loads supplied by the structural engineer. The ultimate load carrying capacity of multi-helix screw piles in vertical compression may be calculated based on a rational method assuming resistance is developed from the shearing resistance of the soil cylinder between the top and bottom helixes and the compressive bearing on the base for helix spacings of less than 2.5D.

The ultimate load carrying capacity of a screw pile in vertical compression in cohesive (clay) soil may be calculated using the following formula.

$$Q_U = (N_C\, C_u\, A_H) + (SF\, \pi\, C_u\, D\, (H_3 - H_1)) \qquad \text{(Cohesive Soil } H/D \geq 4\text{)}$$

Where:
- Q_U = ultimate unfactored pile load (kN)
- C_U = undrained shear strength of soil at the depth of the helix plates (kPa)
- N_C = bearing capacity factors for cohesive soils (for $H/D > 4$ use $N_C = 9$)
- H_3 = depth to bottom helix (m)
- H_1 = depth to top helix (m)
- A_H = area of the top helix (m^2)
- D = average diameter of helix plates (m)
- SF = spacing factor (use 1 for $S/D < 3$)
- S = helix spacing (use < 2D)

The "factored" resistance for ULS analysis for axial compression should be calculated by multiplying the unfactored values above by a geotechnical resistance factor of 0.4, in accordance with the building code. The GRF for resistance to axial compression may be increased to 0.6 if the pile capacities are verified by a static load test. The parameters for the screw pile design formula provided above are given in the following table:

TABLE 5: DESIGN PARAMETERS FOR SCREW PILES

Design Parameter	Upper Clay Till	Lower Clay Till
Elevation (m)	Above 666.0	Below 666.0
Effective Unit Weight of Soil, γ' (kN/m^3)	18	18.5
Bearing Capacity Factor for Cohesive Soil (N_C) H/D > 4	9	9
Undrained Shear Strength, C_U (kPa)	95	120

The effective unit weight used in the relationship will depend on the position of the helix relative to the groundwater table. Below the groundwater table use $\gamma' = \gamma'_{SOIL} - \gamma'_{WATER}$. Screw piles should have a minimum embedment depth from ground surface to achieve sufficient frost jacking resistance.

Other design and construction recommendations include the following:

1. The maximum torque allowed during installation or "torque rating" of the proposed pile section must be considered during screw pile selection. The torque rating is an allowable value based on the ultimate torque strength or point of torsional fracture for the cross-sectional area of the steel in the pile shaft. The torque rating should be provided by the pile manufacturer. The estimated torque required to install the screw pile to the design resistance should not exceed the torque rating for the pile.

   For preliminary purposes, the minimum required torque may be taken as:

   $$T = Q / K_t \qquad \text{(Hoyt \& Clemence, 1989)}$$

   Where: T = Minimum Torque Requirement (kN-m)
   Q = Design resistance of the pile (kN)
   K_t = empirical torque correlation factor = 10 m^{-1} for $D_S \geq 0.22$ m

2. The torque rating for the pile shaft should not be exceeded during installation of the pile. Using excessive torque on the pile may cause damage to the pile shaft which would require the pile to be replaced.

3. The minimum allowable center to center pile spacing should be taken as the greater of four helix diameters. If groups of piles are installed at a pile spacing less than the minimum, a detailed analysis should be carried out to evaluate the group capacity.

4. Screw piles should have a minimum embedment depth from ground surface to achieve sufficient resistance to tension loads and frost jacking. For piles subjected to tension loads, the minimum screw pile embedment depth from ground surface to the top helix should be taken as five times the helix diameter. For frost protection, the minimum screw pile embedment depth from ground surface to the top helix should be the design frost depth plus one helix diameter. The greater of the two embedment depths should govern pile designs.

5. The maximum vertical spacing for the helixes is 3 times the helix diameter for piles loaded in compression or tension. The method of determining pile capacity must be reviewed if this criterion is not met. The practical limit for helixes per pile is 4 for cohesive soil.

6. Pile foundations which are required to resist uplift forces should be checked for both resistance to pullout and to their structural ability to carry tensile stresses. Uplift loads due to frost and wind loads are not additive since the two load mechanisms are vastly different.

7. Corrosion of the pile shaft in a partially saturated medium must be considered in selecting pipe shaft wall thickness. It is suggested to fill the pile shafts with concrete after installation to add strength to the pile shaft and reduce the corrosion potential inside the shaft.

8. The soil strength is considered to be sufficient to provide lateral confinement to the pile shaft. Therefore, buckling of the shaft is not expected to be a concern.

9. Monitoring of the pile installation by experienced geotechnical personnel is recommended to confirm that the piles are installed in accordance with design assumptions and that the installation criteria are satisfied. The installation records should include a summary of the torque required to install the pile, particularly the average torque achieved during the last 1.5 m of pile installation.

5.8 GRADE SUPPORTED SLABS

Typical to many areas of the Peace Region, the site soil conditions are not well suited for slab on grade floor construction due to the high plastic supporting subgrade. Ideally, the preferred design option is to provide structurally support slabs. However, it is acknowledged that many builders choose to select slab on grade floors due to budgetary constraints and have had performance ranging from very poor to good. The swelling potential for the clay on this site is estimated between 50 and 150 mm, depending on what precautions are taken to minimize drying of the subgrade during construction. Possible problems with non uniform heaving and shrinking can be minimized (but not eliminated) using construction practices as discussed in Section 5.2. The following recommendations should be followed:

1. Lightly loaded (less than 10 kPa) grade supported concrete slabs should be underlain with 150 mm of well graded, free draining, crushed gravel compacted to 100 percent of SPMDD;

2. It is crucial not to allow this subgrade to dry out during or after construction. Prior to placement of the gravel base for the slab, the subgrade underneath the slab should be properly moisture conditioned to provide moisture for swelling prior to placement of slabs to reduce potential for swelling after the slab is placed;

3. Slabs should be provided with construction joints or sawcuts in accordance with local practice. The concrete slab should be reinforced with steel bars or equivalent wire mesh and dimensioned in accordance with the structural engineer's requirements. The reinforcing bars can be carried through the construction joints. As a minimum, it is recommended that floor slabs be reinforced with 10 mm bars at 600 mm spacings in both directions, or by an equivalent wire mesh;

4. Slabs should be constructed independently of all walls, columns and grade beams. Slab on grade floors should be tied into the grade beam with dowels at doorways. Alternatively, the slab may tied to grade beams if a construction joint is placed parallel to the wall at a distance of about 2.0 m;

5. Non-load bearing partitions should be designed to accommodate slight vertical movements of at least 50 mm. Service connections should be flexible enough to allow for small differential movements;

6. Water lines below slab in high plastic subgrades should be placed in trenches which are lined with a geo-membrane and graded to collection areas, so that water from leaks or a pipe break can be contained. Allowing water to be trapped below the slab at this site significantly increases the potential of differential subgrade heave;

7. A geotextile separator should be placed between the gravel base course and the prepared clay subgrade; and

8. Heating ducts beneath the floor should not be used unless the subgrade is protected from drying out with the use of rigid insulation.

To emphasize the comments above, steps can be taken to reduce the detrimental effects of swelling clays on foundations and slab work. Due the nature of these soils however, there is no procedure that can be followed that can totally eliminate the risk of vertical movement other than the provision of a properly protected structural slab.

5.9 CONCRETE

The water soluble sulphate concentration indicated a severe potential for sulphate attack and therefore it is recommended that an S-2 classification be applied to all concrete exposed to soils, as per the CAN/CSA-A23.1-14 standards. High Sulphate Resistant (Type HS) hydraulic cement may be used for concrete placed in contact with native soil. The minimum 56 day compressive strength is 32 MPa with a maximum water to cement ratio of 0.45. All concrete exposed to a freezing environment either during or after construction should be air entrained.

5.10 SEWAGE LAGOON

5.10.1 General Discussion

Groundwater is a renewable resource and it must be managed. The most common sources of contaminants that can impact groundwater originate on or near the ground surface. Contaminant sources can include leachate from landfills, effluent from leaking lagoons, septic fields and petroleum products from storage tanks or pipeline breaks. Agricultural activities that generate contaminants include the use or storage of fertilizers, pesticides, herbicides, and sewage.

Water retained in the proposed lagoon will either evaporate, infiltrate into the groundwater table or be discharged via man-made outlets into the natural local surface water drainage system. The potential for groundwater contamination is based on the concept that contamination from surface sources like lagoons may seep down into the groundwater table and migrate in the direction of preferential movement. In areas of downward groundwater flow (i.e. recharge areas), the groundwater moves downward towards local aquifers, but low-permeable materials within the profile impede the movement of contaminants downward. As water moves through the soil profile, contaminants are removed by processes of natural attenuation (i.e. aquitard layers). The evaluation of treatment lagoons with clay liners is based on assessing whether the seepage rates are within acceptable criteria; and whether the migration of contaminants with seepage water will impact the subgrade and groundwater table outside of the lagoon basin. The assessment of seepage rates is based on a review of the local subgrade soil quality and measurement of groundwater movement around the lagoon (i.e. gradients, estimated lateral and vertical groundwater velocity). The impact of contaminants in the subgrade is based on review of the soil and groundwater chemistry.

A conventional engineered clay liner or natural clay lined lagoon is typically designed to allow seepage at a slow rate which allows the subgrade soil and other environmental conditions to attenuate or remove the contaminants from the groundwater through natural processes (i.e. filtration, biodegradation, absorption, dilution, plant uptake, etc.). If the seepage rates are too fast, the ability of the subgrade to attenuate contaminants is diminished and there will be a tendency for contaminant levels in the soil to start to rise. In addition to the operational aspects of the lagoon, the assessment should also consider physical attributes such as berm and shoreline conditions (i.e. slope stability, wave erosion, encroachment of vegetation, inter-cell piping, etc.). The relevant regulation for a liquid sewage storage facility in Alberta is Alberta Private Sewage Systems Standard of Practice (APSSSP) Third edition (December 2015) published by Safety Codes Council.

5.10.2 Assessment

As per APSSSP 9.1.1.1 regulations, the required or proposed thickness of liners consisting of porous material in which seepage is calculated by the following equation:

$$K_T = (C \times T) / (T + 2)$$

Where: K_T = maximum hydraulic conductivity of liner in the field, being at least one order of magnitude greater than the laboratory value, (m/s)
T = required or proposed thickness of liner, (m)
C = 5.2×10^{-9} (m/s)

The hydrogeological setting for the proposed lagoon is a layer of very low permeable clay till more than 15 m thick. Based on laboratory testing, the hydraulic conductivity of the undisturbed clay till is 3.8×10^{-11} m/s. Using the above equation, the minimum thickness of a liner using the native clay till is 0.15 m. The test results verify that the clay till layer alone meets the requirements for a natural barrier for a liquid sewage storage lagoon as a low permeable porous material. Seepage from the lagoon is expected to move very slowly downward from the lagoon basin to the to the underlying soils and generally be drawn upward very slowly into the upper soils formation through the surrounding vegetation root system and evapo-transpiration.

Due to the presence of a thick layer of clay till, the site is considered to be well suited for a sewage lagoon with a natural clay base. The native clay till is medium to high plastic and considered to be suitable for berm construction.

Based on the large distance to possible receptors (ie. creeks, aquifers) and the significant potential for natural attenuation of seepage water infiltration in close proximity to the lagoon basin, the potential for significant negative environmental impacts from the proposed lagoon is considered to be negligible at this site.

5.10.3 Lagoon Depth and Berm Configuration

A slope angle of 3H:1V or flatter is required for the outside face of the proposed clay berms. The interior slopes should be constructed at slope angles of 3H:1V or flatter. Recommendations for steeper side-slopes may be provided upon review of proposed face armoring. The pond shore line should be protected against erosion from wave action, because shoreline erosion may destabilize the pond berms. Side slopes should be vegetated to protect against slumping and erosion.

According to APSSSP requirements Part 9.1.1.3, a minimum berm width of 1.8 m with slope angle of 3H:1V or flatter is required. The finished elevation of the berm should also be above the surrounding grade, to prevent the entry of surface run-off water into the lagoon. Typical berm is approximately 3.0 m in width at the top to allow vehicle access around the entire perimeter for maintenance purposes. Berm crests are often covered in 150 mm of crushed gravel to create a vehicle running surface and sloped from the centreline at a minimum of 2 percent to promote surface runoff. Alternatively, the crest of the berm can be covered in grass and maintained by periodic cutting.

The vertical distance between the high water level and the top of the berm, or "freeboard," should be a minimum of 0.6 m according to APSSSP Part 9.1.1.3 requirements, to allow for fluctuation of the operating high water level in the lagoon cell. This freeboard distance may be required to be increased in areas where high winds and steep embankment result in water scouring.
For stability under normal "dry" conditions, the groundwater table at the toe of dry pond slopes should be maintained at least 0.6 m below final grade. Some restrictions might apply to pond operations, because fast draw-down rates will impact slope stability. The use of a geomembrane liner within lagoon cells subject to large and frequent fluctuations would reduce the degree of saturation of the berms, thereby maintaining a higher degree of slope stability.

5.10.4 Liner Requirements

Overall acceptance of lagoon subgrade is dependent on having a native subgrade or a compacted liner of select clay material with a required hydraulic conductivity determined from tests on either in-situ field or lab samples. The undisturbed native clay till had a hydraulic conductivity of 3.8×10^{-11} m/s. The native clay till is considered suitable for containment of the lagoon.

5.10.5 Berm Materials

Ideally, fill used for general berm construction of this lagoon should consist of select low to medium plastic clay fill. Most of the native surficial clay till is medium to high plastic and may be considered to be marginally suitable for berm material. However, since high plastic clay are slightly weaker than the desirable medium plastic materials, flatter slopes may be required for stability. Material selection should be reviewed by a geotechnical engineer during construction.

5.10.6 Lagoon Construction General Considerations

Slope stability is influenced by precipitation, surface erosion, groundwater, and soil moisture conditions. The main trigger for slope movement is expected to be erosion, wave action, and over-steepening due to slumping from surficial wetting and weathering of the berms. The lagoon shore line should be protected against erosion from wave action because shoreline erosions may destabilize the lagoon slopes. Re-vegetation of the exposed berms immediately after construction is highly recommended to protect the slope face from weathering. The inside slope on the windward side of the prevailing wind should be armored with rip-rap or other engineered revetment. Exterior berm slopes should be covered with topsoil and vegetated with a shallow root, broadleaf grasses as soon as possible after construction to reduce erosion. Trees and shrubs should not be permitted to grow on the berm as the larger root system of these larger plants tends to fracture the soil. Burrowing and hoofed animals can also cause significant damage to a berm and liner and should not be permitted to congregate in the area of the lagoon.

After construction, the berms slopes should be monitored by maintenance personnel on a periodic basis. The exterior berm slope will be most prone to failure during periods of snow-melt and heavy or prolonged periods of precipitation. The interior slope faces will be most prone to failure during periods of pond draw-down. Any significant new slumping or tension crack development along the crests or slope faces should be reviewed by a qualified geotechnical engineer to assess the potential impacts on the berm integrity.

5.10.7 Site Preparation, Materials and Placement

The development area should be stripped of all topsoil and weak or unsuitable foundation soils. The lagoon should be cut or raised to design configuration and, if encountered, any structural features such as fissuring or sand lenses which might promote seepage below the berms or base should be subcut and replaced with select clay fill material.

Due to the sensitive, fine grained nature of the surficial soils, subgrade conditions may be adversely impacted by wet weather and seasonal perched groundwater conditions. Problems related to weather conditions are not expected to persist after construction is completed, provided steps are taken during construction to identify and remedy possible soft subgrade areas.

Moisture conditioning of the native soils may be required prior to use as fill in order to achieve specified densities.

- The engineered fill within the proposed berms should be placed and compacted to at least 97 percent of SPMDD at a moisture content between 0 and 3 percent above OMC.
- The floor of the lagoon requires scarification, moisture adjustment, and recompaction of the subgrade to improve uniformity and remove possible surface desiccation due to drying prior to use. The lagoon subgrade should be compacted to at least 95 percent of SPMDD at a moisture content at least 0 to 3 percent above OMC.

The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. It is recommended to use a maximum lift thickness of 150 mm for clay fill. Clay fill is best compacted with large vibratory "padfoot" or "sheepsfoot" rollers. Proper moisture conditioning will help remould the clay fill and reduce compactive effort needed to achieve maximum density (i.e. minimizing the potential risk of subgrade disturbance). Uniformity of compaction is most important.

5.10.8 Winter Construction

Construction is not recommended during freezing conditions due to the difficulties with moisture conditioning and achieving the desired hydraulic conductivity with the compacted soils. Fill should not be placed frozen, or on frozen ground, unless the effect of thawing soil has been evaluated by a qualified geotechnical engineer.

5.10.9 Decommissioning of Groundwater Piezometers

No boreholes were drilled within the proposed lagoon. If the lagoon is moved to an area where a piezometer was installed in one of the boreholes, the piezometers must be properly decommissioned prior to any construction activity.

5.11 DRY MANURE STORAGE

5.11.1 Guidelines and Acts

The relevant regulation for a dry manure storage facility in Alberta is regulated by Natural Resources Conservation Board (NRCB, February 2018). The specific requirement for hydraulic conductivity requirements for a naturally occurring layer are provided in this guideline which states:

"Naturally occurring protective layer(s) for solid sewage collection and storage facilities must have a minimum thickness of two metres, a maximum hydraulic conductivity of 1×10^{-6} centimeters/second (cm/s), and a positive slope, to prevent liquids from ponding on the surface of the protective layer."

5.11.2 Assessment

The hydrogeological setting for the proposed storage cell is at least 15 m thick layer of very low permeable clay overlying low permeable clay till. The hydraulic conductivity of the clay is lower than 1×10^{-8} cm/s which is two orders of magnitude lower than the requirements outlined in Section 5.5.1 for a naturally occurring protective layer. The test results verify that the clay till layer alone meets the requirements for a natural barrier for dry manure storage. Seepage from the storage cell is expected to move very slowly downward from the storage cell to the to the underlying soils and generally be drawn upward very slowly into the upper soils formation through the surrounding vegetation root system and evapo-transpiration.

Due to the presence of a thick layer of clay till, the site is considered to be well suited for a dry sewage storage facility with a natural clay till base. The construction of berms will be required to provide storage capacity above natural ground surface. The native clay till is considered to be suitable for berm construction. The floor of the storage area requires scarification, moisture adjustment, and recompaction of the subgrade to improve uniformity and remove possible surface desiccation due to drying prior to use. The storage area subgrade should be compacted to at least 95 percent of SPMDD at a moisture content at least 0 to 3 percent above OMC and sloped away from the centre of the storage area at 2 percent.

The measured groundwater levels indicate a relatively deep groundwater table. Based on the distance to possible receptors (ie. creeks, aquifers) and the significant potential for natural attenuation of seepage water infiltration in close proximity to the storage cell basin, the potential for significant negative environmental impacts from the proposed dry manure storage is considered to be negligible at this site.

5.12 INSPECTION

It is recommended that on-site inspection and testing be performed to verify that actual site conditions are consistent with assumed conditions which meet or exceed design criteria. Based on the Alberta Building Code, adequate levels of inspection include: testing of engineered fill and inspection of deep foundation installations.

6.0 LIMITATIONS AND CLOSURE

Geological conditions are variable. The recommendations presented in this report, and any subsequent correspondence, are based on an evaluation of information derived from ten (10) borehole locations and from local experience. The conditions found are thought to be reasonably representative of the site. If different subsoil and groundwater conditions are encountered, this office must be notified and recommendations submitted herein will be reviewed and revised as required.

This report has been prepared for the exclusive use of **Hines Creek Farms** and their approved agents for specific application to the project and site described in this report. It has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty is made either express or implied. Parkland Geotechnical Ltd. and The ParklandGEO Consulting Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. Use of the report is subject to acceptance of the General Terms and Conditions provided in Limitation Appendix of this report.

We trust that this report meets with your current requirements. If there are any questions, please contact the undersigned.

Respectfully submitted,
PARKLAND GEOTECHNICAL LTD.
APEGA Permit to Practice No. P9516

PROFESSIONAL ENGINEER
CONNAN J. SQUAIR
ALBERTA
August 2, 2019

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Geotechnical Engineer-In-Training

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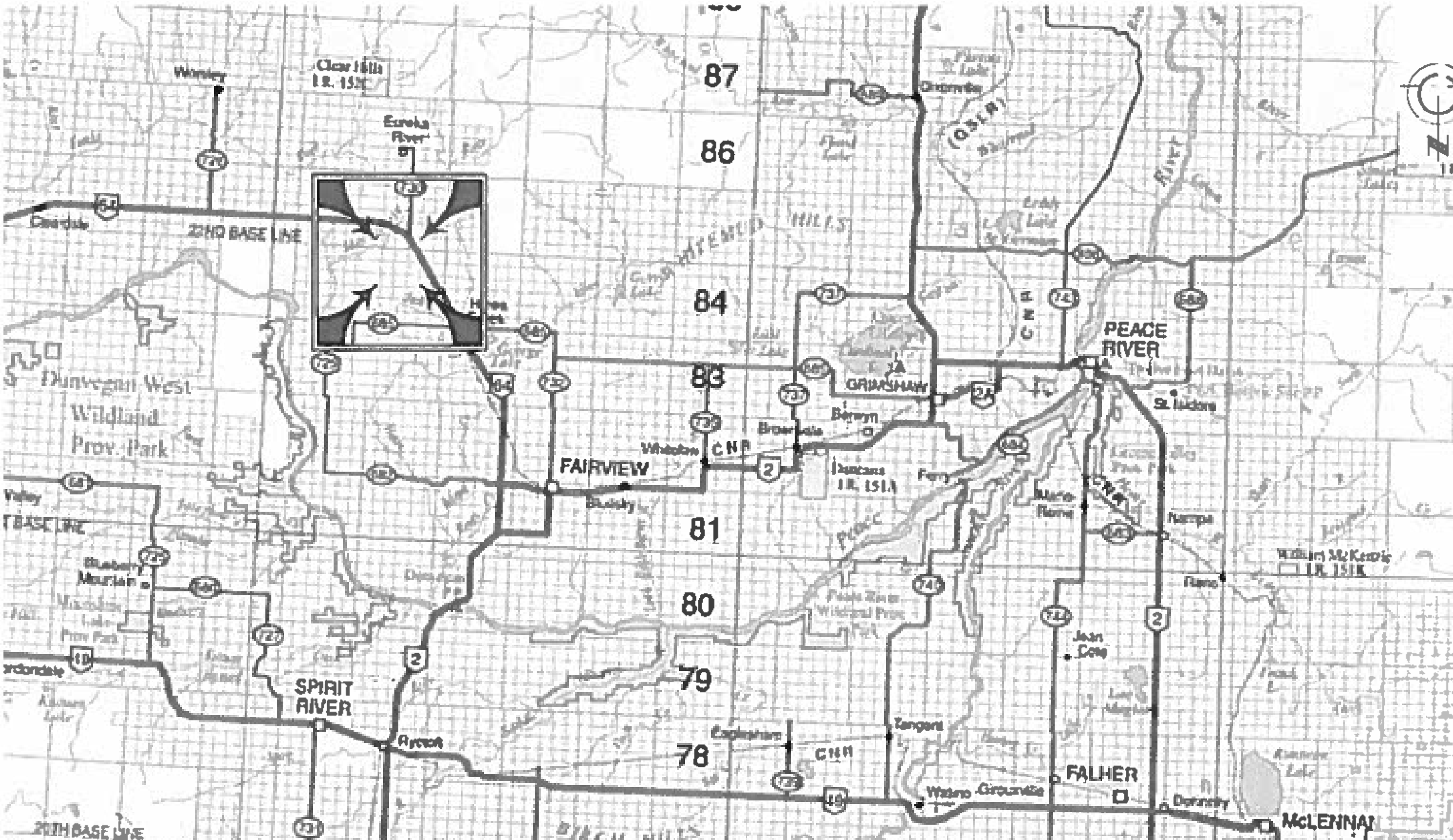
Geotechnical Engineer

Reviewed by:
Mohamed El-Marassi, Ph.D., P.Eng.
Senior Associate Geotechnical Engineer

FIGURES

FIGURE 1: AREA PLAN
FIGURE 2: AERIAL PLAN
FIGURE 3: SITE PLAN
FIGURE 4: SPT VS. ELEVATION
SITE PHOTOGRAPHS



Parkland GEO

CLIENT:

HINES CREEK FARMS COLONY

AREA PLAN

GEOTECHNICAL INVESTIGATION
NE-04-85-05-W6M, NEAR HINES CREEK, AB

DRAWN:	CHK'D.:	REV
CL	MB	

SCALE:	JOB NO.
NTS	

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NOTES:

1. AERIAL PHOTOGRAPH OBTAINED FROM ABADATA DATAGRAPHICS. ON MAY 22, 2019.

ParklandGEO

CLIENT:

HINES CREEK FARMS COLONY

AERIAL PLAN

GEOTECHNICAL INVESTIGATION
NE-04-85-05-W6M, NEAR HINES CREEK, AB

DRAWN: CL
CHK'D.: MB
R'

SCALE: NTS
JOB NO.

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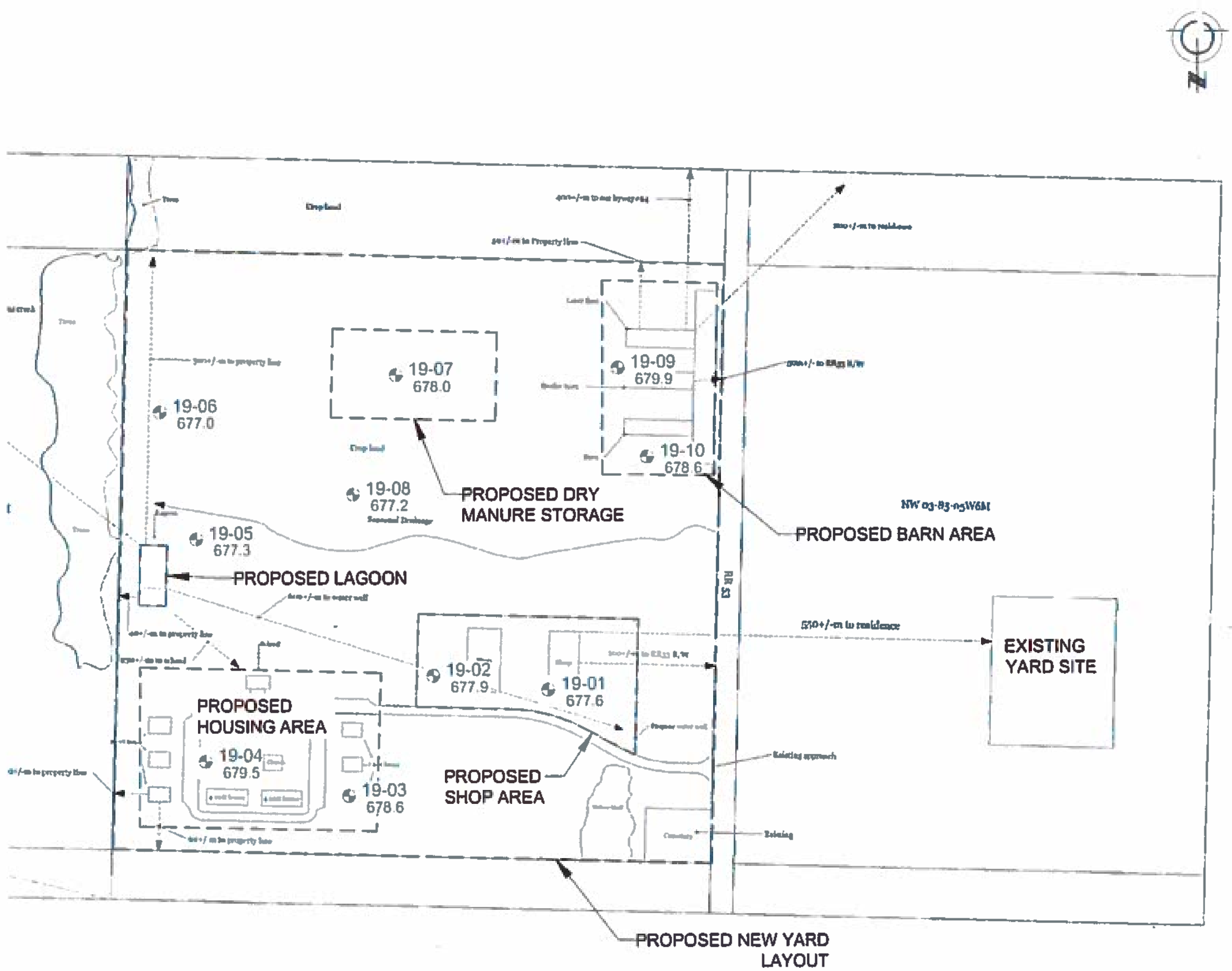
AO Comment: Page 29/96 most accuracte for barns/pads this drawing includes entire farm layout



NOTES:

1. SITE PLAN PROVIDED BY MURK CONSTRUCTION SERVICES DATED NOVEMBER 7, 2018.
2. SURVEY DATA OBTAINED BY PARKLAND GEO, USING TRIMBLE ON MARCH 15 AND 16, 2019.
3. DRAWING INTENDED FOR BOREHOLE REFERENCE ONLY. NOT TO BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

LEGEND

19-01 BOREHOLE
650.0 ELEVATION (m)

SCALE (metres)

-25 -12.5 0 12.5 25 50

Parkland GEO	CLIENT: HINES CREEK FARMS COLONY	SITE PLAN
		GEOTECHNICAL INVESTIGATION NE-04-85-05-W6M, NEAR HINES CREEK, AB
		DRAWN: CL · CHK'D.: MB · RF
		SCALE: 1:1250 · JOB NO.

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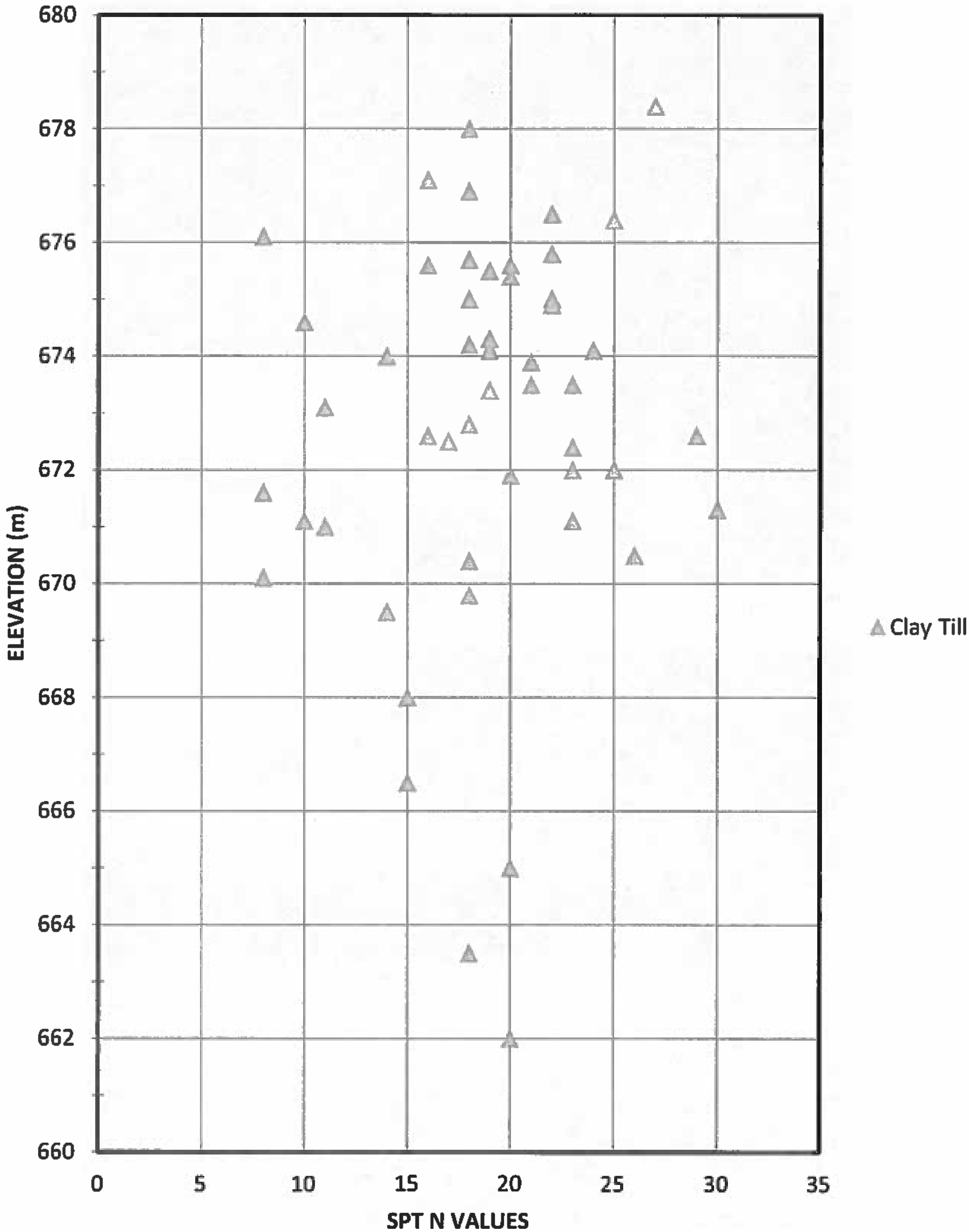
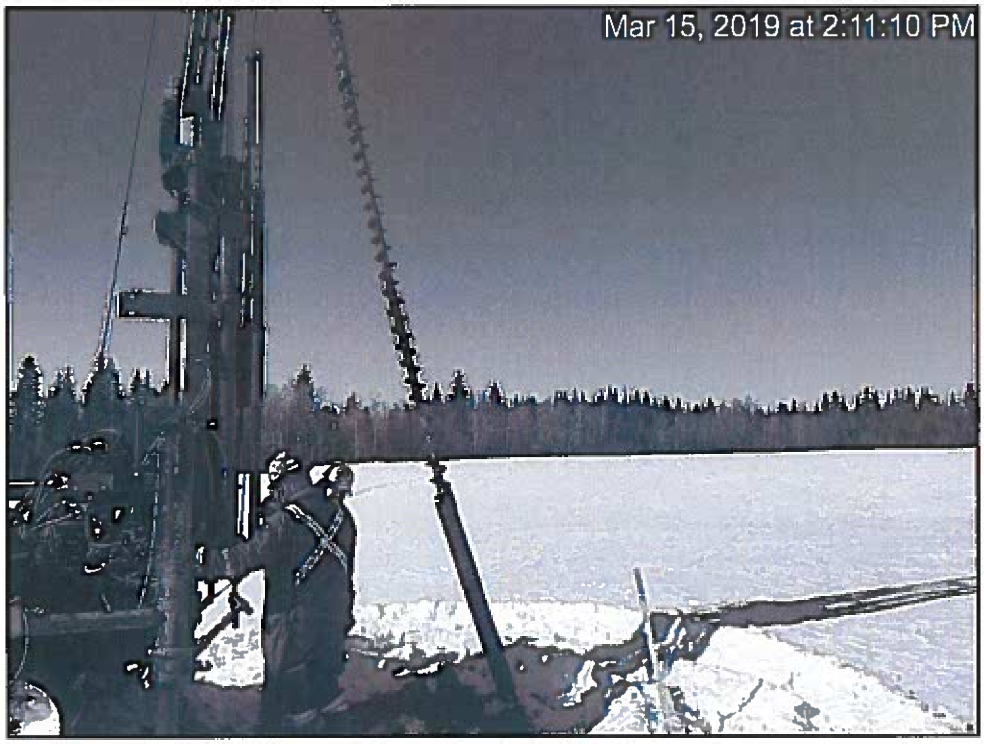
SPT vs ELEVATION



ParklandGEO	CLIENT: HINES CREEK FARMS COLONY	SPT VS. ELEVATION
		GEOTECHNICAL INVESTIGATION NE-04-85-05-W6M, NEAR HINES CREEK, AB
		DRAWN: CL · CHK'D.: MB · P
		SCALE: NTS · JOB NO. · Page 62 of 91



Photograph 1: Looking west from Borehole 19-05. Existing trees in background.

Photograph 2: Looking southwest from proposed lagoon location.

APPENDIX A

BOREHOLE LOGS
EXPLANATION SHEETS

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-01
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Moisture (Wp — X — Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE							677.6
0	***Topsoil*** Little peat, root and organic inclusions, damp	>100					Backfilled To Surface With Auger Cuttings	
			G	1G1				676.8
1	***Clay Till*** Some silt, little sand, trace gravel, stiff, high plastic, grey, rust inclusions, damp to moist; - From 0 to 0.4 m, frozen	28	G	1G2				
		29		1D1	8			
3		30		1D2	10	Grain Size Analysis (at 3.0 m) Clay: 45.5% Silt: 40.3% Sand: 13.2% Gravel: 1.0% Atterberg Limits PL: 15.0% LL: 56.0% PI: 41.0%		
4		30						
5		36		1D3	11	No recovery		
6		31		1D4	8			
7		31	G	1G3				
				1D5	8			669.6
8	END OF BOREHOLE; Borehole dry on completion							

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 677.6
NORTHING (m): 6245695.6
EASTING (m): 393918.3

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-02
PROJECT NO.: GP4287
BH LOCATION:

SUBSURFACE PROFILE / SAMPLES

Depth (m)	Description	Moisture (Wp |—X—| Wl)	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE						677.9
	Topsoil Root and organic inclusions, damp	21					
	Clay Till Some silt, little sand, trace gravel, very stiff, high plastic, mottled, rust inclusions, damp	15					
1			G	2G1			
	- From 0 to 0.4 m, frozen						
		16	SPT	2D1	25		
2							
3		20	SPT	2D2	22		
4	- From 4.0 to 8.0 m, grey	22					
5		26	SPT	2D3	19		
6		29	SPT	2D4	20	No recovery	
7		24	G	2G2			
			SPT	2D5	18	No recovery	
8	END OF BOREHOLE						669.9
	Borehole dry on completion						
9							
10							

Well Completion Details: Backfilled To Surface With Auger Cuttings (0 to 8.0 m)

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 677.9
NORTHING (m): 6245714.3
EASTING (m): 393764.4

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-03
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Symbol	Moisture (Wp |---X---| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								678.6
0	**Topsoil** Some silt, root and organic inclusions, damp		18	G	3G6			25 mm PVC; Bentonite	
	Clay Till Some silt, little sand, trace gravel and cobbles, stiff to very stiff, high plastic, rust inclusions, damp		16	G	3G1				
1	- From 0 to 0.4 m, frozen								
2			23		3D1	16			
3			27	G	3G2				
					3D2	16	No recovery		
4			22						
5			21		3D3	19		25 mm Slotted PVC; Sand	
6	- From 6.0 to 8.0 m, increased silt, grey		20		3D4	16			
7			20						
					3D5	10			
8	END OF BOREHOLE								670.6
	Borehole dry on completion Borehole dry on April 4, 2019								
9									
10									

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 678.6
NORTHING (m): 6245553.1
EASTING (m): 393650.9

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-04
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Moisture (Wp |—X—| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE						Backfilled To Surface With Auger Cuttings	679.5
	Topsoil Dark brown, root and organic inclusions, damp	18	G	4G1				
1	***Clay Till*** Some silt, little sand, trace gravel, very stiff, high plastic, brown, rust inclusions, damp - From 0 to 0.3 m, frozen	18						
		19				Grain Size Analysis Clay: 50.3% Silt: 35.5% Sand: 14.1% Gravel: 0.1% Atterberg Limits PL: 17.0% LL: 54.0% PI: 37.0%		
2		20		4D1	18			
3		27		4U1				
4		19		4D2	72	Hit rock		
5		20		4D3	18			
6		20		4D4	23			
7		18						
8				4D5	25			671.5
	END OF BOREHOLE Borehole dry on completion							
9								
10								

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 679.5
NORTHING (m): 6245599.5
EASTING (m): 393457.7

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-05
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Moisture (Wp |---X---| Wl)	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE							677.3
0	***Topsoil*** Little silt, root and organic inclusions, damp	18					Backfilled To Surface With Auger Cuttings	
0.7	***Clay Till*** Some silt, some sand, trace gravel, very stiff, medium plastic, brown, rust inclusions, damp; - From 0 to 0.3 m, frozen	20	G	5G1				
1.9		23	D	5D1	22			
3.3		23	D	5D2	19			
4		20						
4.8		22	U	5U1		Grain Size Analysis (at 4.5 m) Clay: 39.7% Silt: 34.4% Sand: 22.1% Gravel: 3.7% Atterberg Limits PL: 18.0% LL: 45.0% PI: 27.0%		
5.3			D	5D3	18			
5.7			G	5G2				
6		22				Grain Size Analysis (at 6.0 m) Clay: 39.2% Silt: 36.2% Sand: 24.2% Gravel: 0.4% Atterberg Limits PL: 15.0% LL: 44.0% PI: 29.0%		
6.3			D	5D4	30			
7		19						
7.8			D	5D5	18			
8	END OF BOREHOLE; Borehole dry on completion							669.3

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 677.3
NORTHING (m): 6245897.4
EASTING (m): 393445.0

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-06
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Moisture (Wp |—X—| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE							677.0
	Topsoil Wood, root and organic inclusions, damp	18	G	6G2				
1	***Clay Till*** Some silt, little sand, trace gravel, stiff to very stiff, medium plastic, brown, rust and coal inclusions, damp - From 0 to 0.3 m, frozen	19	G	6G1			50 mm PVC; Bentonite	
2		18	D	6D1	19			
3		19	D	6D2	14	Grain Size Analysis (at 3.0 m) Clay: 42.3% Silt: 36.6% Sand: 19.8% Gravel: 1.2% Atterberg Limits PL: 14.0% LL: 47.0% PI: 33.0%		
4		21						
5	- From 4.5 to 5.2 m, gypsum inclusions	21; 21	D	6D3	17	Grain Size Analysis Clay: 42.6% Silt: 36.3% Sand: 20.8% Gravel: 0.3% Atterberg Limits PL: 15.0% LL: 47.0% PI: 32.0%		
6	- From 6.0 to 15.5 m, increased silt, decreased inclusions	21	U	6U1				
7		24	D	6D4	11			
8		27	D	6D5	14			
9		25	U	6U2				
10		20	D	6D6	15			

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

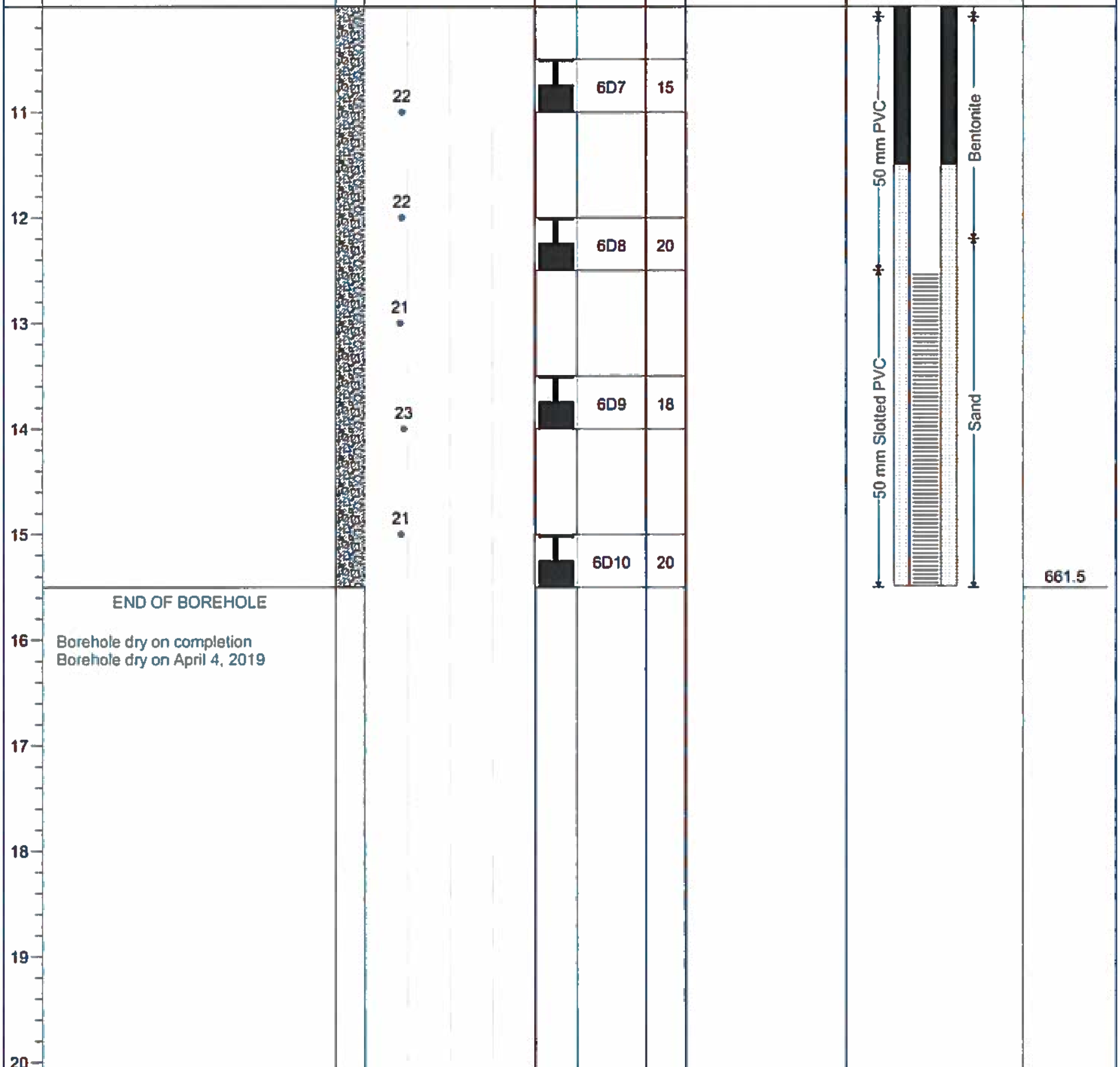
DATE: March 15, 2019
GROUND ELEVATION (m): 677.0
NORTHING (m): 6246068
EASTING (m): 393396.4

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-06
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Sample Type	Sample No	SPT (N)	Moisture (%)	Elevation (m)
~10.9					22	
~10.7			6D7	15		
~11.9					22	
~12.3			6D8	20		
~12.9					21	
~13.8			6D9	18	23	
~14.9					21	
~15.3			6D10	20		661.5
15.5	END OF BOREHOLE Borehole dry on completion Borehole dry on April 4, 2019					



LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 15, 2019
GROUND ELEVATION (m): 677.0
NORTHING (m): 6246068
EASTING (m): 393396.4

ParklandGEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-07
PROJECT NO.: GP4287
BH LOCATION:

SUBSURFACE PROFILE / SAMPLES

Moisture (Wp |----X----| Wl) scale: 25 50 75

Depth (m)	Description	Moisture	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE						678.0
0–0.4	***Topsoil*** Root and organic inclusions, damp	23					
	Clay Till Some silt, little sand, trace gravel, very stiff, medium plastic, brown, gypsum, rust and coal inclusions, damp - From 0 to 0.4 m, frozen	21					
1.5		25 (Wp–Wl range shown)				Grain Size Analysis (at 1.5 m) Clay: 72.0% Silt: 24.8% Sand: 3.3% Atterberg Limits PL: 19.0% LL: 67.0% PI: 48.0%	
1.5–2.0		30	SPT	7D1	22		
2.5–2.8			G	7G1			
3.0		26					
3.0–3.5			U	7U1			
3.5–4.0		24	SPT	7D2	22		
4.5–5.0		23	SPT	7D3	21		
6.0		23					
6.0–6.5			SPT	7D4	23		
7.0		27					
7.5–8.0			SPT	7D5	26		
8.0	END OF BOREHOLE Borehole dry on completion Borehole dry on April 4, 2019						670.0

Well Completion Details:
- 25 mm PVC
- Bentonite
- 25 mm Slotted PVC
- Sand

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 16, 2019
GROUND ELEVATION (m): 678.0
NORTHING (m): 6246116.9
EASTING (m): 393714.7

ParklandGEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-08
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description	Moisture (Wp |--X--| Wl)	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE							677.2
0	***Topsoil*** Root and organic inclusions, damp	19					Backfilled To Surface With Auger Cuttings	
	Clay Till Some silt, trace to little sand, trace gravel, very stiff, medium plastic, bentonite, rust and coal inclusions, damp - From 0 to 0.4 m, frozen - At 1.0 m, dry to damp	17						
2		27	D	8D1	18			
			G	8G1				
3		25	D	8D2	18			673.7
	END OF BOREHOLE Borehole dry on completion							

LOGGED BY: SK	DATE: March 16, 2019
CONTRACTOR: Frontier Enviro-Drilling	GROUND ELEVATION (m): 677.2
RIG/METHOD: Track Mounted Solid Stem Auger	NORTHING (m): 6245957.3
NOTES:	EASTING (m): 393657.4

Parkland GEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-09
PROJECT NO.: GP4287
BH LOCATION:

SUBSURFACE PROFILE

GROUND SURFACE (Elevation 679.9 m)

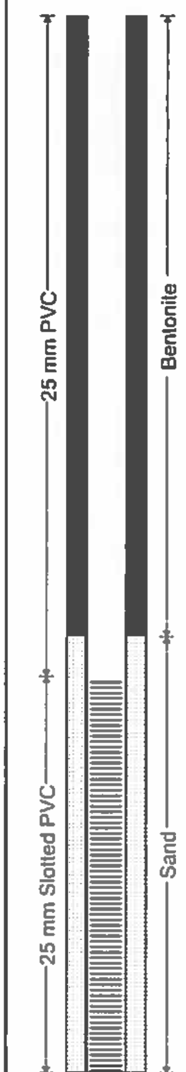
Depth (m)	Description
0 – 0.6	***Topsoil*** Dark brown, root and organic inclusions, damp
0.6 – 8.0	***Clay Till*** Some silt, trace to little sand, very stiff, medium plastic, brown, gypsum, rust and coal inclusions, damp - From 0 to 0.5 m, frozen
8.0	END OF BOREHOLE Borehole dry on completion Borehole dry on April 4, 2019

SAMPLES

Type	Sample No	SPT (N)
G	9G2	
	9D1	27
G	9G1	
	9U1	
	9D2	18
	9D3	20
	9D4	21
	9D5	23

Moisture (Wp |---X---| Wl) 25 50 75: 18, 18, 22, 22, 19, 27, 25, 24

Well Completion Details



Elevation (m): 679.9 (ground surface); 671.9 (end of borehole)

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 16, 2019
GROUND ELEVATION (m): 679.9
NORTHING (m): 6246123.9
EASTING (m): 394011.8

ParklandGEO

CLIENT: Hines Creek Farms
SITE: Hines Creek Farms Colony

BOREHOLE NO.: 19-10
PROJECT NO.: GP4287
BH LOCATION:

Depth (m)	Description (SUBSURFACE PROFILE)	Moisture (Wp |—X—| Wl)	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE							678.6
0	***Topsoil*** Root and organic inclusions, damp	23					Backfilled To Surface With Auger Cuttings	
	Clay Till Some silt, little sand, trace gravel, very stiff, medium plastic, brown, gypsum, rust and coal inclusions, damp	18						
1	- From 0 to 0.8 m, frozen		G	10G1				
				10D1	16			
2		20						
3		23		10D2	20			
4		24						
5		27		10D3	24			
6		31		10D4	29			
7		24						
				10D5	23			670.6
8	END OF BOREHOLE							
	Borehole dry on completion							
9								
10								

LOGGED BY: SK
CONTRACTOR: Frontier Enviro-Drilling
RIG/METHOD: Track Mounted Solid Stem Auger
NOTES:

DATE: March 16, 2019
GROUND ELEVATION (m): 678.6
NORTHING (m): 6246007.7
EASTING (m): 394051.3

The terms and symbols used on the borehole logs to summarize the results of the field investigation and subsequent laboratory testing are described on the following pages.

The borehole logs are a graphical representation summarizing the soil profile as determined during site specific field investigation. The materials, boundaries, and conditions have been established only at the borehole location at the time of drilling. The soil conditions shown on the borehole logs are not necessarily representative of the subsurface conditions elsewhere across the site. The transitions in soil profile can have gradual rather than distinct boundaries.

1. **PRINCIPAL SOIL TYPE** – The major soil type by weight of material or by behaviour.

Material	Grain Size
Boulders	Larger than 300 mm
Cobbles	75 mm to 300 mm
Coarse Gravel	19 mm to 75 mm
Fine Gravel	5 mm to 19 mm
Coarse Sand	2 mm to 5 mm
Medium Sand	0.425 mm to 2 mm
Fine Sand	0.075 mm to 0.425 mm
Silt	0.020 to 0.075 mm
Clay	Smaller than 0.020 mm

2. **DESCRIPTION OF MINOR SOIL TYPE** – Minor soil types are identified by weight of minor component.

Descriptor	Percent
and	35 to 50
some	20 to 35
little	10 to 20
trace	1 to 10

3. **CONSISTENCY OF FINE GRAINED SOILS** – The following terms are used relative to undrained shear strength and Standard Penetration Test (SPT), N value, for blows per 300 mm penetration (ASTM D1586).

Description	Undrained Shear Strength, C_u (kPa)	SPT N Value
Very Soft	Less than 12	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 150	15 to 30
Hard	Over 150	Over 30

4. **RELATIVE DENSITY OF COARSE GRAINED SOIL** – The following terms are used relative to Standard Penetration Test (SPT), N value, for blows per 300 mm penetration (ASTM D1586).

Description	SPT N Value
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Over 50

5. **TYPICAL SEDIMENTARY BEDROCK TYPES AND CLASSIFICATION** – The following terms are based on visual inspection and field/laboratory identification tests.

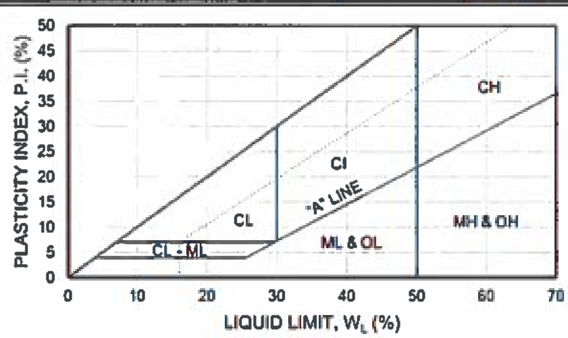
Characteristic	Sandstone	Mudrocks			
		Siltstone	Mudstone	Clayshale	Claystone
Composition	>50% Sand $CaCO_3$ or silica binder. Use weak acid to test for $CaCO_3$.	>50% Silt	33% to 66% Silt & 33% to 66% Clay	>50% Clay & <33% Silt	
Bedding	Banding possible Non- Fissile Wackes – dirty sandstone matrix (>15% clay)	Non-Fissile & Non-laminated	Non-Fissile & Non-laminated	Fissile	Non-Fissile

Definitions

Fissile	Breaks apart on bedding planes, not fractures.
Shale	Only used to describe a fissile clay mudrock.
Slate	Hard mudstone exposed to high pressure and temperature.
Limestone	Sedimentary rock (i.e. particles) formed from calcium carbonate minerals from skeletal fragments of marine organisms such as coral. Particles generally too small to see with eye.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURE, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} \geq 4$ AND $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS WITH LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} \geq 6$ AND $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		INORGANIC SILTS & VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY SOILS		
		$30\% < W_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS		
		$W_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY		
		$W_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS		
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



NOTES ON SOIL CLASSIFICATION AND DESCRIPTION:

1. Soil are classified and described according to their engineering properties and behaviour.
2. Boundary classification for soil with characteristics of two groups are given combined group symbols (e.g. GW-GC is a well graded gravel sand mixture with clay binder between 5 and 12%).
3. Soil classification is in accordance with the Unified Soil Classification System (ASTM D2487) with the exception that an inorganic clay of medium plasticity (CI) is recognized.
4. The use of modifying adjectives may be employed to define the estimated percentage range of minor components.

GENERAL SYMBOLS

FS	factor of safety
V	volume
W	weight
π	Pi = 3.1416
g	acceleration due to gravity = 9.81 m/s^2
t	time
Δ	change in, (e.g. Δt is change in time)

SOIL INDEX PROPERTIES

w, mc	soil water (moisture) content
ρ	bulk density
ρ_d	dry density
ρ_w	density of water
ρ_s	density of solid particles
γ	bulk unit weight = ρg (i.e. mass density x gravity)
γ_d	dry unit weight
γ_w	unit weight of water = 9.81 kN/m^3
γ_s	unit weight of solid particles
γ'	unit weight of submerged soil
D_R	relative density of solid particles ($D_R = \rho_s / \rho_w$) (formerly specific gravity Gs)
e	void ratio
n	porosity
S	degree of saturation
LL, w_L	liquid limit
PL, w_P	plastic limit
PI, I_P	plasticity index = (LL - PL)
ws	shrinkage limit
I_L	liquidity index = (w - PL) / PI
Ic	consistency index = (LL - w) / PI
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

ONE DIMENSIONAL CONSOLIDATION PROPERTIES

C_c	compression index in normally consolidated range
C_r	recompression index in over-consolidated range
C_s	swelling index
C_a	coefficient of secondary consolidation
C_v	coefficient of consolidation
mv	coefficient of volume change
Tv	time factor (vertical direction)
U	degree of consolidation
σ_p	pre-consolidation stress
OCR	over-consolidation ratio = σ_p / σ'_{vo}

HYDRAULIC PROPERTIES

h	hydraulic head
i	hydraulic gradient
i_v	vertical hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
K	permeability (m^2)
q	volumetric rate of flow
v	velocity of flow
j	seepage force per unit volume

SHEAR STRENGTH PROPERTIES

τ	shear strength = $c' + \sigma' \tan \varphi'$
τ	shear strength = $q_u / 2$
qu	compressive strength = $(\sigma_1 - \sigma_3) = 2\ c_u$
τ_p	peak shear strength
τ_r	residual shear strength
φ'	effective angle of internal friction (phi)
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
cu, su	undrained shear strength (for $\varphi = 0$ case)
p	mean total stress = $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress = $(\sigma'_1 + \sigma'_3)/2$
S_t	sensitivity

STRESS AND STRAIN PROPERTIES

γ	shear strain
ε	linear strain
εv	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress = $(\sigma' = \sigma - u)$
u	pore water pressure
σ'_{vo}	initial effective overburden stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
σ_{oct}	octahedral (mean) stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
E	Young's modulus (modulus of elasticity)
G	shear modulus of deformation
G_{max}	small strain shear modulus = ρV_S
V_S	shear wave velocity
K	bulk modulus of compressibility

APPENDIX B

LABORATORY RESULTS

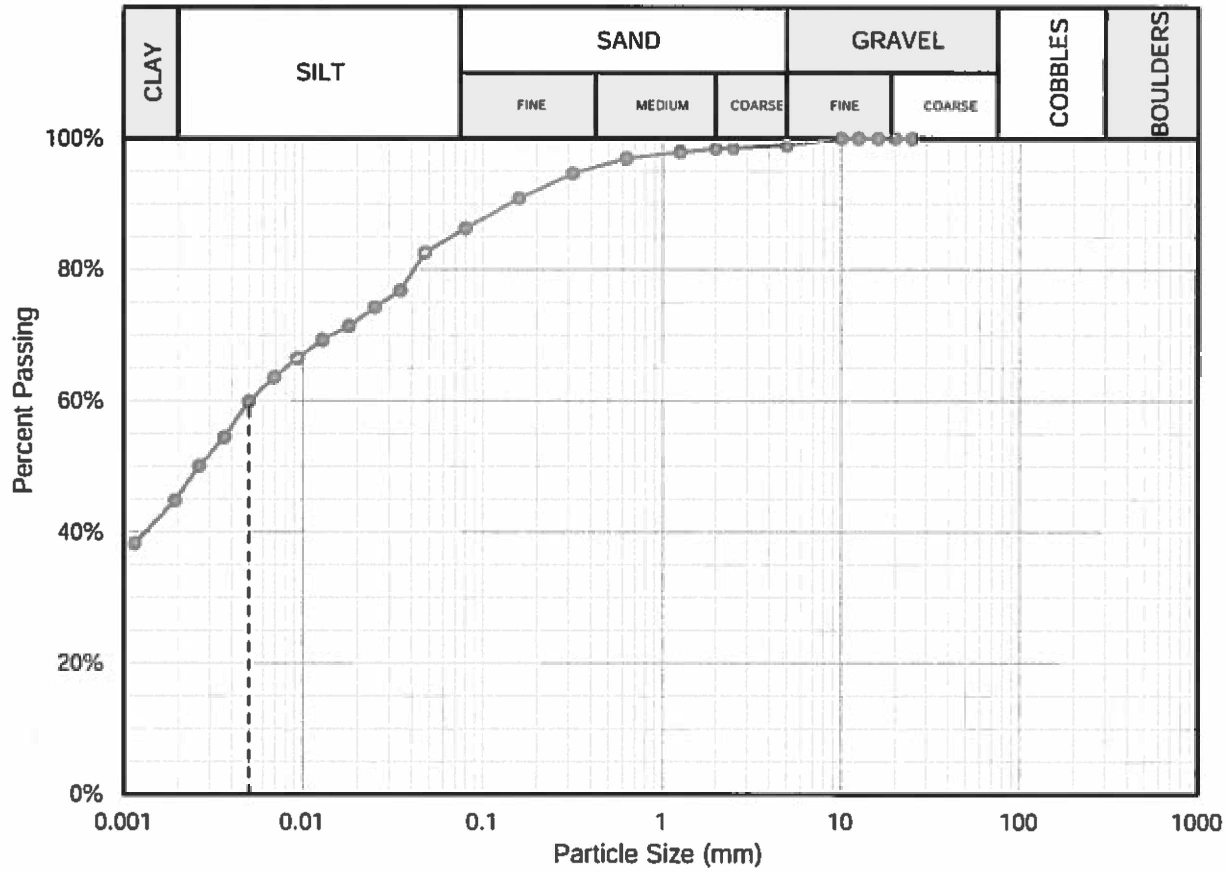
Parkland GEO

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

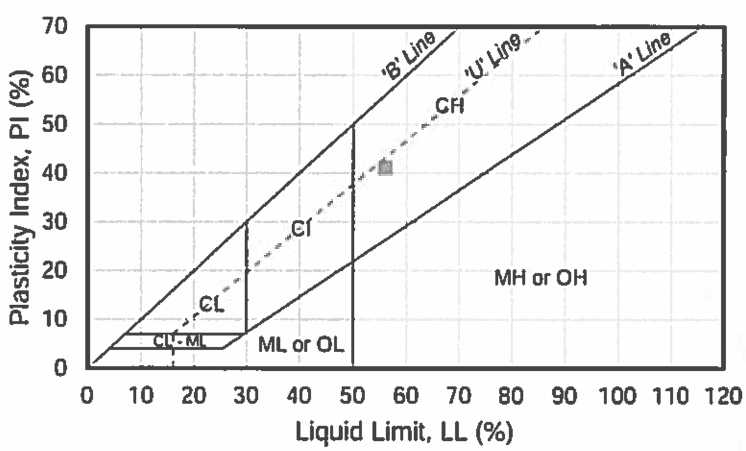
ASTM D422 & ASTM D4318

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, and silt, little sand

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 1D2
DEPTH: 3.0 m



PARTICLE-SIZE ANALYSIS	Gravel	1.0%
	Sand	13.2%
	Silt	40.3%
	Clay	45.5%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0050 mm
	C_U	---
	C_C	---
LIMITS	PL	15
	LL	56
	PI	41



Modified Unified Soil Classification	Group Symbol
Fat clay	CH

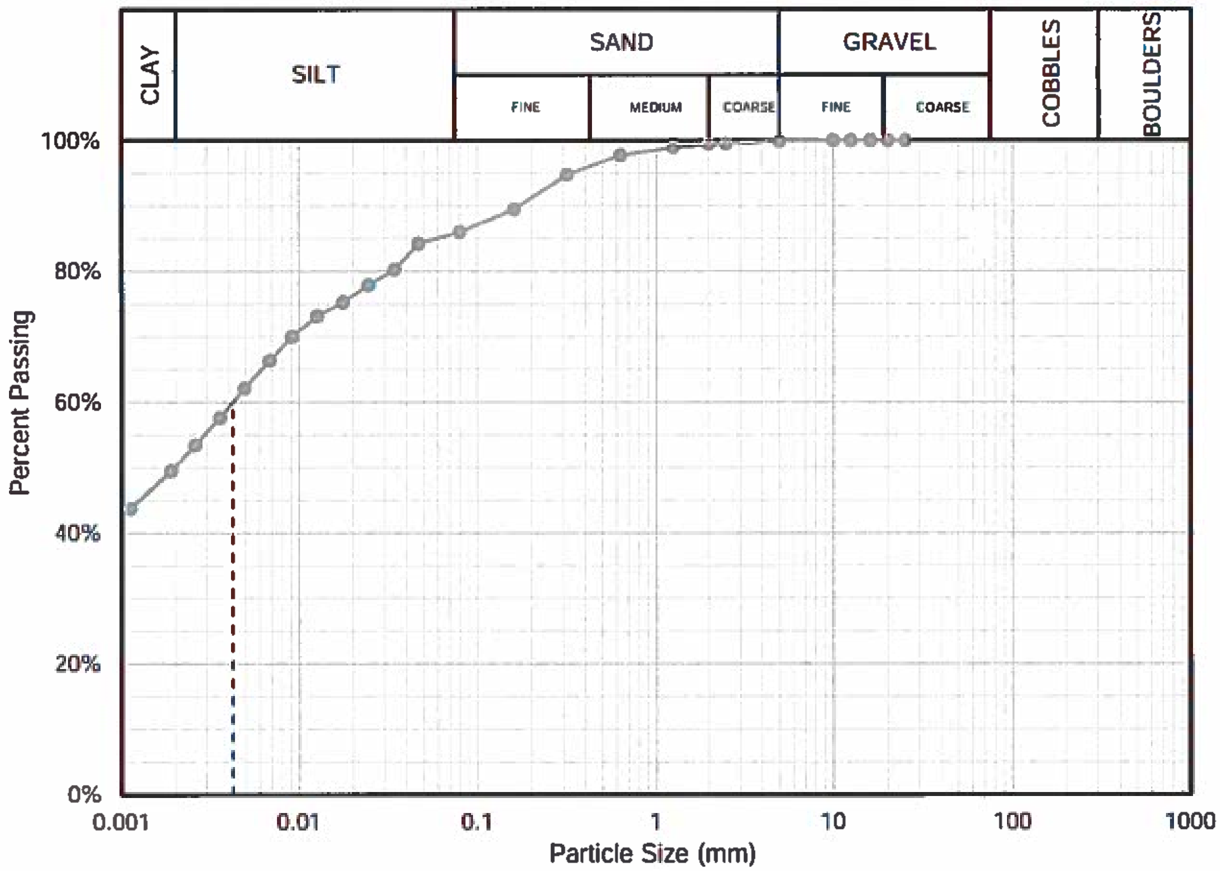
V14.5 U20170131
S:\PROJECTS\GP4251 - GP4300\GP4287 - Hines Creek Farms Colony - GEO\GP4287 Testing\GP4287 Hydro and Limit 1D2@3.0 m

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

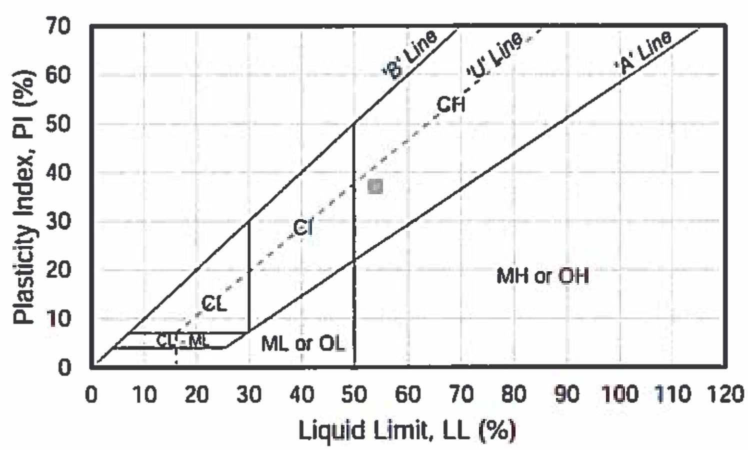
ASTM D422 & ASTM D4318

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, and silt, little sand

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 4D1
DEPTH: 1.5 m



PARTICLE-SIZE ANALYSIS		
	Gravel	0.1%
	Sand	14.1%
	Silt	35.5%
	Clay	50.3%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0042 mm
	C_U	---
	C_C	---
LIMITS	PL	17
	LL	54
	PI	37



Modified Unified Soil Classification	Group Symbol
Fat clay	CH

V14.5 U20170131
S:\PROJECTS\GP4251 - GP4300\GP4287 - Hines Creek Farms Colony - GEO\GP4287 Testing\GP4287 Hydro and Limit 4D1@1.5 m

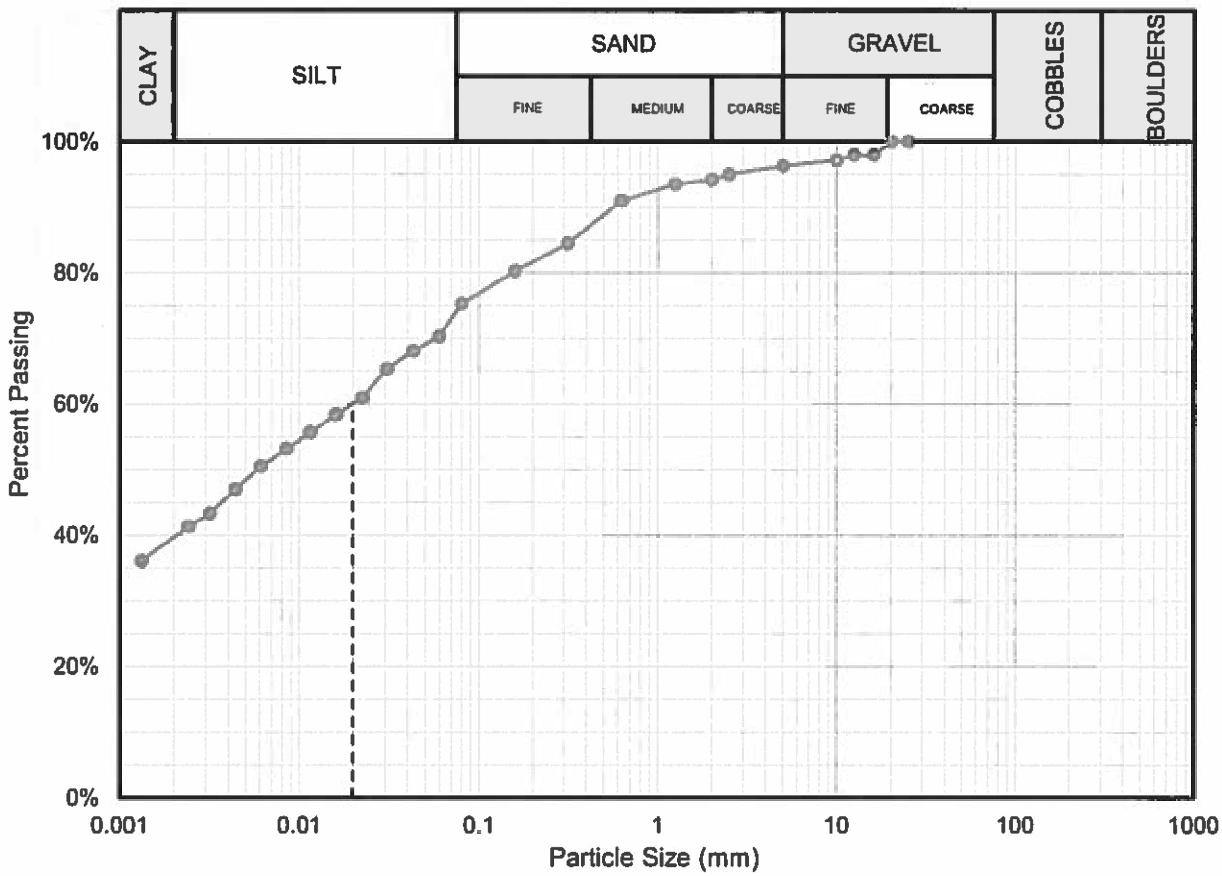
PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D422 & ASTM D4318

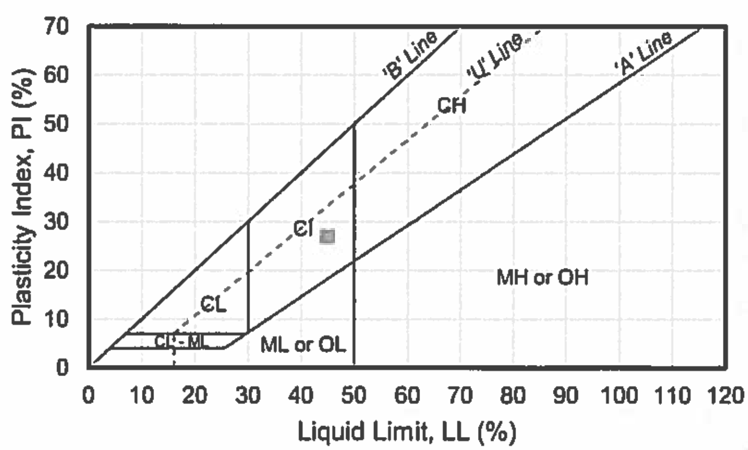
ParklandGEO

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, some silt, some sand, trace gravel

SAMPLE DATE: March 16, 2019
TEST DATE: April 12, 2019
SAMPLE ID: 19-05
DEPTH: 4.5 m



PARTICLE-SIZE ANALYSIS		
	Gravel	3.7%
	Sand	22.1%
	Silt	34.4%
	Clay	39.7%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0198 mm
	C_U	---
	C_C	---
LIMITS	PL	18
	LL	45
	PI	27



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

V14.5 U20170131
P:\GP Projects\GP4201-GP4400\GP4287 Hines Creek Farms Colony\Lab\ED4287 Hydro BH19-05 @ 4.5 m

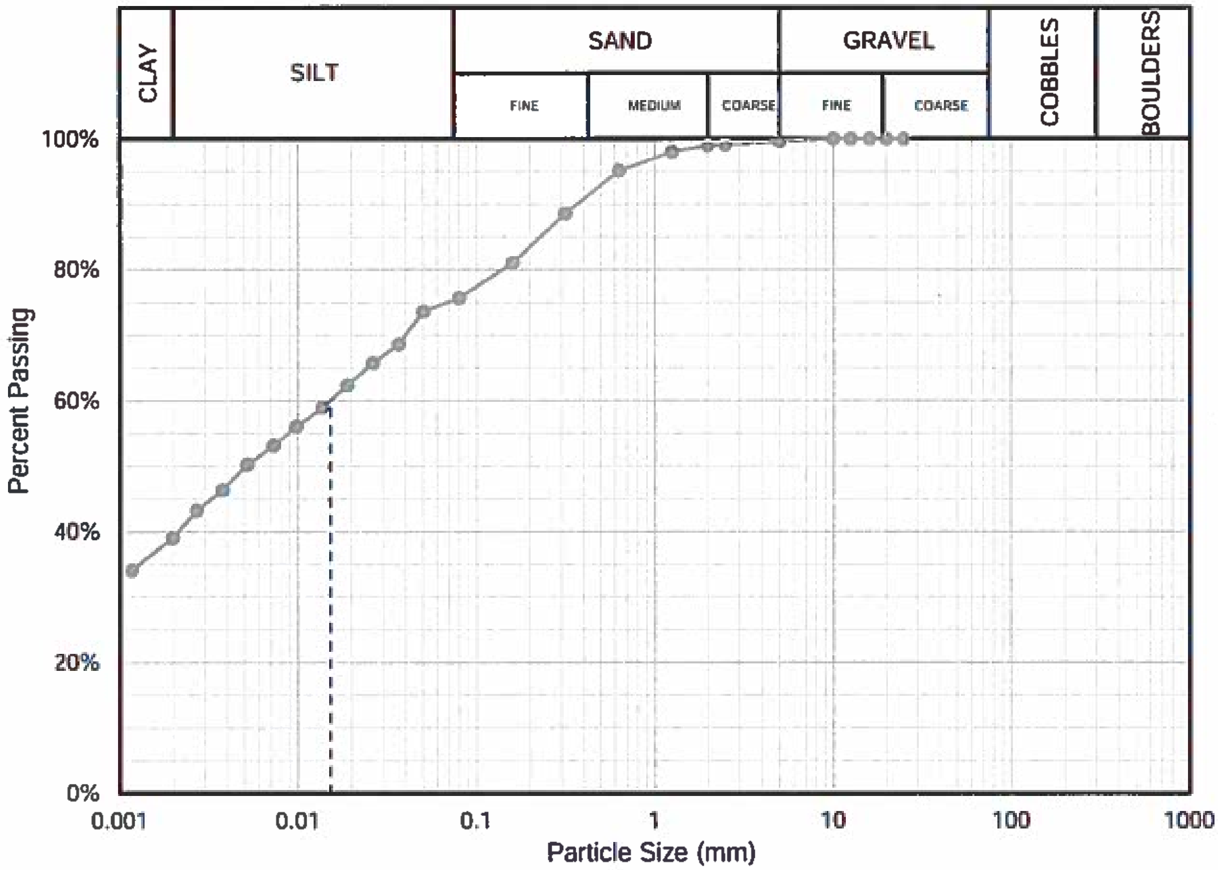
PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D422 & ASTM D4318

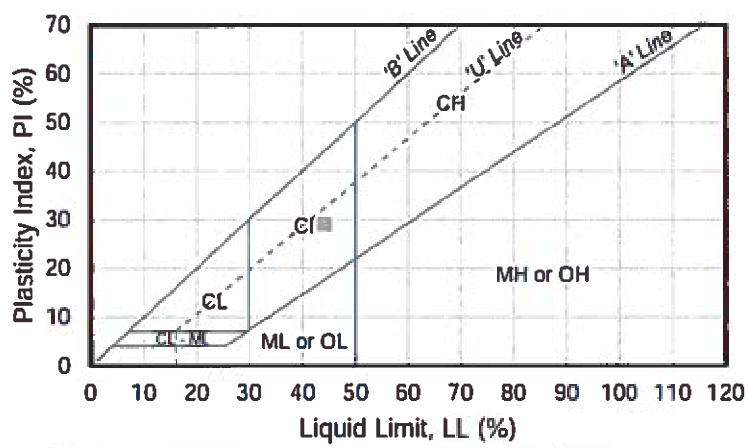
ParklandGEO

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, and silt, some sand

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 5D4
DEPTH: 6.0 m



PARTICLE-SIZE ANALYSIS		
	Gravel	0.4%
	Sand	24.2%
	Silt	36.2%
	Clay	39.2%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0152 mm
	C_U	---
	C_C	---
LIMITS	PL	15
	LL	44
	PI	29



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

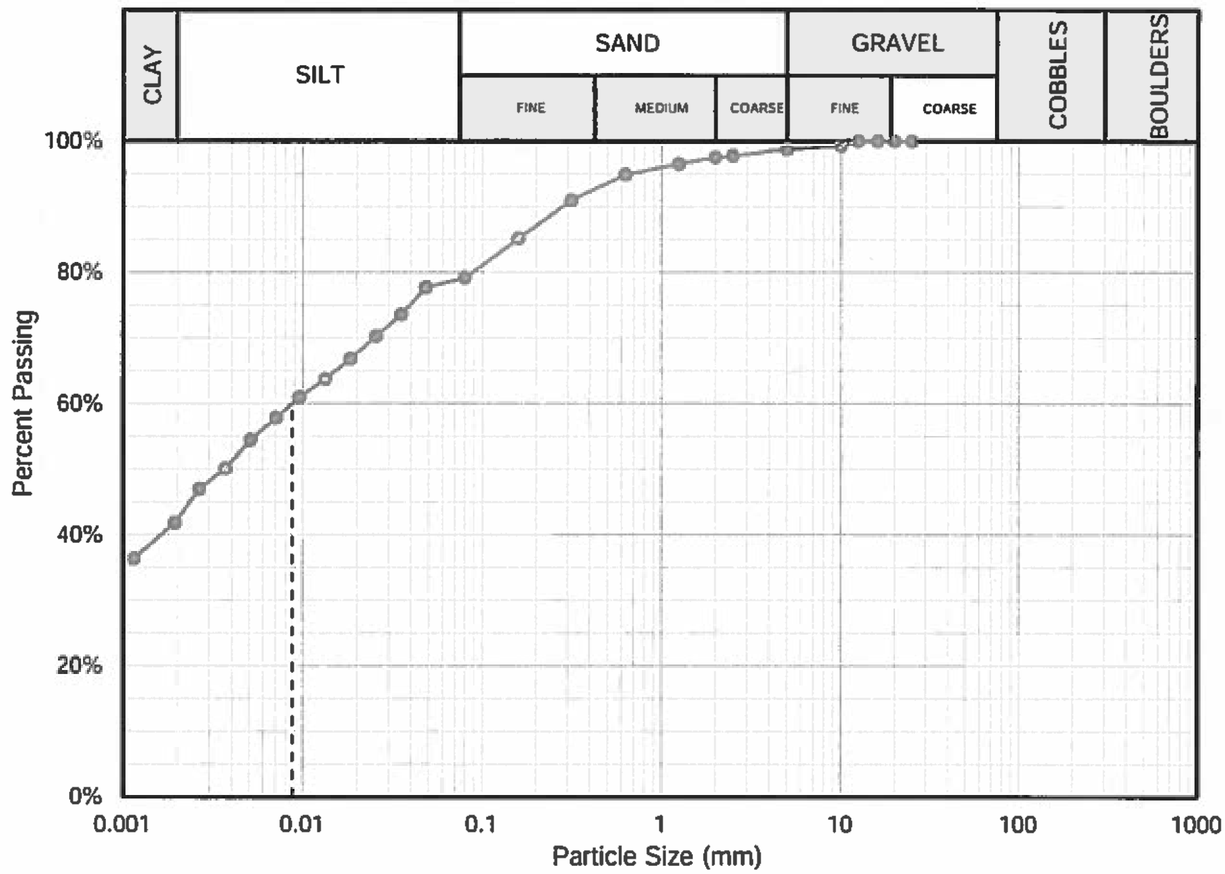
Parkland GEO

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

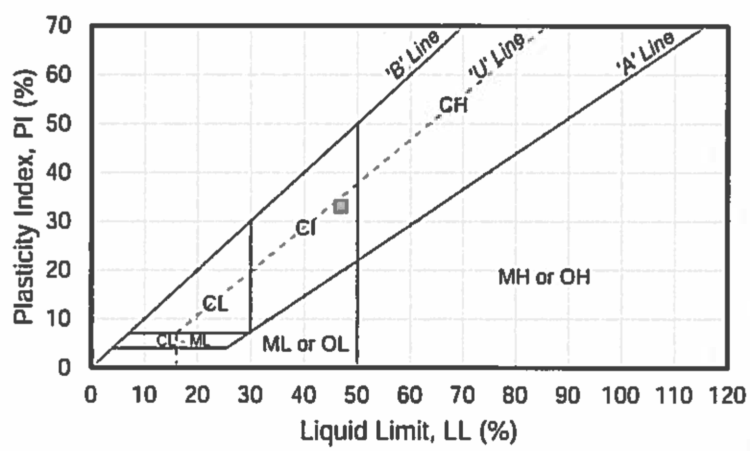
ASTM D422 & ASTM D4318

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, and silt, little sand, trace gravel

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 6D2
DEPTH: 3.0 m



PARTICLE-SIZE ANALYSIS		
	Gravel	1.2%
	Sand	19.8%
	Silt	36.6%
	Clay	42.3%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0087 mm
	C_U	---
	C_C	---
LIMITS	PL	14
	LL	47
	PI	33



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

V14.5 U20170131
S:\PROJECTS\GP4251 - GP4300\GP4287 - Hines Creek Farms Colony - GEO\GP4287 Testing\GP4287 Hydro and Limit 6D2@3.0 m

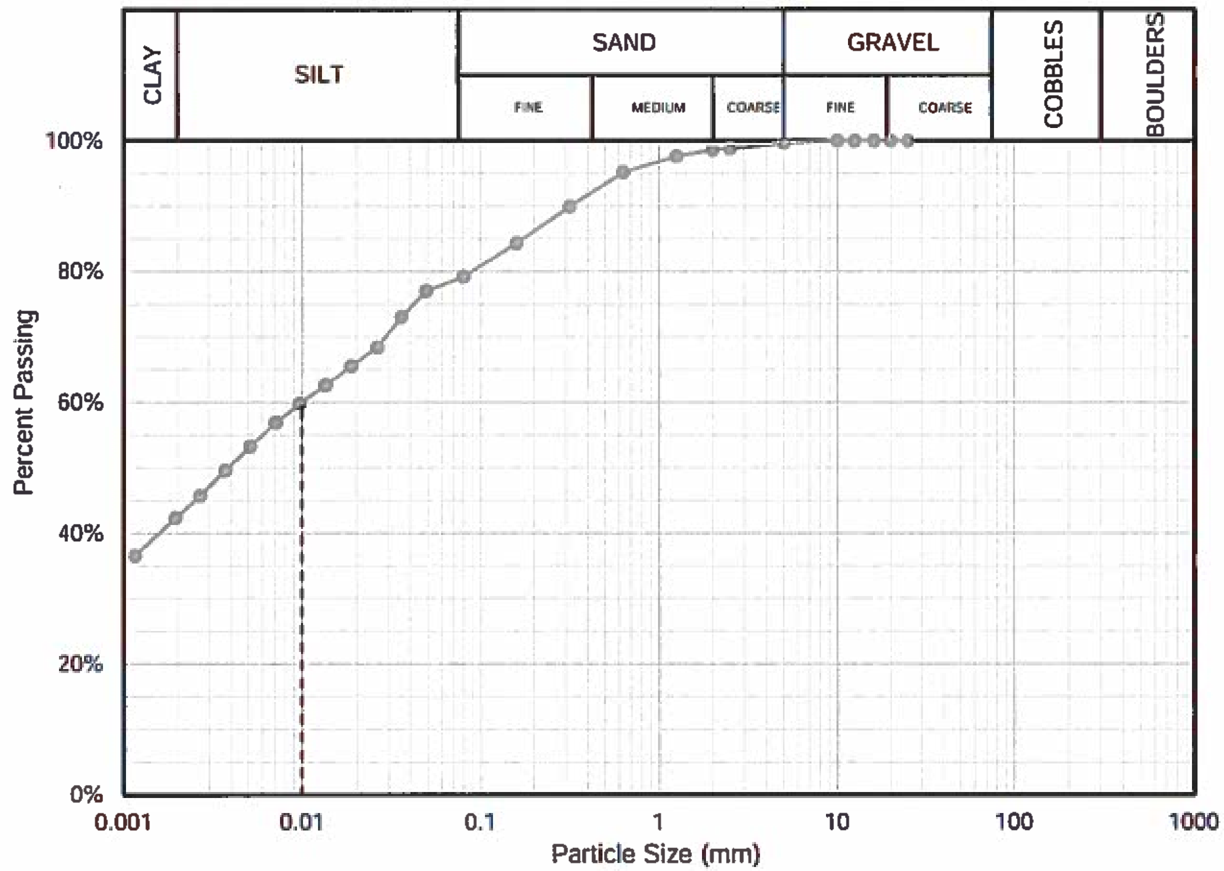
ParklandGEO

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

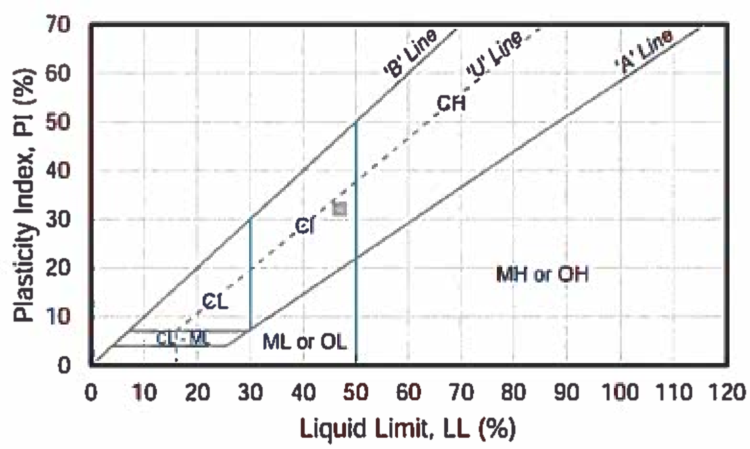
ASTM D422 & ASTM D4318

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, and silt, some sand

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 6D3
DEPTH: 4.5 m



PARTICLE-SIZE ANALYSIS		
	Gravel	0.3%
	Sand	20.8%
	Silt	36.3%
	Clay	42.6%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0099 mm
	C_U	---
	C_C	---
LIMITS	PL	15
	LL	47
	PI	32



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

V14.5 U20170131
S:\PROJECTS\GP4251 - GP4300\GP4287 - Hines Creek Farms Colony - GEO\GP4287 Testing\GP4287 Hydro and Limit 6D3@4.5 m

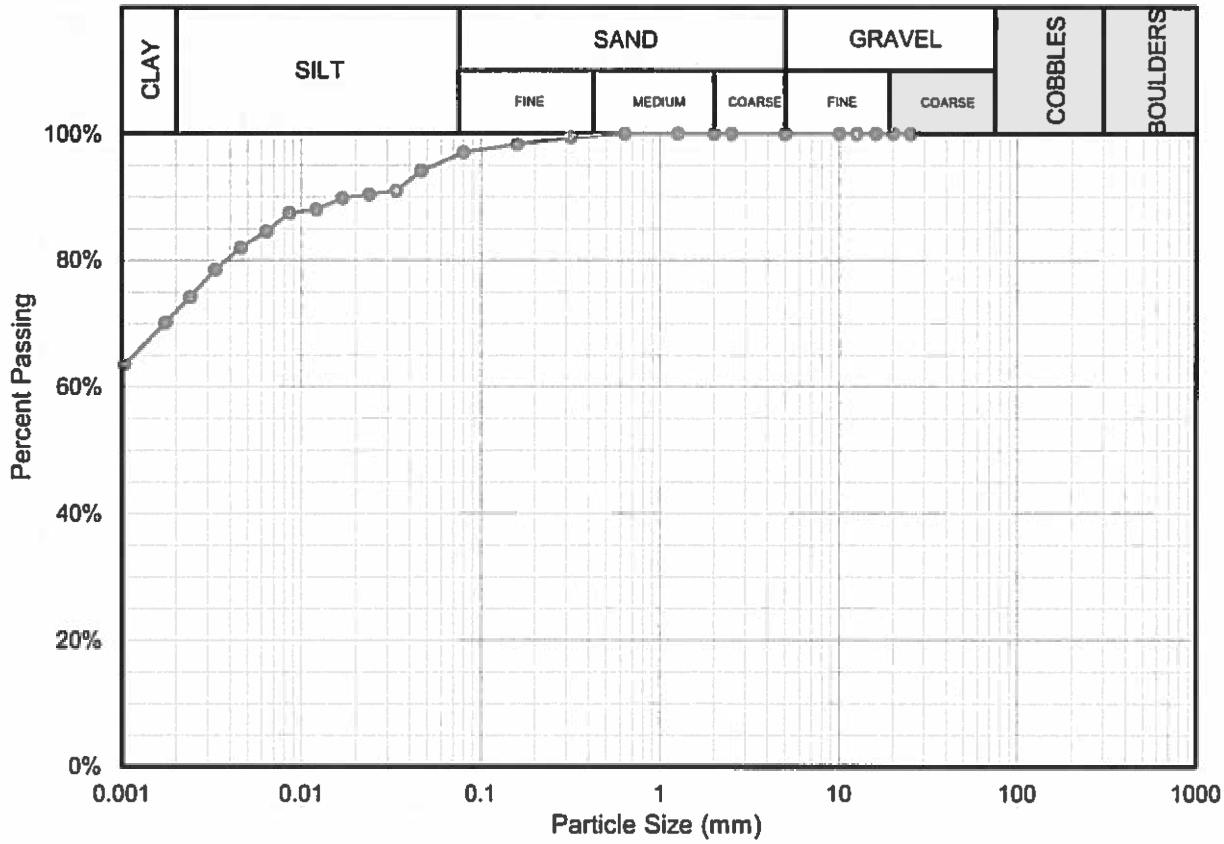
Parkland GEO

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

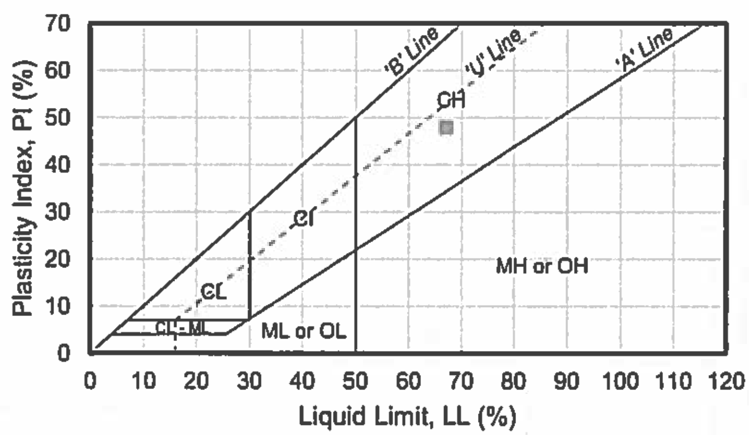
ASTM D422 & ASTM D4318

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, some silt, trace sand

SAMPLE DATE: March 15-16, 2019
TEST DATE: March 27, 2019
SAMPLE ID: 7D1
DEPTH: 1.5 m



PARTICLE-SIZE ANALYSIS		
	Gravel	0.0%
	Sand	3.3%
	Silt	24.8%
	Clay	72.0%
	D_{10}	---
	D_{30}	---
	D_{60}	---
	C_U	---
	C_C	---
LIMITS	PL	19
	LL	67
	PI	48



Modified Unified Soil Classification	Group Symbol
Fat clay	CH

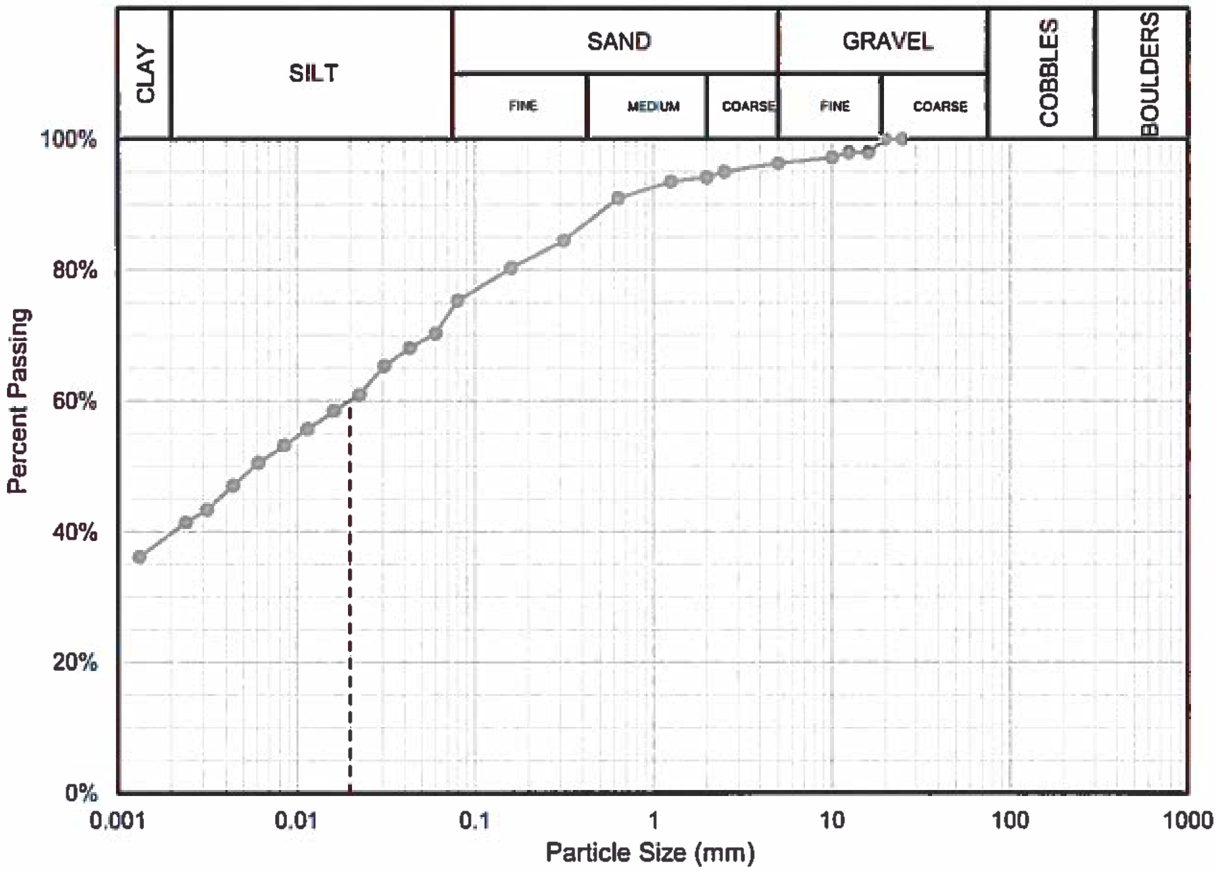
PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D422 & ASTM D4318

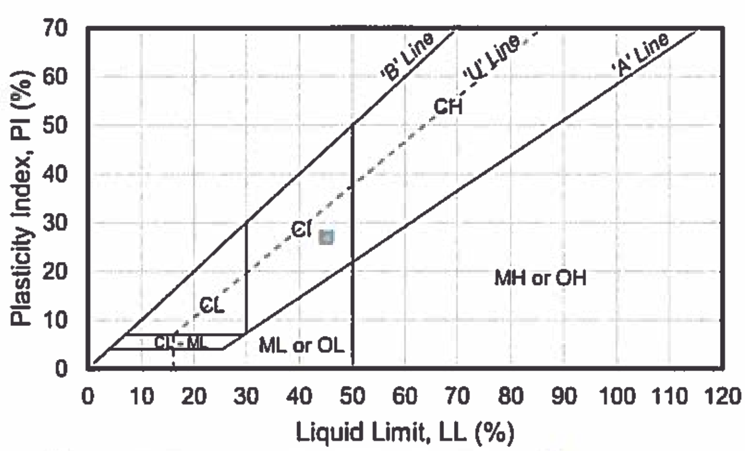
ParklandGEO

PROJECT: Hines Creek Farms Colony
PROJECT#: GP4287
CLIENT: Hines Creek Farms
SOIL DESCRIPTION: clay, some silt, some sand, trace gravel

SAMPLE DATE: March 16, 2019
TEST DATE: April 12, 2019
SAMPLE ID: 19-05
DEPTH: 4.5 m



PARTICLE-SIZE ANALYSIS		
	Gravel	3.7%
	Sand	22.1%
	Silt	34.4%
	Clay	39.7%
	D_{10}	---
	D_{30}	---
	D_{60}	0.0198 mm
	C_U	---
	C_C	---
LIMITS	PL	18
	LL	45
	PI	27



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19G448008
PROJECT: GP4287

10203B 123 STREET
GRANDE PRAIRIE, ALBERTA
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CLIENT NAME: PARKLAND GEO
SAMPLING SITE:

ATTENTION TO: Connan Squair
SAMPLED BY:

Soil Analysis - Sulphates - GP

DATE RECEIVED: 2019-03-19

DATE REPORTED: 2019-03-28

Parameter	Unit	G / S	RDL	9978276	9978278	9978279
SAMPLE DESCRIPTION:				BH1 @ 3.0m	BH3 @ 3.0m	BH7 @ 2.0m
SAMPLE TYPE:				Soil	Soil	Soil
DATE SAMPLED:						
Sulfur (as Sulfate), Soluble	mg/L		2	385	2310	3860
Sulfur (as Sulfate), Soluble (meq/L)	meq/L		0.04	8.02	48.1	80.4
Sulfur (as Sulfate), Soluble (mg/kg)	mg/kg		2	323	1920	3780

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Grande Prairie (unless marked by *)

Certified By: Corey Curl

ParklandGEO

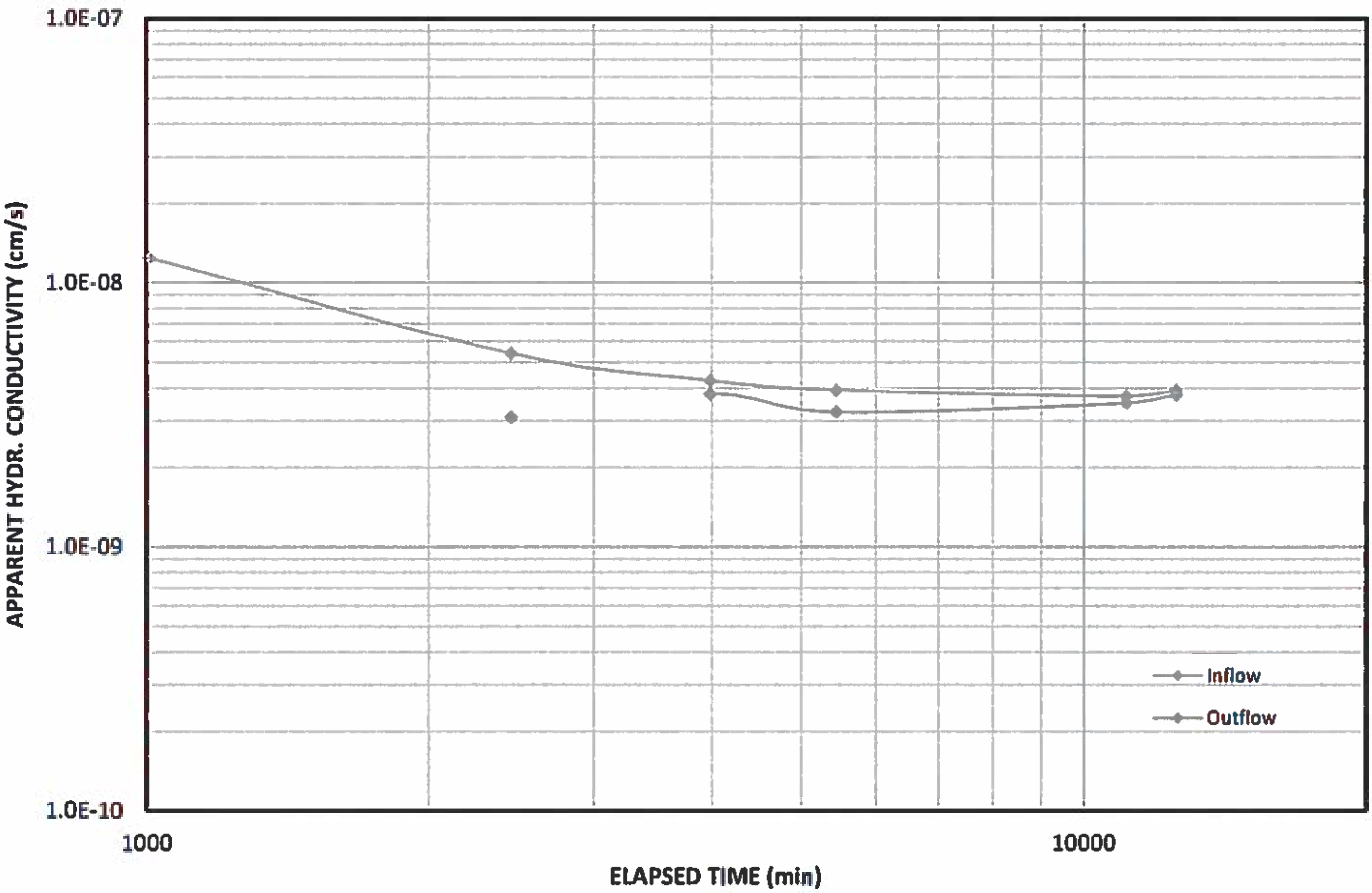
TRIAXIAL HYDRAULIC CONDUCTIVITY TEST

ASTM D5084

PROJECT:	Hines Creek Farms Colony	SAMPLE DATE:	March 16, 2019
PROJECT#:	GP4287	TEST DATE:	April 8, 2019
CLIENT:	Hines Creek Farms	SAMPLE ID:	5U1@4.5 m
SOIL TYPE:	Clay Till	LOCATION:	-
SAMPLE TYPE:	Undisturbed	PERMEANT LIQUID:	Deaired Water

Parameter	Value	
Initial Height:	41.2	mm
Initial Diameter:	73.0	mm
Initial Water Content:	18.6	%
Initial Compaction:	-	%
Initial Dry Density:	1.77	Mg/m^3

Parameter	Value	
Final Height:	41.8	mm
Final Diameter:	73.0	mm
Final Water Content:	21.8	%
Average Temperature:	22	°C
Average Confining Pressure:	11.86	kPa
Average Hydraulic Gradient:	0.61	



COEFFICIENT OF PERMEABILITY				
K_{20}=	3.8E-09	cm/s @	12542	minutes
K_{20}=	3.8E-11	m/s @	12542	minutes

LIMITATIONS

GENERAL TERMS, CONDITIONS AND LIMITATIONS

The use of this attached report is subject to the following general terms and conditions.

1. STANDARD OF CARE - In the performance of professional services, ParklandGEO used the degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No other warranty expressed or implied is made in any manner.

2. INTERPRETATION OF THE REPORT - The CLIENT recognizes that subsurface conditions will vary from those encountered at the location where borings, surveys, or explorations are made and that the data, interpretations and recommendation of ParklandGEO are based solely on the information available to him. Classification and identification of soils, rocks, geological units, contaminated materials and contaminant quantities will be based on commonly accepted practices in geotechnical or environmental consulting practice in this area. ParklandGEO will not be responsible for the interpretation by others of the information developed.

3. SITE INFORMATION - The CLIENT has agreed to provide all information with respect to the past, present and proposed conditions and use of the Site, whether specifically requested or not. The CLIENT acknowledged that in order for ParklandGEO to properly advise and assist the CLIENT, ParklandGEO has relied on full disclosure by the CLIENT of all matters pertinent to the Site investigation.

4. COMPLETE REPORT - The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to ParklandGEO by the CLIENT, communications between ParklandGEO and the CLIENT, and to any other reports, writings or documents prepared by ParklandGEO for the CLIENT relative to the specific Site, all of which constitute the Report. The word "Report" shall refer to any and all of the documents referred to herein. In order to properly understand the suggestions, recommendations and opinions expressed by ParklandGEO, reference must be made to the whole of the Report. ParklandGEO cannot be responsible for use of any part or portions of the report without reference to the whole report. The CLIENT has agreed that "This report has been prepared for the exclusive use of the named CLIENT. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. ParklandGEO accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

   The CLIENT has agreed that in the event that any such report is released to a third party, the above disclaimer shall not be obliterated or altered in any manner. The CLIENT further agrees that all such reports shall be used solely for the purposes of the CLIENT and shall not be released or used by others without the prior written permission of ParklandGEO.

5. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY DISCLAIMER
   There is no warranty, expressed or implied, by ParklandGEO that:
   a) the investigation uncovered all potential geo-hazards, contaminants or environmental liabilities on the Site; or
   b) the Site is entirely free of all geo-hazards or contaminants as a result of any investigation or cleanup work undertaken on the Site, since it is not possible, even with exhaustive sampling, testing and analysis, to document all potential geo-hazards or contaminants on the Site.

   The CLIENT acknowledged that:
   a) the investigation findings are based solely on the information generated as a result of the specific scope of the investigation authorized by the CLIENT;
   b) unless specifically stated in the agreed Scope of Work, the investigation will not, nor is it intended to assess or detect potential contaminants or environmental liabilities on the Site;
   c) any assessment regarding geological conditions on the Site is based on the interpretation of conditions determined at specific sampling locations and depths and that conditions may vary between sampling locations, hence there can be no assurance that undetected geological conditions, including soils or groundwater are not located on the Site;
   d) any assessment is also dependent on and limited by the accuracy of the analytical data generated by the sample analyses;
   e) any assessment is also limited by the scientific possibility of determining the presence of unsuitable geological conditions for which scientific analyses have been conducted; and
   f) the laboratory testing program and analytical parameters selected are limited to those outlined in the CLIENT's authorized scope of investigation; and
   g) there are risks associated with the discovery of hazardous materials in and upon the lands and premises which may inadvertently discovered as part of the investigation. The CLIENT acknowledges that it may have a responsibility in law to inform the owner of any affected property of the existence or suspected existence of hazardous materials and in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed. The CLIENT further acknowledges that any such discovery may result in the fair market value of the lands and premises and of any other lands and premises adjacent thereto to be adversely affected in a material respect.

6. COST ESTIMATES - Estimates of remediation or construction costs can only be based on the specific information generated and the technical limitations of the investigation authorized by the CLIENT. Accordingly, estimated costs for construction or remediation are based on the known site conditions, which can vary as new information is discovered during construction. As some construction activities are an iterative exercise, ParklandGEO shall therefore not be liable for the accuracy of any estimates of remediation or construction costs provided.

7. LIMITATION OF LIABILITY - The CLIENT has agreed that to the fullest extent permitted by the law ParklandGEO's total liability to CLIENT for any and all injuries, claims, losses, expenses or damages whatsoever arising out of or in anyway relating to the Project is contractually limited, as outlined in ParklandGEO's standard Consulting Services Agreement. Further, the CLIENT has agreed that to the fullest extent permitted by law ParklandGEO is not liable to the CLIENT for any special, indirect or consequential damages whatsoever, regardless of cause.

8. INDEMNIFICATION - To the fullest extent permitted by law, the CLIENT has agreed to defend, indemnify and hold ParklandGEO, its directors, officers, employees, agents and subcontractors, harmless from and against any and all claims, defence costs, including legal fees on a full indemnity basis, damages, and other liabilities arising out of or in any way related to ParklandGEO's work, reports or recommendations.