December 11, 2017 Reference No. 11149336

Maureen Bilawchuk
Senior Policy Specialist
Ministry of Environment and Climate Change Strategy
Environmental Standards Branch
325, 1011 Fourth Avenue
Prince George, BC V2L 3H9

Dear Ms. Bilawchuk

Re: Clay Basal Liner Evaluation
Landfill Closure Activities at Cobble Hill Holdings
460 Stebbings Rd Near Shawnigan Lake, British Columbia

The purpose of this letter is to provide the Ministry of Environment and Climate Change Strategy (Ministry) with a summary of the results of the Permanent Encapsulation Area (PEA) secondary clay basal liner evaluation conducted by GHD. The evaluation was conducted in September 2017 in conjunction with the landfill closure activities being completed at the Cobble Hill Holdings (CHH) site located at 460 Stebbings Rd near Shawnigan Lake, BC (Site) pursuant to the June 29, 2017 Spill Prevention Order MO1701 (SPO), the August 11, 2017 and September 18, 2017 letters from the Ministry to the Named Parties, and associated correspondence.

The evaluation consisted of the following three tasks. These tasks are further discussed in detail in the sections that follow:

1. Four test pits were completed by Allterra Construction Ltd (Allterra) adjacent to the PEA toe to facilitate collecting samples of the secondary clay basal liner by GHD. GHD also collected clay samples at a fifth location adjacent to the south side of the PEA. The completion of four test pits exceeded the Ministry requirement per the September 18, 2017 letter to complete one test pit during the 2017 Minor Works.
2. GHD collected samples of the clay from three of the PEA toe test pits and the one southern location for the analysis of carbon content and grain size. Two samples from one PEA toe test pit were also submitted for mineralogy and hydraulic conductivity.
3. A subcontractor to GHD completing a ground penetrating radar (GPR) survey around the north, west and south sides of the PEA to assess for the presence and thickness of the secondary clay basal liner.

For reference, the following table summarizes the testing that was completed and is discussed in the following subsections:

Summary of Testing

Parameter	TP-1	TP-2	TP-3	TP-4	South Ditch
Grain Size (including percent moisture)	X	X	X		X
Total Organic Carbon	X	X	X		X
Permeability			X		
Mineralogy			X		
Ground Penetrating Radar	Line 1	Line 2	Line 2	Line 2	

1. Landfill Criteria

The legally enforceable design elements for the PEA were stipulated in the Site's Waste Discharge Permit PR-105809. Specifically, the Permit required the design to include "*engineered lined landfill cells, …* [and] *primary and secondary containment detection and inspection sumps…*". (paragraph 1.3.1)

Supplemental guidance in the form of recommended practices are provided in the Ministry's Landfill Criteria[1]. When the Permit was issued, the Landfill Criteria for Municipal Solid Waste dated June 1993 (1993 Landfill Criteria) were applicable. For the landfill base liner, the 1993 Landfill Criteria identified a minimum requirement of a 1-metre thick clay layer with a maximum permeability of $1x10^{-7}$ cm/s. The 1993 Landfill Criteria also allowed for alternate liner systems of equivalent environmental protection, including higher hydraulic conductivity liner systems, if appropriate depending on factors such as the leachate generation potential and natural attenuation capacity of the landfill site.

The basal clay liner evaluation discussed herein considered the requirements of the Permit and 1993 Landfill Criteria since these were in effect at the time the PEA was constructed. Noting that they were not applicable at the time, GHD also considered the specifications listed in the Landfill Criteria for Municipal Solid Waste, 2nd Edition dated June 2016 (2016 Landfill Criteria), which identify several additional requirements. This comparison was completed to evaluate the basal clay liner against current-day best management practices. The 2016 Landfill Criteria specifications for a basal liner include a primary liner (geomembrane) and a secondary compacted clay liner meeting the following specifications:

1. Soil containing minimum 25 percent clay and minimum 60 percent silt and clay by weight.
2. A minimum compacted thickness of 750 mm. Thickness is to be measured perpendicular to the slope.
3. Compacted hydraulic conductivity of 1 x 10-7 cm/sec or less.
4. Organic carbon content of at least 0.1 percent.
5. Clay structure and permeability to remain stable when exposed to leachate.

[1] Fact Sheet for *Landfill Criteria for Municipal Solid Waste Guideline* (Ministry of Environment, June 2016) provides explanation of the relationship between the Landfill Guidelines and operational certificates or permits.

Similar to the 1993 Landfill Criteria, the 2016 Landfill Criteria (Section 2.1.1) also allow for alternate liner systems of equivalent or better environmental protection with sufficient technical justification, and are recommended practices; the landfill's certificate or permit would stipulate the mandatory requirements.

2. Test Pitting

The Ministry's September 18, 2017 letter required the completion of one test pit during the 2017 Minor Works and additional test pits "*as early as possibly in 2018, but no later than April 30, 2018*". During the 2017 Minor Works, Allterra determined that additional locations could be exposed and subsequently completed a total of four, exceeding the Ministry's requirement.

The test pit and clay sampling locations are illustrated on Figure 1 provided in Attachment A. Attachment A also includes photographs of these locations.

Three test pits (TP-1 through TP-3) were initially excavated by Allterra along the northern toe of the PEA to measure the thickness of the secondary clay basal liner, if present, and collect clay samples. The three test pit locations were identified by Allterra to GHD and Ministry representatives during an on-Site meeting on September 27, 2017 as being within each of the three cells of the PEA (1A, 1B and 1C). One additional test pit (TP-4) was excavated by Allterra along the PEA toe 10 metres further to the west of the first three to confirm the presence of the clay liner at the request of a citizen as mentioned in GHD's October 23, 2017 monthly update.

As illustrated on Figure 1 in Attachment A, the test pit locations were surveyed and ultimately confirmed to be completed in the following locations: TP-1 was located within cell 1A, TP-2 and TP-3 were located within cell 1B, and TP-4 was located within cell 1C. A fifth sampling location was located along the south edge of the PEA below the run-on ditch to collect clay samples. As discussed in the following subsections, the clay samples were collected from TP-1 through TP-3, as these locations were identified by Allterra to be in the three cells, and below the south ditch. The intent of TP-4 was for visual confirmation of the presence of the clay liner.

The clay liner thickness observed in TP-1, TP-2 and TP-3 was generally 1 metre, although several locations were observed to be between 0.7 and 1.0 metres as illustrated in the photographs in Attachment A. The clay liner thickness observed in TP-4 was not confirmed as it was excavated to only identify the presence of the clay liner; a clay liner thickness of 0.5-m was observed prior to backfilling the test pit but the base of the clay liner was not confirmed.

GHD noted that the secondary clay basal liner was investigated outside of the footprint of the PEA since Allterra and GHD did not want to undermine the PEA; consequently, GHD's observations and test results are potentially unrepresentative of the secondary clay basal liner directly underneath the PEA.

3. Clay Sampling

To evaluate the PEA basal clay liner against the 1993 and 2016 Landfill Criteria, GHD collected samples of the clay from the following locations in TP-1 (in cell 1A) and TP-2 and TP-3 (in cell 1B) and below the southern PEA ditch (in cell 1A). As previously noted, the evaluation focused on comparisons to the applicable Permit and 1993 Landfill Criteria; comparisons to the 2016 Landfill Criteria were for supplementary evaluation purposes.

- For the grain size and carbon content tests (2016 Landfill Criteria specification):
  - A total of three clay samples were collected within test pits TP-1, TP-2 and TP-3 from approximately 0.35 metres above the base of the clay layer
  - One clay sample was collected from approximately 0.15 metres beneath the exposed clay surface of the southern PEA ditch
- For the mineralogy tests (2016 Landfill Criteria specification):
  - A total of two clay samples were collected within test pit TP-3 from approximately 0.35 and 0.2 metres above the base of the clay layer
- For the permeability tests (1993 and 2016 Landfill Criteria specifications):
  - One Shelby tube was inserted approximately 0.6 m into the clay within TP-3 to obtain samples of the upper and lower portions of the secondary clay basal liner (the laboratory split the clay in the Shelby tube into an upper sample and a lower sample). The Shelby tube was inserted between 0.2 and approximately 0.8 m below the top of the clay liner.

Based on a visual inspection, the clay is described as brown lean clay with sand, moist, and medium plasticity.

Grain size

As presented in Attachment B, the percent clay ranged from 36.1 to 51.9 percent, which exceed the requirements of the 2016 Landfill Criteria. The total silt and clay content ranged from 58.4 to 81.9 percent. Although one sample with a total silt and clay content of 58.4 percent was just shy of meeting the 60 percent requirement, it should be noted that the sample's corresponding clay content of 36.1 percent significantly exceeded the requirement of 25 percent. These data generally meet or exceed the requirements of the 2016 Landfill Criteria.

Carbon Content

As presented in Attachment B, the carbon content ranged from 0.246 to 0.5 percent. These numbers exceed the requirements of the 2016 Landfill Criteria of 0.1 percent.

Permeability

As presented in Attachment C, both clay samples exhibited a permeability of less than $1x10^{-7}$ cm/s [2] and exceed the requirements of both the 1993 and 2016 Landfill Criteria.

Mineralogy

As presented in Attachment D, over 30 percent of the crystalline mineral assemblage was reported as smectite, which includes montmorillonite and nontronite that exhibit swelling/shrinking characteristics. Usage of this type of clay for basal liners warrants consideration due to the potential swelling/shrinkage and due to reactions with leachate as mentioned in Section 3.4 of the Updated Final Closure Plan (Sperling Hansen Associates, July 21, 2017), both which could cause an increase in permeability. It should be noted that the extent to which the basal clay liner under the PEA could be affected, if at all, depends on factors such as the amount of smectite (and other minerals) present and the characteristics of the leachate.

Comments

The dual basal liner system (LLDPE geomembrane liner and clay layer) that was constructed under the PEA appears to meet the Permit requirements. Although portions of the clay layer were observed to be less than 1 m thick or, based on comparisons to the 2016 Landfill Criteria contained slightly less than the required silt and clay content, the presence of both the geomembrane and clay liners would generally have been considered to exceed the 1993 Landfill Criteria requirements. The clay liner also generally meets the 2016 Landfill Criteria requirements, notably in light of the lesser 0.75-m thickness requirement.

The Ministry may want to consider whether obtaining additional technical justification is warranted regarding the basal liner that was installed based on the Permit and 1993 Landfill Criteria. Field data, such as the cell 1C clay basal liner thickness, could be obtained during the next phase of construction.

4. GPR Survey

Frontier Geosciences was retained by GHD to conduct a GPR survey around the perimeter of the PEA, specifically to evaluate the presence and thickness of the secondary clay basal liner. Although conducting the GPR survey over the toe of the PEA was originally considered, it was determined by Allterra, GHD and Frontier that the risk of puncturing the PEA liner with the GPR system (a ‘sled’ which is pulled over the ground surface) was too high. In addition, the health and safety risk of walking on the side slopes on a

[2] Regarding the upper Shelby tube sample, the chart in Appendix B shows a gradually decreasing permeability with three different gradients. Based on GHD’s discussion with the geotechnical laboratory, to start a test, the gradient is based on two conditions: low enough such that it doesn’t affect the integrity of the sample but high enough that a representative flow through the sample can be determined. When the test for the first sample begun, a gradient of 10 was chosen; however, the permeability changed (decreased) indicating that the gradient likely wasn’t high enough. As shown on the graph, the permeability evened out with a gradient of 30, which is where on the graph the permeability should be read.

liner was also considered as a prohibitive factor. As a result, the GPR traverses were located on the soil surfaces beyond the edge of the PEA liner.

Specifically, the GPR traverses were completed around the northern, western and southern perimeter of the PEA (see Figure 2 of Attachment E). The eastern perimeter was not included due to time constraints. The complete GPR report is included in Attachment E and explains the methodology, results, and limitations (which include that the GPR data is indirect and the interpreted features are subjective in nature). A total of 240 metres of survey was completed around the perimeter of the PEA. Figure 2 provided in the GPR report illustrates the four traverses.

As stated in the report, the GPR traverses along the northern PEA toe "*show a complex of reflectors at approximately 1 metre depth that likely represents the base of the placed clay. The absence of a defined shallower reflector suggests that this layer extends to near surface, consistent with the observed presence of clays at surface*." Similar to the north traverse, the southeast traverse (primarily south of cells 1A and 1B) also showed "*a return at a depth of approximately 1 metre*." On the profile figures for these traverses, a dashed black line approximately 1 metre below ground surface shows the location of the interpreted base of the secondary clay basal liner.

Attachment F presents a marked-up version of Figure 2 and the GPR traverses 1 and 2 along the north toe of the PEA. GHD has added the approximate locations of the four test pits for reference. Note that the test pits were completed following the GPR work so there is no indication of them in the traverse figures. Although the dashed lines where the test pits are marked indicate a clay depth of approximately 1 m, this is interpretive as discussed above. Actual field observations should take precedence.

The west/southwest traverse was located adjacent to cell 1C. "*In this location, the line is reported to be beyond the extent of the secondary clay basal liner. This line shows a more diffuse response with scattering diffractors present. This is consistent with the likelihood that the berm materials contain rip-rap similar to the materials exposed in the ditch*."

5. Summary and Conclusions

GHD does not have any fundamental concerns regarding the adequacy of the basal clay liner in relation to the protection of human health and the environment based on the information reviewed and data obtained during the clay liner investigation.

1. GHD's observations of the secondary clay basal liner in four locations along the northern toe of the PEA in all three landfill cells as well as along the southern PEA perimeter and the results of the GPR study support the conclusion that the secondary clay basal liner is present beneath the PEA as indicated in the as-built drawings provided in the July 21, 2017 Updated Final Closure Plan.
2. The dual liner system meets the objectives of the Site's Waste Discharge Permit PR-105809, which required "*primary and secondary containment detection and inspection sumps*".

3. Based on two sample results, the clay quality meets the permeability requirements of the 1993 Landfill Criteria, which was in effect at the time. GHD noted that not all of the clay layer thickness observed met the default 1-m requirement identified in the 1993 Landfill Criteria, one clay sample contained less silt and clay than the sample tested for permeability, and the clay contained smectite minerals that, under certain circumstances, could affect the permeability of the clay. However, the presence of both the geomembrane and clay liners that were installed would generally have been considered to exceed the 1993 Landfill Criteria requirements and thus be a greater level of environmental protection. The clay liner also generally meets the 2016 Landfill Criteria requirements.

6. Recommendations

Prior to approving the Final Closure Plan, GHD recommends that the Ministry ensure sufficient technical justification is provided for the engineering design and specifications, and consider any newly acquired information in order to determine whether the basal liner system will be protective of the environment. The technical justification such as the dual-liner system, leachate generation quantity, and natural attenuation capacity of the Site can be incorporated into the overall evaluation of the basal liner's effectiveness at protecting the environment. Additional new information that can be considered may include water quality monitoring results currently being collected from the seepage wells and other monitoring locations, and additional field data such as the cell 1C clay basal liner thickness that could be obtained during the next phase of construction.

7. Closing

Should you have any questions regarding this letter, please do not hesitate to contact the undersigned.

Sincerely,

GHD

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
J. A. M. REID
33832
Dec 11, 2017

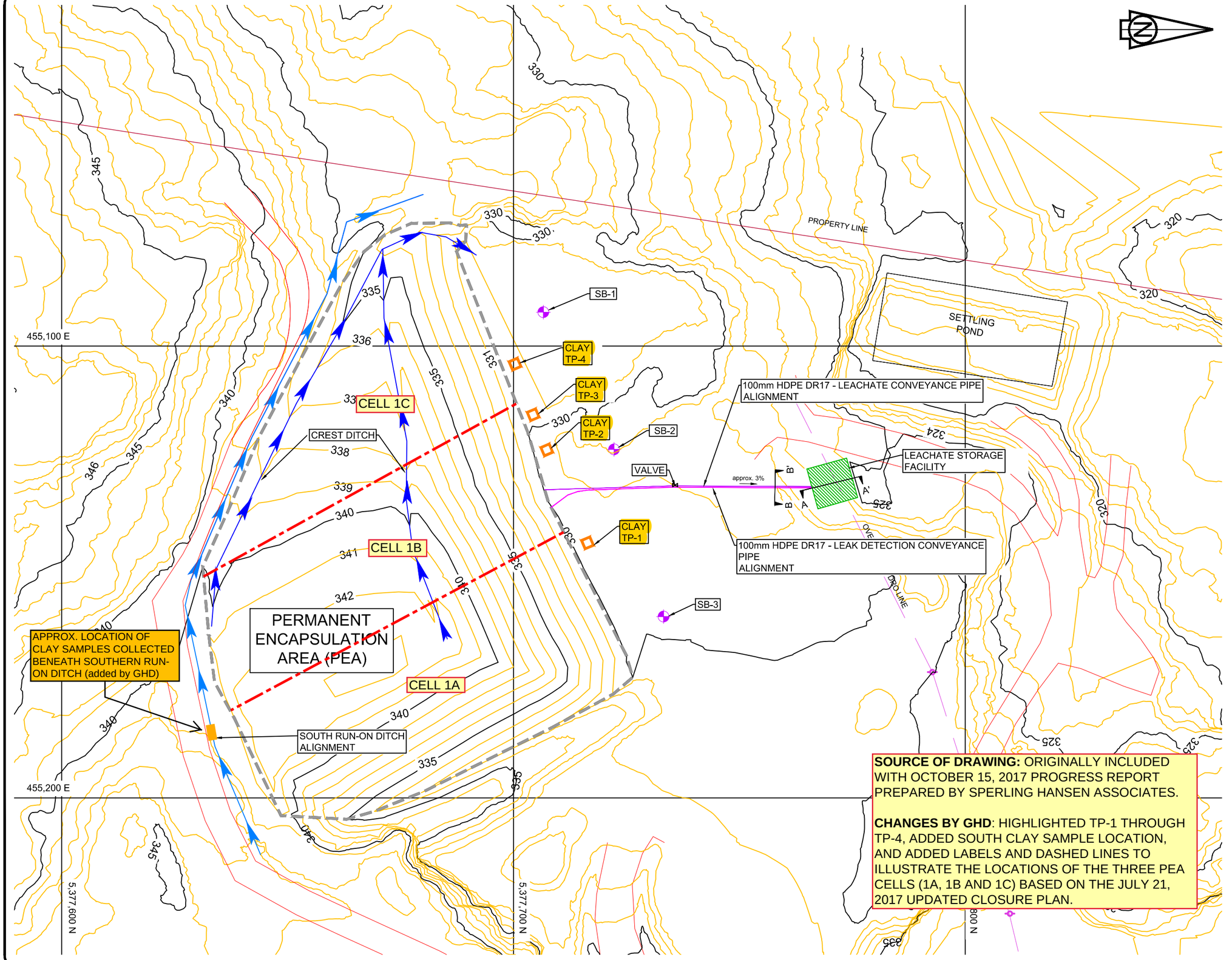
James A. Reid, P. Eng.

Reinhard Trautmann, AScT

JAR/sz/04

Encl.

Attachment A
Test Pit & Clay Sampling Locations, and Test Pit Photographs



SOURCE OF DRAWING: ORIGINALLY INCLUDED WITH OCTOBER 15, 2017 PROGRESS REPORT PREPARED BY SPERLING HANSEN ASSOCIATES.

CHANGES BY GHD: HIGHLIGHTED TP-1 THROUGH TP-4, ADDED SOUTH CLAY SAMPLE LOCATION, AND ADDED LABELS AND DASHED LINES TO ILLUSTRATE THE LOCATIONS OF THE THREE PEA CELLS (1A, 1B AND 1C) BASED ON THE JULY 21, 2017 UPDATED CLOSURE PLAN.

SPERLING HANSEN ASSOCIATES

Landfill Services Group
- Landfill Siting
- Design & Operations Plans
- Landfill Closure
- Environmental Monitoring

#8 - 1225 East Keith Road
North Vancouver, B.C. V7J 1J3

Phone: (604) 986-7723
Fax: (604) 986-7734

LEGEND:

- 5m EXISTING CONTOUR
- 1m EXISTING CONTOUR
- ROAD
- SURFACE WATER DITCH
- RUN-ON DIVERSION DITCH
- PROPERTY LINES
- LEACHATE CONVEYANCE PIPE
- LEAK DETECTION CONVEYANCE PIPE
- CLAY TEST PIT LOCATIONS
- SEEPAGE BLANKET MONITORING LOCATION
- LEACHATE CONVEYANCE VALVE
- LEACHATE STORAGE FACILITY

CLIENT:
COBBLE HILL HOLDINGS LTD.

PROJECT:
COBBLE HILL LANDFILL
DETAILED CONSTRUCTION PLAN FOR 2017 MINOR WORKS

TITLE:
AS-BUILT PLAN VIEW

SCALE:	DATE:	PROJECT NO:
1:1,250	2017/10/12 yyyy/mm/dd	PRJ 17039
DESIGNED		DRAWING NO:
DRAWN	SG	**FIGURE 1**
CHECKED		

PHOTO LOG

CLIENT: Ministry of Environment and Climate Change
PROJECT: Landfill Closure Activities at Cobble Hill Holdings, 460 Stebbings Rd Near Shawnigan Lake, BC
TASK: Secondary Liner Investigation

1) SECONDARY CLAY LINER INVESTIGATION

Photo 1.1 – Clay observed in Test pit #1. Blue lines represent top and bottom of observed clay layer.

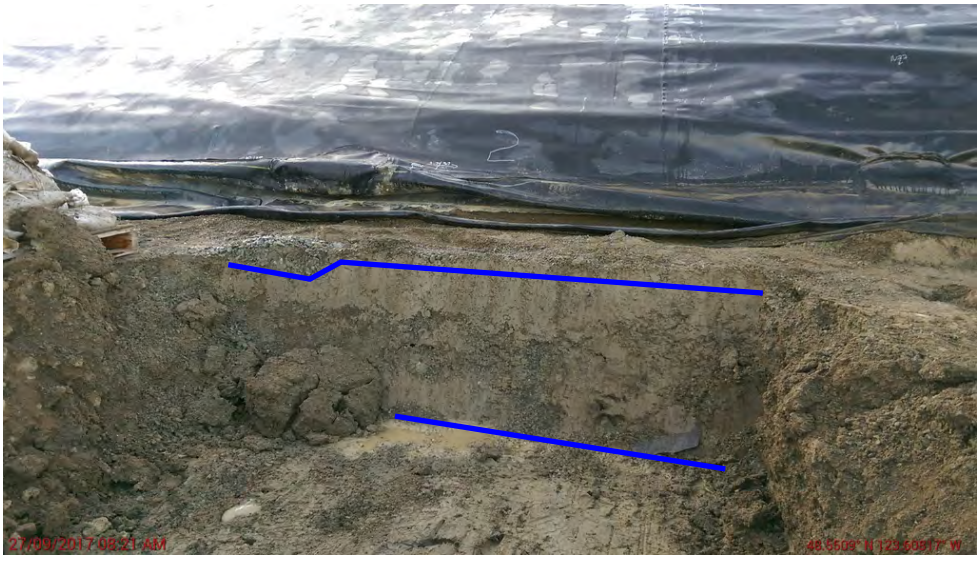


Photo 1.2 – Clay observed in Test pit #2. Blue lines represent top and bottom of observed clay layer.

PHOTO LOG

CLIENT: Ministry of Environment and Climate Change
PROJECT: Landfill Closure Activities at Cobble Hill Holdings, 460 Stebbings Rd Near Shawnigan Lake, BC
TASK: Secondary Liner Investigation

Photo 1.3 – Clay observed in Test pit #3. Blue lines represent top and bottom of observed clay layer.

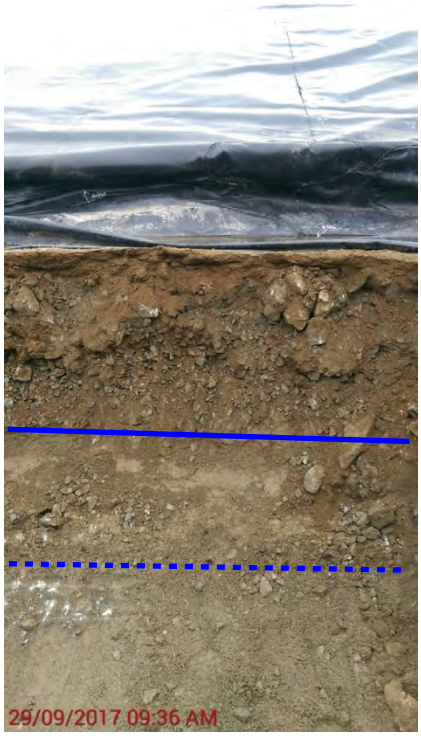


Photo 1.4 – Clay observed in additional test pit located 10 metres west of test pit #3. Blue solid line represents top of observed clay layer. Dashed line represents base of excavation; the presence of clay below the dashed line was undefined.

PHOTO LOG

CLIENT: Ministry of Environment and Climate Change
PROJECT: Landfill Closure Activities at Cobble Hill Holdings, 460 Stebbings Rd Near Shawnigan Lake, BC
TASK: Secondary Liner Investigation

Photo 1.5 – Clay observed under south perimeter ditch. Blue lines represent approx. edges of observed clay.

Photo 1.6 – Clay sample being collected with a Shelby tube in test pit #3.

PHOTO LOG

CLIENT: Ministry of Environment and Climate Change
PROJECT: Landfill Closure Activities at Cobble Hill Holdings, 460 Stebbings Rd Near Shawnigan Lake, BC
TASK: Secondary Liner Investigation

Photo 1.7 – Frontier calibrating their GPR instrument.

Photo 1.8 – Conducting GPR scanning near test pit #2.

Attachment B
Grain Size and Carbon Content Tests

Client Sample ID			E309806_REG	E309807_REG	E309808_REG	E309809_REG
Date Sampled			27-Sep-2017	27-Sep-2017	27-Sep-2017	28-Sep-2017
Time Sampled			10:00	0:00	10:00	9:00
ALS Sample ID			L1999659-1	L1999660-1	L1999661-1	L1999662-1
GHD Sample Location			collected from TP-1, 0.35 m from base of clay layer	collected from TP-2, 0.35 m from base of clay layer	collected from TP-3, 0.35 m from base of clay layer	collected below south PEA ditch, 0.15 m below surface of clay in ditch
Parameter	Lowest Detection Limit	Units	Soil	Soil	Soil	Soil
Physical Tests (Soil)						
Grain Size Curve		-	see lab report	see lab report	see lab report	see lab report
% Moisture	0.10	%	17.4	19.4	19.3	24.4
Particle Size (Soil)						
Gravel (4.75mm - 3in.)	1.0	%	1.4	7.0	3.1	<1.0
Medium Sand (0.425mm - 2.0mm)	1.0	%	5.7	13.3	8.9	4.7
Coarse Sand (2.0mm - 4.75mm)	1.0	%	4.5	7.5	5.2	3.0
Fine Sand (0.075mm - 0.425mm)	1.0	%	9.4	13.8	13.2	10.0
Silt (0.005mm - 0.075mm)	1.0	%	31.5	22.3	24.4	30.0
Clay (<0.005mm)	1.0	%	47.5	36.1	45.3	51.9
Total Clay and Silt			79.0	58.4	69.7	81.9
Organic / Inorganic Carbon (Soil)						
Total Organic Carbon	0.050	%	0.339	0.5	0.271	0.246

BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
ATTN: Maureen Bilawchuk
102 Industrial Place
Penticton BC V2A 7C8

Date Received: 29-SEP-17
Report Date: 17-OCT-17 10:48 (MT)
Version: FINAL

Client Phone: 250-354-6333

Certificate of Analysis

Lab Work Order #: L1999659

Project P.O. #: 50232951
Job Reference: SHAWNIGAN SIA LOT 23-EAST SIDE
C of C Numbers:
Legal Site Desc:

Other Information: Client: TQ
EMS ID: E309806

Dean Watt, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1999659-1				
	Description	Soil				
	Sampled Date	27-SEP-17				
	Sampled Time	10:00				
	Client ID	E309806_REG				
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED				
	% Moisture (%)	17.4				
Particle Size	Gravel (4.75mm - 3in.) (%)	1.4				
	Medium Sand (0.425mm - 2.0mm) (%)	5.7				
	Coarse Sand (2.0mm - 4.75mm) (%)	4.5				
	Fine Sand (0.075mm - 0.425mm) (%)	9.4				
	Silt (0.005mm - 0.075mm) (%)	31.5				
	Clay (<0.005mm) (%)	47.5				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.339				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
GRAIN SIZE-HYD-SK	Soil	Grain Size by Hydrometer	ASTM D422-63
Particle size curve is generated from dry sieving (particles > 2 mm), wet sieving (particles 2 mm-75 um and hydrometer readings (particles < 75 um)			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
MOIST-SK	Soil	Moisture Content	ASTM D2216-80
The weighed portion of soil is placed in a 105°C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

Additional Information:

Sampling Agency Code: GHD

Average Cooler Temperature (Deg Celsius): 6.2

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1999659 Report Date: 17-OCT-17

Client: BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
102 Industrial Place
Penticton BC V2A 7C8
Contact: Maureen Bilawchuk

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-TIC-PCT-SK	**Soil**							
Batch R3848850								
WG2632324-2 LCS								
Inorganic Carbon			101.6		%		80-120	06-OCT-17
WG2632324-3 MB								
Inorganic Carbon			<0.050		%		0.05	06-OCT-17
C-TOT-LECO-SK	**Soil**							
Batch R3848908								
WG2631906-2 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.5		%		80-120	05-OCT-17
WG2631906-3 MB								
Total Carbon by Combustion			<0.05		%		0.05	05-OCT-17
GRAIN SIZE-HYD-SK	**Soil**							
Batch R3852204								
WG2632339-2 IRM		**2017-PSA**						
Medium Sand (0.425mm - 2.0mm)			8.9		%		3.9-13.9	10-OCT-17
Fine Sand (0.075mm - 0.425mm)			33.4		%		27.6-37.6	10-OCT-17
Silt (0.005mm - 0.075mm)			28.6		%		25.8-35.8	10-OCT-17
Clay (<0.005mm)			29.0		%		22.7-32.7	10-OCT-17
MOIST-SK	**Soil**							
Batch R3852326								
WG2633376-3 LCS								
% Moisture			90.3		%		90-110	11-OCT-17
WG2633376-2 MB								
% Moisture			<0.10		%		0.1	11-OCT-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

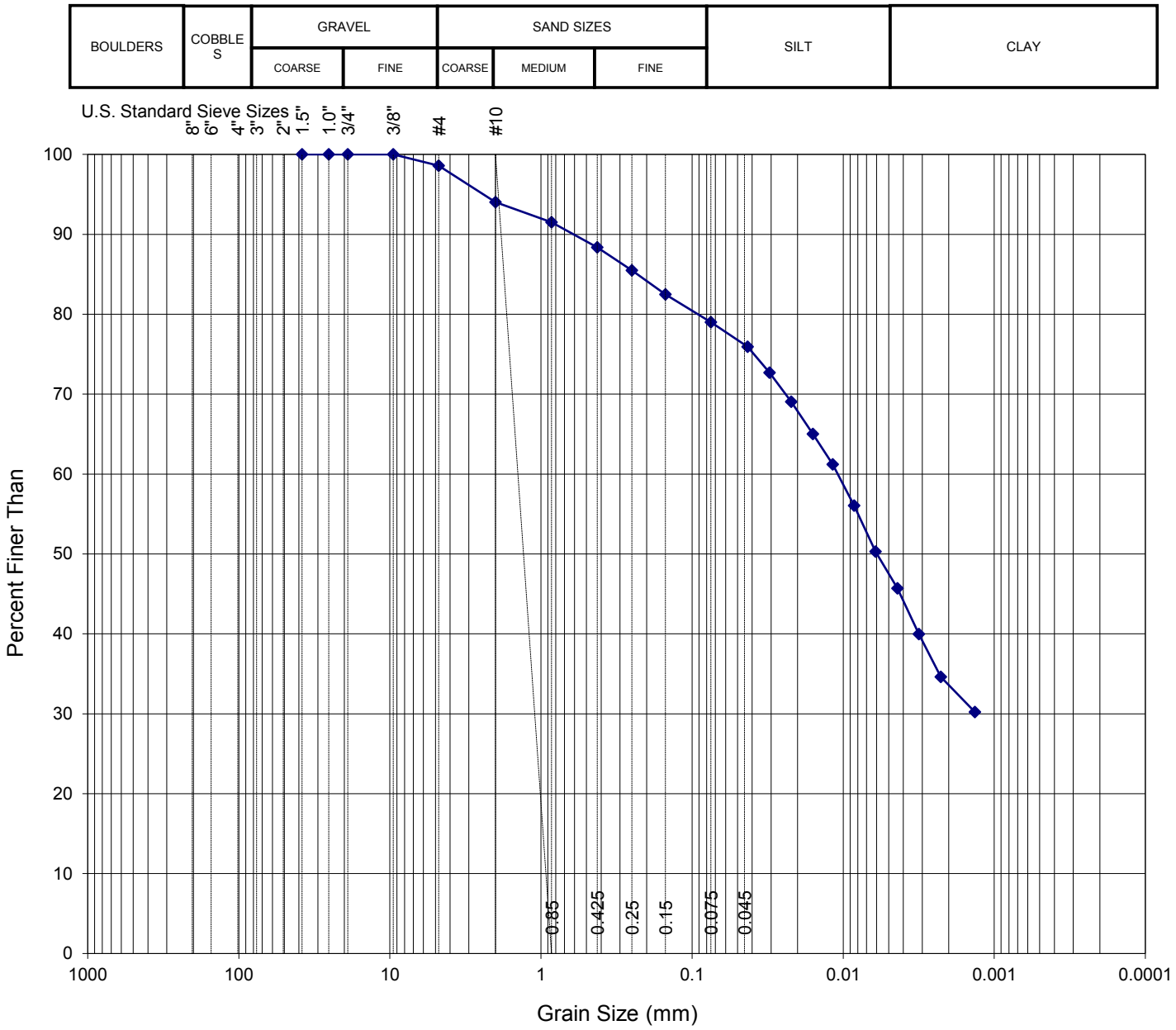
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group

819-58th Street, Saskatoon,SK

PARTICLE SIZE DISTRIBUTION CURVE

Client Name:	BC MINISTRY OF ENVIRONMENT - Sc
Project Number:	
Client Sample ID	E309806_REG
Lab Sample ID	L1999659-1
Date Sample Received	29-Sep-17
Test Completion Date:	06-Oct-17
Analyst:	SHC



METHOD DESCRIPTION

Method Reference: ASTM D 422 - 63 (2002)

Dispersion method: Mechanical

Dispesion period: 1 minute cm/s

Soil classification system used: ASTM D422-63 Classification

DESCRIPTION OF SAND AND GRAVEL PARTICLES

Shape: Angular

Hardness: Hard

SUMMARY OF RESULTS

GRAIN SIZE	WT %	DIA. RANGE (mm)
% GRAVEL :	1.42	> 4.75
% COARSE SAND :	4.54	2.0 - 4.75
% MEDIUM SAND :	5.67	0.425 - 2.0
% FINE SAND :	9.35	0.075 - 0.425
% SILT :	31.47	0.075 - 0.005
% CLAY :	47.54	< 0.005

WATER, GENERAL CHEMISTRY AND BACTERIOLOGICAL REQUISITION

ALS Global

Province Of British Columbia
Ministry of Environment

Req # 50232951

Urgent?	**Csr No.**	**Office** 90	**Client** TQ
Study		**Project** N/A	
Lab	ALS Global		
Ministry Contact	MBILAWCH BILAWCHUK, MAUREEN		
Sampler	Reinhard Trautman		
Signature			
EMS Id	E309806	**Well Plate #**	
Location	SHAWNIGAN SIA LOT 23 - EAST SIDE		

Sampling Agency
Code GHD **Name** GHD Limited
Address 10271 Shellbridge Way
Suite 165
City Richmond
Postal Code V6X2W8 **Phone** (604) 214-0510

Number of Containers 7

Instructions To Lab See Other Tests secetion. 1 TEST FOR EACH LOCATION

State SO Descriptor SO Collection Method GRB

SAMPLE C
SPARK A

No.	Class	Collection Start YYYY-MM-DD HH:MI	Collection End YYYY-MM-DD HH:MI	Depth Upper	Depth Lower	Tide	Comment
1	REG	17/09/27	17/09/27				
2							ONE SAMPLE TO BE
3							
4		0900	1000				KEPT FOR FUTURE
5							
6							CONSIDERATION

GENERAL (250 mL PLASTIC)	
	Acidity pH 8.3
	Alkalinity Titration Curve
	Alkalinity: Total: pH 4.5
	Alkalinity: Phenolphthalein
	(500 mL Plastic) Biochemical Oxygen Demand (BOD)
	Bromide
	(500 mL Plastic) Carb. Biochem. Oxygen Demand (CBOD)
	Carbon: TIC
	Chloride
	Colour: True
	Fluoride
	Nitrogen: Nitrate and Nitrite
	Nitrogen: Nitrate
	Nitrogen: Nitrite
	pH
	Phosphorus: Diss. ortho-phosphate
	(500 mL Plastic) Residue: Filterable (TDS)
	(500 mL Plastic) Residue: Nonfilterable (TSS) -Subsample (3 mg/L LOR)
	(500 mL Plastic) Residue: Nonfilterable, Fixed
	(500 mL Plastic) Residue: Total (TS)
	Specific Conductance
	Turbidity
	Sulphate

GENERAL NUTRIENTS (125 mL AMBER GLASS) - H2SO4	
	Carbon: TOC
	Chemical Oxygen Demand (COD)
	Nitrogen: Ammonia
	Nitrogen: Total
	Nitrogen: Total Kjeldahl (Calc)
	Nitrogen: Total Organic
	Phosphorus: Total

GENERAL (125 mL AMBER GLASS) - FIELD FILTER, H2SO4	
	Carbon: DIC (Field Filter)
	Carbon: DOC (FF, H2SO4)
	Nitrogen: Dissolved Kjeldahl (Calc) (FF, H2SO4)
	Nitrogen: Total Dissolved (FF, H2SO4)
	Phosphorus : Total Dissolved (FF, H2SO4)

METALS: TOTAL		
High	Low	
	■	Metal Pkg. (ICPMS) - HIGH (60 mL Plastic) - HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic) - HNO3
		Mercury - 40mL Glass, HCl
		Hardness (60 mL Plastic) - HNO3

METALS: DISSOLVED		
High	Low	
	■	Metal Pkg (ICPMS) - HIGH (60 mL Plastic)-Field Filter, HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic)-Field Filter, HNO3
		Mercury - 40mL Glass, Field Filter, HCl
		Hardness (60 mL Plastic) - Field Filter, HNO3

SPECIFIC Tests	
	Obs Well Package
	Cyanide: SAD (60 mL Plastic + NaOH)
	Cyanide: WAD (60 mL Plastic + NaOH)
	Sulphide: Total (125 mL Plastic, ZnAc & NaOH)
	Residue: Nonfilterable (TSS) -Whole Bottle - 1 mg/L LOR (150 mL Plastic)
	Chlorophyll a (250 mL Brown Plastic Bottle or Filter) Vol:
	Phaeophytin (250 mL Brown Plastic Bottle or Filter) Vol:

ORGANICS	
	BTEX (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VOC Full List (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Volatile Hydrocarbons (VH) (2X40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Trihalomethanes (THM) (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VPH (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	EPH (2 X 100 mL Amber Glass, NaHSO4)
	PAH (2 X100 mL Amber Glass, NaHSO4)
	LEPH/HEPH (Calc) (2 X 100 mL Amber Glass, NaHSO4)
	Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Mineral Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Organochlorine Pesticides (OCP) (2 X 500 mL Amber Glass)
	Organophosphorus Pesticides (OPP) (2 X 500 mL Amber Glass)
	Polychlorinated Biphenyls (PCBs) (2 X 500 mL Amber Glass)
	Chlorophenols (Tri, Tetra & Penta) (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Non-Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenols, Colorimetric (125 mL Amber Glass, H2SO4)
	Acid Extractable Herbicides (2 X 1 L Amber Glass, NaHSO4)
	Resin Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Fatty Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)

BACTERIOLOGY	
	E. coli - MF
	Enterococci - MF
	Fecal coliform - MF
	Fecal coliform - MPN
	Fecal streptoc - MF
	Total coliform - MF
	Total coliform - MPN

OTHER Tests	
X	Grain Size / Hydrometer
X	Moisture Content
X	Organic Carbon Content

Smpl No.	FIELD TEST Details	Method Results	Units

Paul Sep 29 @ 08:50
6.2°C

L1999659-COFC

Report ID: EMSR0900

Date: 2017-09-26 15:05

BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
ATTN: Maureen Bilawchuk
102 Industrial Place
Penticton BC V2A 7C8

Date Received: 29-SEP-17
Report Date: 17-OCT-17 11:46 (MT)
Version: FINAL

Client Phone: 250-354-6333

Certificate of Analysis

Lab Work Order #: L1999660

Project P.O. #: 50232952
Job Reference: SHAWNIGAN SIA LOT 23-WEST OF OLD TANKS #2
C of C Numbers:
Legal Site Desc:

Other Information: Client: TQ
EMS ID: E309807

Dean Watt, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1999660-1				
	Description	Soil				
	Sampled Date	27-SEP-17				
	Sampled Time					
	Client ID	E309807_REG				
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED				
	% Moisture (%)	19.4				
Particle Size	Gravel (4.75mm - 3in.) (%)	7.0				
	Medium Sand (0.425mm - 2.0mm) (%)	13.3				
	Coarse Sand (2.0mm - 4.75mm) (%)	7.5				
	Fine Sand (0.075mm - 0.425mm) (%)	13.8				
	Silt (0.005mm - 0.075mm) (%)	22.3				
	Clay (<0.005mm) (%)	36.1				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.500				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
GRAIN SIZE-HYD-SK	Soil	Grain Size by Hydrometer	ASTM D422-63
Particle size curve is generated from dry sieving (particles > 2 mm), wet sieving (particles 2 mm-75 um and hydrometer readings (particles < 75 um)			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
MOIST-SK	Soil	Moisture Content	ASTM D2216-80
The weighed portion of soil is placed in a 105°C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

Additional Information:

Sampling Agency Code: GHD

Average Cooler Temperature (Deg Celsius): 6.2

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
102 Industrial Place
Penticton BC V2A 7C8
Contact: Maureen Bilawchuk

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-TIC-PCT-SK	**Soil**							
Batch R3848850								
WG2632324-2 LCS								
Inorganic Carbon			101.6		%		80-120	06-OCT-17
WG2632324-3 MB								
Inorganic Carbon			<0.050		%		0.05	06-OCT-17
C-TOT-LECO-SK	**Soil**							
Batch R3848908								
WG2631906-2 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.5		%		80-120	05-OCT-17
WG2631906-3 MB								
Total Carbon by Combustion			<0.05		%		0.05	05-OCT-17
GRAIN SIZE-HYD-SK	**Soil**							
Batch R3852204								
WG2632339-2 IRM		**2017-PSA**						
Medium Sand (0.425mm - 2.0mm)			8.9		%		3.9-13.9	10-OCT-17
Fine Sand (0.075mm - 0.425mm)			33.4		%		27.6-37.6	10-OCT-17
Silt (0.005mm - 0.075mm)			28.6		%		25.8-35.8	10-OCT-17
Clay (<0.005mm)			29.0		%		22.7-32.7	10-OCT-17
MOIST-SK	**Soil**							
Batch R3852326								
WG2633376-3 LCS								
% Moisture			90.3		%		90-110	11-OCT-17
WG2633376-2 MB								
% Moisture			<0.10		%		0.1	11-OCT-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

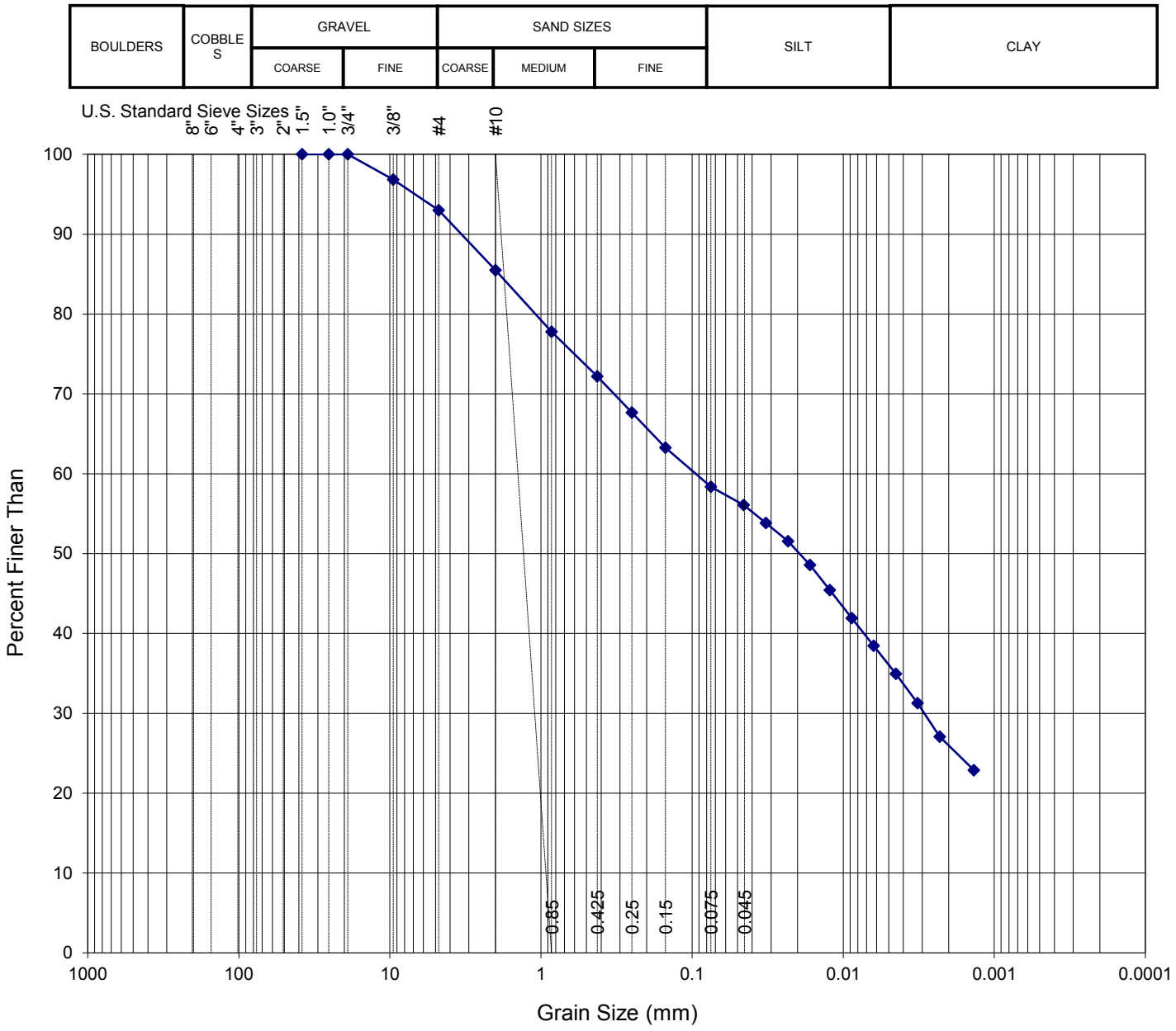
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group

819-58th Street, Saskatoon,SK

PARTICLE SIZE DISTRIBUTION CURVE

Client Name: BC MINISTRY OF ENVIRONMENT - Sc
Project Number:
Client Sample ID E309807_REG
Lab Sample ID L1999660-1
Date Sample Received 29-Sep-17
Test Completion Date: 06-Oct-17
Analyst: SHC



METHOD DESCRIPTION
Method Reference: ASTM D 422 - 63 (2002)
Dispersion method: Mechanical
Dispesion period: 1 minute cm/s
Soil classification system used: ASTM D422-63 Classification

DESCRIPTION OF SAND AND GRAVEL PARTICLES
Shape: Angular
Hardness: Hard

SUMMARY OF RESULTS

GRAIN SIZE	WT %	DIA. RANGE (mm)
% GRAVEL :	7.02	> 4.75
% COARSE SAND :	7.49	2.0 - 4.75
% MEDIUM SAND :	13.29	0.425 - 2.0
% FINE SAND :	13.82	0.075 - 0.425
% SILT :	22.31	0.075 - 0.005
% CLAY :	36.07	< 0.005

WATER, GENERAL CHEMISTRY AND BACTERIOLOGICAL REQUISITION

ALS Global

Province Of British Columbia
Ministry of Environment

Req # 50232952

Urgent?	**Csr No.**	**Office** 90	**Client** TQ
Study		**Project** N/A	
Lab	ALS Global		
Ministry Contact	MBILAWCH BILAWCHUK, MAUREEN		
Sampler	Reinhard Trautman		
Signature			
EMS Id	E309807	**Well Plate #**	
Location	SHAWNIGAN SIA LOT 23 - WEST OF OLD TANKS #2		

Sampling Agency

Code GHD	**Name** GHD Limited
Address	10271 Shellbridge Way
	Suite 165
City	Richmond
Postal Code	V6X2W8 **Phone** (604) 214-0510

Number of Containers 12

Instructions To Lab Please see 'Other Test' section. 4 TUBES FOR EACH LOCATION

State SO Descriptor SO Collection Method GRB

SAMPLE C
SPARE A

No.	Class	Collection Start YYYY-MM-DD HH:MI	Collection End YYYY-MM-DD HH:MI	Depth Upper	Depth Lower	Tide	Comment
1	REG						
2		17/09/27	17/09/27				ONE SAMPLE TO BE
3							
4							HELD FOR FUTURE
5							
6							CONSIDERATION

GENERAL (250 mL PLASTIC)	
	Acidity pH 8.3
	Alkalinity Titration Curve
	Alkalinity: Total: pH 4.5
	Alkalinity: Phenolphthalein
	(500 mL Plastic) Biochemical Oxygen Demand (BOD)
	Bromide
	(500 mL Plastic) Carb. Biochem. Oxygen Demand (CBOD)
	Carbon: TIC
	Chloride
	Colour: True
	Fluoride
	Nitrogen: Nitrate and Nitrite
	Nitrogen: Nitrate
	Nitrogen: Nitrite
	pH
	Phosphorus: Diss. ortho-phosphate
	(500 mL Plastic) Residue: Filterable (TDS)
	(500 mL Plastic) Residue: Nonfilterable (TSS) -Subsample (3 mg/L LOR)
	(500 mL Plastic) Residue: Nonfilterable, Fixed
	(500 mL Plastic) Residue: Total (TS)
	Specific Conductance
	Turbidity
	Sulphate

GENERAL NUTRIENTS (125 mL AMBER GLASS) - H2SO4	
	Carbon: TOC
	Chemical Oxygen Demand (COD)
	Nitrogen: Ammonia
	Nitrogen: Total
	Nitrogen: Total Kjeldahl (Calc)
	Nitrogen: Total Organic
	Phosphorus: Total

GENERAL (125 mL AMBER GLASS) - FIELD FILTER, H2SO4	
	Carbon: DIC (Field Filter)
	Carbon: DOC (FF, H2SO4)
	Nitrogen: Dissolved Kjeldahl (Calc) (FF, H2SO4)
	Nitrogen: Total Dissolved (FF, H2SO4)
	Phosphorus : Total Dissolved (FF, H2SO4)

METALS: TOTAL		
High	**Low**	
	■	Metal Pkg. (ICPMS) - HIGH (60 mL Plastic) - HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic) - HNO3
		Mercury - 40mL Glass, HCl
		Hardness (60 mL Plastic) - HNO3

METALS: DISSOLVED		
High	**Low**	
	■	Metal Pkg (ICPMS) - HIGH (60 mL Plastic)-Field Filter, HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic)-Field Filter, HNO3
		Mercury - 40mL Glass, Field Filter, HCl
		Hardness (60 mL Plastic) - Field Filter, HNO3

SPECIFIC Tests	
	Obs Well Package
	Cyanide: SAD (60 mL Plastic + NaOH)
	Cyanide: WAD (60 mL Plastic + NaOH)
	Sulphide: Total (125 mL Plastic, ZnAc & NaOH)
	Residue: Nonfilterable (TSS) -Whole Bottle - 1 mg/L LOR (150 mL Plastic)
	Chlorophyll a (250 mL Brown Plastic Bottle or Filter) Vol:
	Phaeophytin (250 mL Brown Plastic Bottle or Filter) Vol:

ORGANICS	
	BTEX (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VOC Full List (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Volatile Hydrocarbons (VH) (2X40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Trihalomethanes (THM) (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VPH (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	EPH (2 X 100 mL Amber Glass, NaHSO4)
	PAH (2 X100 mL Amber Glass, NaHSO4)
	LEPH/HEPH (Calc) (2 X 100 mL Amber Glass, NaHSO4)
	Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Mineral Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Organochlorine Pesticides (OCP) (2 X 500 mL Amber Glass)
	Organophosphorus Pesticides (OPP) (2 X 500 mL Amber Glass)
	Polychlorinated Biphenyls (PCBs) (2 X 500 mL Amber Glass)
	Chlorophenols (Tri, Tetra & Penta) (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Non-Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenols, Colorimetric (125 mL Amber Glass, H2SO4)
	Acid Extractable Herbicides (2 X 1 L Amber Glass, NaHSO4)
	Resin Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Fatty Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)

BACTERIOLOGY	
	E. coli - MF
	Enterococci - MF
	Fecal coliform - MF
	Fecal coliform - MPN
	Fecal streptoc - MF
	Total coliform - MF
	Total coliform - MPN

OTHER Tests	
X	Grain Size / Hydrometer
X	Moisture Content
X	Organic Carbon

Smpl No.	FIELD TEST Details	Method Results	Units

Paul Sep 29 @ 08:50
6.2°C

L1999660-COFC

Report ID: EMSR0900

Date: 2017-09-26 15:09

BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
ATTN: Maureen Bilawchuk
102 Industrial Place
Penticton BC V2A 7C8

Date Received: 29-SEP-17
Report Date: 17-OCT-17 12:20 (MT)
Version: FINAL

Client Phone: 250-354-6333

Certificate of Analysis

Lab Work Order #: L1999661

Project P.O. #: 50232953
Job Reference: SHAWNIGAN SIA LOT 23-WEST OF TANK AT FAR END #3
C of C Numbers:
Legal Site Desc:

Other Information: Client: TQ
EMS ID: E309808

Dean Watt, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1999661-1				
	Description	Soil				
	Sampled Date	27-SEP-17				
	Sampled Time	10:00				
	Client ID	E309808_REG				
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED				
	% Moisture (%)	19.3				
Particle Size	Gravel (4.75mm - 3in.) (%)	3.1				
	Medium Sand (0.425mm - 2.0mm) (%)	8.9				
	Coarse Sand (2.0mm - 4.75mm) (%)	5.2				
	Fine Sand (0.075mm - 0.425mm) (%)	13.2				
	Silt (0.005mm - 0.075mm) (%)	24.4				
	Clay (<0.005mm) (%)	45.3				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.271				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
GRAIN SIZE-HYD-SK	Soil	Grain Size by Hydrometer	ASTM D422-63
Particle size curve is generated from dry sieving (particles > 2 mm), wet sieving (particles 2 mm-75 um and hydrometer readings (particles < 75 um)			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
MOIST-SK	Soil	Moisture Content	ASTM D2216-80
The weighed portion of soil is placed in a 105°C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

Additional Information:

Sampling Agency Code: GHD

Average Cooler Temperature (Deg Celsius): 6.2

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
102 Industrial Place
Penticton BC V2A 7C8
Contact: Maureen Bilawchuk

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-TIC-PCT-SK	**Soil**							
Batch R3848850								
WG2632324-2 LCS								
Inorganic Carbon			101.6		%		80-120	06-OCT-17
WG2632324-3 MB								
Inorganic Carbon			<0.050		%		0.05	06-OCT-17
C-TOT-LECO-SK	**Soil**							
Batch R3848908								
WG2631906-2 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.5		%		80-120	05-OCT-17
WG2631906-3 MB								
Total Carbon by Combustion			<0.05		%		0.05	05-OCT-17
GRAIN SIZE-HYD-SK	**Soil**							
Batch R3852204								
WG2632339-2 IRM		**2017-PSA**						
Medium Sand (0.425mm - 2.0mm)			8.9		%		3.9-13.9	10-OCT-17
Fine Sand (0.075mm - 0.425mm)			33.4		%		27.6-37.6	10-OCT-17
Silt (0.005mm - 0.075mm)			28.6		%		25.8-35.8	10-OCT-17
Clay (<0.005mm)			29.0		%		22.7-32.7	10-OCT-17
MOIST-SK	**Soil**							
Batch R3852326								
WG2633376-3 LCS								
% Moisture			90.3		%		90-110	11-OCT-17
WG2633376-2 MB								
% Moisture			<0.10		%		0.1	11-OCT-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

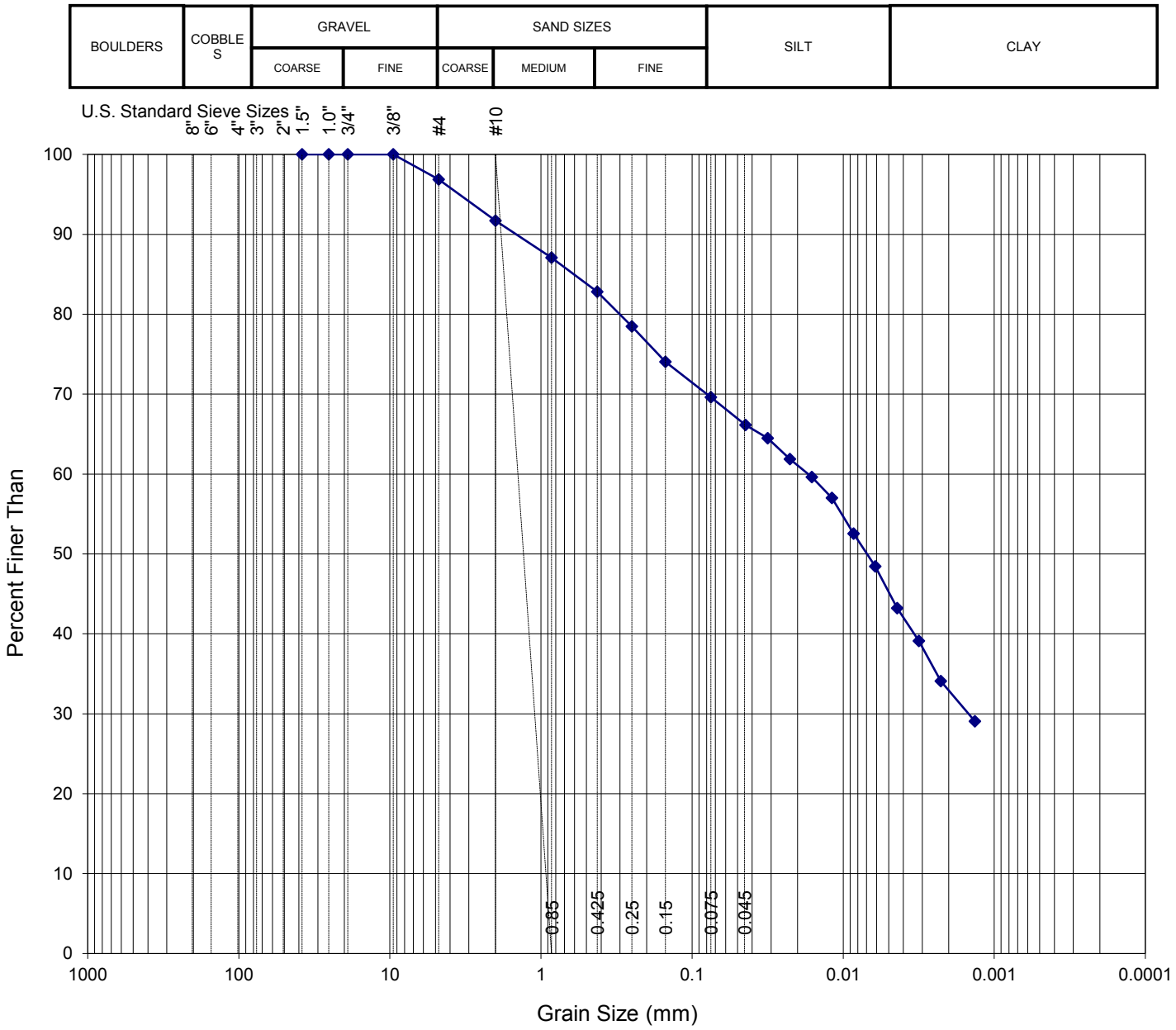
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group

819-58th Street, Saskatoon,SK

PARTICLE SIZE DISTRIBUTION CURVE

Client Name:	BC MINISTRY OF ENVIRONMENT - Sc
Project Number:	
Client Sample ID	E309808_REG
Lab Sample ID	L1999661-1
Date Sample Received	29-Sep-17
Test Completion Date:	06-Oct-17
Analyst:	SHC



METHOD DESCRIPTION

Method Reference: ASTM D 422 - 63 (2002)

Dispersion method: Mechanical

Dispesion period: 1 minute cm/s

Soil classification system used: ASTM D422-63 Classification

DESCRIPTION OF SAND AND GRAVEL PARTICLES

Shape: Angular

Hardness: Hard

SUMMARY OF RESULTS

GRAIN SIZE	WT %	DIA. RANGE (mm)
% GRAVEL :	3.14	> 4.75
% COARSE SAND :	5.17	2.0 - 4.75
% MEDIUM SAND :	8.88	0.425 - 2.0
% FINE SAND :	13.19	0.075 - 0.425
% SILT :	24.37	0.075 - 0.005
% CLAY :	45.25	< 0.005

WATER, GENERAL CHEMISTRY AND BACTERIOLOGICAL REQUISITION

ALS Global

Province Of British Columbia
Ministry of Environment

Req # 50232953

Urgent?	**Csr No.**	**Office** 90	**Client** TQ
Study		**Project** N/A	
Lab	ALS Global		
Ministry Contact	MBILAWCH BILAWCHUK, MAUREEN		
Sampler	Reinhard Trautman		
Signature			
EMS Id	E309808	**Well Plate #** #3	
Location	SHAWNIGAN SIA LOT 23 - WEST OF TANK AT FAR END		

Sampling Agency	
Code GHD	**Name** GHD Limited
Address	10271 Shellbridge Way
	Suite 165
City	Richmond
Postal Code V6X2W8	**Phone** (604) 214-0510
Number of Containers	2

Instructions To Lab Please see 'Other Tests' section — 1 TEST FOR EACH LOCATION

State SO Descriptor SO Collection Method GRB

SAMPLE C

No.	Class	Collection Start YYYY-MM-DD HH:MI	Collection End YYYY-MM-DD HH:MI	Depth Upper	Depth Lower	Tide	Comment
1	REG	17/09/27	17/09/28				SPARE A
2							1 TEST SAMPLE
3		0900	1000				
4							TO BE KEPT FOR
5							
6							FUTURE

GENERAL (250 mL PLASTIC)	
	Acidity pH 8.3
	Alkalinity Titration Curve
	Alkalinity: Total: pH 4.5
	Alkalinity: Phenolphthalein
	(500 mL Plastic) Biochemical Oxygen Demand (BOD)
	Bromide
	(500 mL Plastic) Carb. Biochem. Oxygen Demand (CBOD)
	Carbon: TIC
	Chloride
	Colour: True
	Fluoride
	Nitrogen: Nitrate and Nitrite
	Nitrogen: Nitrate
	Nitrogen: Nitrite
	pH
	Phosphorus: Diss. ortho-phosphate
	(500 mL Plastic) Residue: Filterable (TDS)
	(500 mL Plastic) Residue: Nonfilterable (TSS) -Subsample (3 mg/L LOR)
	(500 mL Plastic) Residue: Nonfilterable, Fixed
	(500 mL Plastic) Residue: Total (TS)
	Specific Conductance
	Turbidity
	Sulphate

GENERAL NUTRIENTS (125 mL AMBER GLASS) - H2SO4	
	Carbon: TOC
	Chemical Oxygen Demand (COD)
	Nitrogen: Ammonia
	Nitrogen: Total
	Nitrogen: Total Kjeldahl (Calc)
	Nitrogen: Total Organic
	Phosphorus: Total

GENERAL (125 mL AMBER GLASS) - FIELD FILTER, H2SO4	
	Carbon: DIC (Field Filter)
	Carbon: DOC (FF, H2SO4)
	Nitrogen: Dissolved Kjeldahl (Calc) (FF, H2SO4)
	Nitrogen: Total Dissolved (FF, H2SO4)
	Phosphorus : Total Dissolved (FF, H2SO4)

METALS: TOTAL		
High	**Low**	
	■	Metal Pkg. (ICPMS) - HIGH (60 mL Plastic) - HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic) - HNO3
		Mercury - 40mL Glass, HCl
		Hardness (60 mL Plastic) - HNO3

METALS: DISSOLVED		
High	**Low**	
	■	Metal Pkg (ICPMS) - HIGH (60 mL Plastic)-Field Filter, HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic)-Field Filter, HNO3
		Mercury - 40mL Glass, Field Filter, HCl
		Hardness (60 mL Plastic) - Field Filter, HNO3

SPECIFIC Tests	
	Obs Well Package
	Cyanide: SAD (60 mL Plastic + NaOH)
	Cyanide: WAD (60 mL Plastic + NaOH)
	Sulphide: Total (125 mL Plastic, ZnAc & NaOH)
	Residue: Nonfilterable (TSS) -Whole Bottle - 1 mg/L LOR (150 mL Plastic)
	Chlorophyll a (250 mL Brown Plastic Bottle or Filter) Vol:
	Phaeophytin (250 mL Brown Plastic Bottle or Filter) Vol:

ORGANICS	
	BTEX (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VOC Full List (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Volatile Hydrocarbons (VH) (2X40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Trihalomethanes (THM) (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VPH (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	EPH (2 X 100 mL Amber Glass, NaHSO4)
	PAH (2 X100 mL Amber Glass, NaHSO4)
	LEPH/HEPH (Calc) (2 X 100 mL Amber Glass, NaHSO4)
	Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Mineral Oil & Grease (2 x 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Organochlorine Pesticides (OCP) (2 X 500 mL Amber Glass)
	Organophosphorus Pesticides (OPP) (2 X 500 mL Amber Glass)
	Polychlorinated Biphenyls (PCBs) (2 X 500 mL Amber Glass)
	Chlorophenols (Tri, Tetra & Penta) (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Non-Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenols, Colorimetric (125 mL Amber Glass, H2SO4)
	Acid Extractable Herbicides (2 X 1 L Amber Glass, NaHSO4)
	Resin Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Fatty Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)

BACTERIOLOGY	
	E. coli - MF
	Enterococci - MF
	Fecal coliform - MF
	Fecal coliform - MPN
	Fecal streptoc - MF
	Total coliform - MF
	Total coliform - MPN

OTHER Tests	
X	Grain Size / Hydrometer
X	Moisture Content
X	Organic Carbon Content

Smpl No.	FIELD TEST Details	Method Results	Units

Paul Sep 29 @ 08:50

6.2°C

L1999661-COFC

BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
ATTN: Maureen Bilawchuk
102 Industrial Place
Penticton BC V2A 7C8

Date Received: 29-SEP-17
Report Date: 17-OCT-17 12:41 (MT)
Version: FINAL

Client Phone: 250-354-6333

Certificate of Analysis

Lab Work Order #: L1999662

Project P.O. #: 50232954
Job Reference: SHAWNIGAN SIA LOT 23-SOUTH DITCH #4
C of C Numbers:
Legal Site Desc:

Other Information: Client: TQ
EMS ID: E309809

Dean Watt, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1999662-1				
	Description	Soil				
	Sampled Date	28-SEP-17				
	Sampled Time	09:00				
	Client ID	E309809_REG				
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED				
	% Moisture (%)	24.4				
Particle Size	Gravel (4.75mm - 3in.) (%)	<1.0				
	Medium Sand (0.425mm - 2.0mm) (%)	4.7				
	Coarse Sand (2.0mm - 4.75mm) (%)	3.0				
	Fine Sand (0.075mm - 0.425mm) (%)	10.0				
	Silt (0.005mm - 0.075mm) (%)	30.0				
	Clay (<0.005mm) (%)	51.9				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.246				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
GRAIN SIZE-HYD-SK	Soil	Grain Size by Hydrometer	ASTM D422-63
Particle size curve is generated from dry sieving (particles > 2 mm), wet sieving (particles 2 mm-75 um and hydrometer readings (particles < 75 um)			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
MOIST-SK	Soil	Moisture Content	ASTM D2216-80
The weighed portion of soil is placed in a 105°C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

Additional Information:

Sampling Agency Code: GHD

Average Cooler Temperature (Deg Celsius): 6.2

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: BC MINISTRY OF ENVIRONMENT - Southern Interior - Penticton
102 Industrial Place
Penticton BC V2A 7C8
Contact: Maureen Bilawchuk

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-TIC-PCT-SK	**Soil**							
Batch R3848850								
WG2632324-1 DUP		**L1999662-1**						
Inorganic Carbon		0.124	0.131		%	5.5	20	06-OCT-17
WG2632324-2 LCS								
Inorganic Carbon			101.6		%		80-120	06-OCT-17
WG2632324-3 MB								
Inorganic Carbon			<0.050		%		0.05	06-OCT-17
C-TOT-LECO-SK	**Soil**							
Batch R3848908								
WG2631906-2 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.5		%		80-120	05-OCT-17
WG2631906-3 MB								
Total Carbon by Combustion			<0.05		%		0.05	05-OCT-17
GRAIN SIZE-HYD-SK	**Soil**							
Batch R3852204								
WG2632339-1 DUP		**L1999662-1**						
Gravel (4.75mm - 3in.)		<1.0	<1.0	RPD-NA	%	N/A	25	10-OCT-17
Coarse Sand (2.0mm - 4.75mm)		3.0	3.0		%	0.3	25	10-OCT-17
Medium Sand (0.425mm - 2.0mm)		4.7	4.6		%	3.0	25	10-OCT-17
Fine Sand (0.075mm - 0.425mm)		10.0	9.9		%	0.9	25	10-OCT-17
Silt (0.005mm - 0.075mm)		30.0	30.1		%	0.1	25	10-OCT-17
Clay (<0.005mm)		51.9	52.1		%	0.4	25	10-OCT-17
WG2632339-2 IRM		**2017-PSA**						
Medium Sand (0.425mm - 2.0mm)			8.9		%		3.9-13.9	10-OCT-17
Fine Sand (0.075mm - 0.425mm)			33.4		%		27.6-37.6	10-OCT-17
Silt (0.005mm - 0.075mm)			28.6		%		25.8-35.8	10-OCT-17
Clay (<0.005mm)			29.0		%		22.7-32.7	10-OCT-17
MOIST-SK	**Soil**							
Batch R3852326								
WG2633376-3 LCS								
% Moisture			90.3		%		90-110	11-OCT-17
WG2633376-2 MB								
% Moisture			<0.10		%		0.1	11-OCT-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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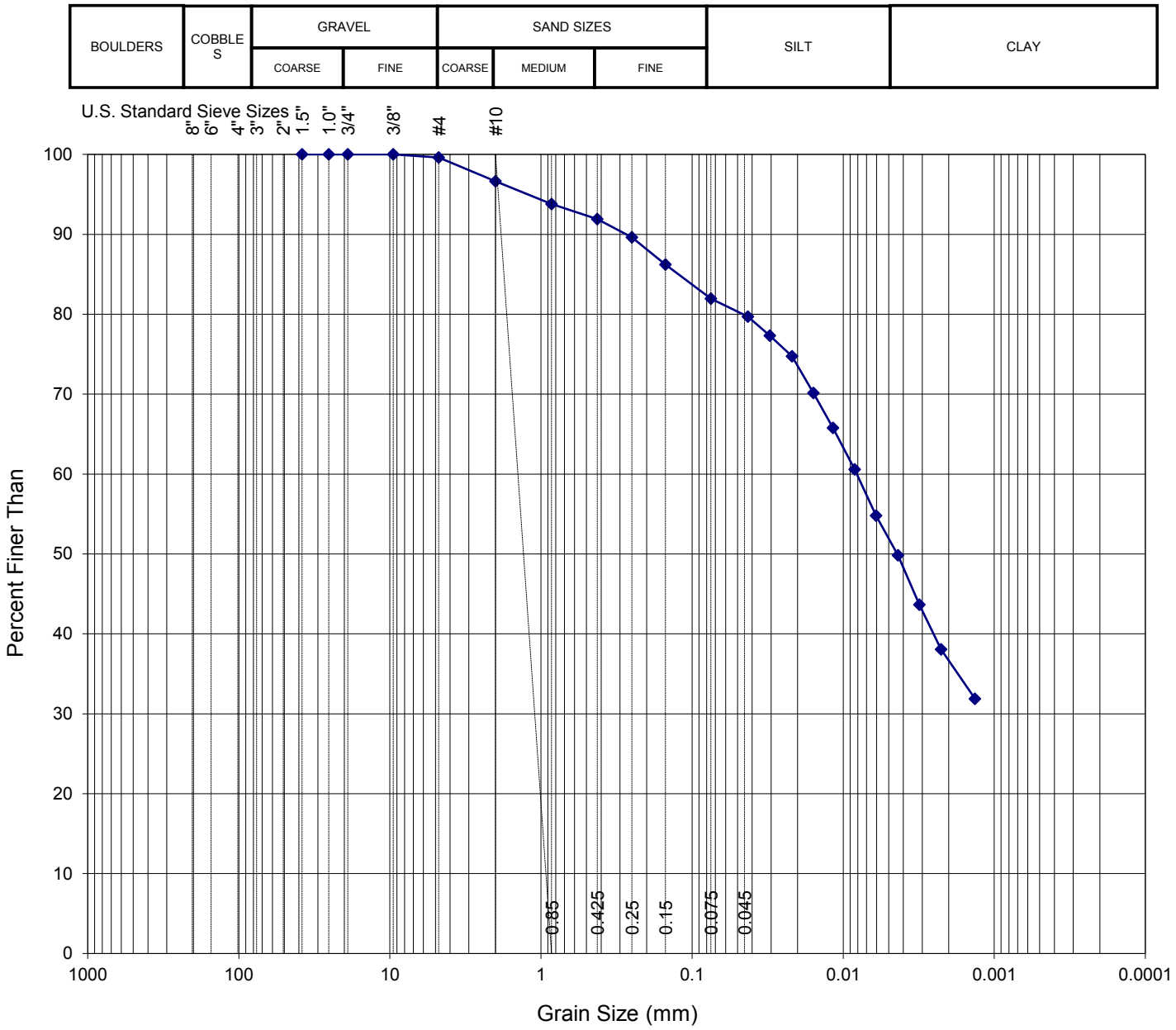
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group

819-58th Street, Saskatoon,SK

PARTICLE SIZE DISTRIBUTION CURVE

Client Name:	BC MINISTRY OF ENVIRONMENT - Sc
Project Number:	
Client Sample ID	E309809_REG
Lab Sample ID	L1999662-1
Date Sample Received	29-Sep-17
Test Completion Date:	06-Oct-17
Analyst:	SHC



METHOD DESCRIPTION

Method Reference: ASTM D 422 - 63 (2002)

Dispersion method: Mechanical

Dispesion period: 1 minute cm/s

Soil classification system used: ASTM D422-63 Classification

DESCRIPTION OF SAND AND GRAVEL PARTICLES

Shape: Angular

Hardness: Hard

SUMMARY OF RESULTS

GRAIN SIZE	WT %	DIA. RANGE (mm)
% GRAVEL :	<1	> 4.75
% COARSE SAND :	2.98	2.0 - 4.75
% MEDIUM SAND :	4.74	0.425 - 2.0
% FINE SAND :	9.95	0.075 - 0.425
% SILT :	30.02	0.075 - 0.005
% CLAY :	51.92	< 0.005

WATER, GENERAL CHEMISTRY AND BACTERIOLOGICAL REQUISITION

ALS Global

Province Of British Columbia
Ministry of Environment

Req # 50232954

Urgent?	**Csr No.**	**Office** 90	**Client** TQ
Study		**Project** N/A	
Lab	ALS Global		
Ministry Contact	MBILAWCH BILAWCHUK, MAUREEN		
Sampler	Reinhard Trautman		
Signature			
EMS Id	E309809	**Well Plate #**	
Location	SHAWNIGAN SIA LOT 23 - SOUTH DITCH #4		

Sampling Agency

Code GHD	**Name** GHD Limited
Address	10271 Shellbridge Way
	Suite 165
City	Richmond
Postal Code	V6X2W8 **Phone** (604) 214-0510

Number of Containers 2

Instructions To Lab Please see 'Other Tests' section.

State: SO Descriptor: SO Collection Method: GRB

No.	Class	Collection Start YYYY-MM-DD HH:MI	Collection End YYYY-MM-DD HH:MI	Depth Upper	Depth Lower	Tide	Comment
1	REG	17/09/20	17/09/28				SAMPLE C SPARE A
2							1 TEST SAMPLE TO
3							
4		0800	0900				BE KEPT FOR
5							
6							FUTURE REFERENCE

GENERAL (250 mL PLASTIC)

	Acidity pH 8.3
	Alkalinity Titration Curve
	Alkalinity: Total: pH 4.5
	Alkalinity: Phenolphthalein
	(500 mL Plastic) Biochemical Oxygen Demand (BOD)
	Bromide
	(500 mL Plastic) Carb. Biochem. Oxygen Demand (CBOD)
	Carbon: TIC
	Chloride
	Colour: True
	Fluoride
	Nitrogen: Nitrate and Nitrite
	Nitrogen: Nitrate
	Nitrogen: Nitrite
	pH
	Phosphorus: Diss. ortho-phosphate
	(500 mL Plastic) Residue: Filterable (TDS)
	(500 mL Plastic) Residue: Nonfilterable (TSS) -Subsample (3 mg/L LOR)
	(500 mL Plastic) Residue: Nonfilterable, Fixed
	(500 mL Plastic) Residue: Total (TS)
	Specific Conductance
	Turbidity
	Sulphate

GENERAL NUTRIENTS (125 mL AMBER GLASS) - H2SO4

	Carbon: TOC
	Chemical Oxygen Demand (COD)
	Nitrogen: Ammonia
	Nitrogen: Total
	Nitrogen: Total Kjeldahl (Calc)
	Nitrogen: Total Organic
	Phosphorus: Total

GENERAL (125 mL AMBER GLASS) - FIELD FILTER, H2SO4

	Carbon: DIC (Field Filter)
	Carbon: DOC (FF, H2SO4)
	Nitrogen: Dissolved Kjeldahl (Calc) (FF, H2SO4)
	Nitrogen: Total Dissolved (FF, H2SO4)
	Phosphorus : Total Dissolved (FF, H2SO4)

METALS: TOTAL

High	Low	
	■	Metal Pkg. (ICPMS) - HIGH (60 mL Plastic) - HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic) - HNO3
		Mercury - 40mL Glass, HCl
		Hardness (60 mL Plastic) - HNO3

METALS: DISSOLVED

High	Low	
	■	Metal Pkg (ICPMS) - HIGH (60 mL Plastic)-Field Filter, HNO3
■		Metal Pkg. (ICPMS) - LOW (60 mL Plastic)-Field Filter, HNO3
		Mercury - 40mL Glass, Field Filter, HCl
		Hardness (60 mL Plastic) - Field Filter, HNO3

SPECIFIC Tests

	Obs Well Package
	Cyanide: SAD (60 mL Plastic + NaOH)
	Cyanide: WAD (60 mL Plastic + NaOH)
	Sulphide: Total (125 mL Plastic, ZnAc & NaOH)
	Residue: Nonfilterable (TSS) -Whole Bottle - 1 mg/L LOR (150 mL Plastic)
	Chlorophyll a (250 mL Brown Plastic Bottle or Filter) Vol:
	Phaeophytin (250 mL Brown Plastic Bottle or Filter) Vol:

ORGANICS

	BTEX (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VOC Full List (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Volatile Hydrocarbons (VH) (2X40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	Trihalomethanes (THM) (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	VPH (2 X 40 mL glass vials, NaHSO4 or Na2S2O3, No headspace)
	EPH (2 X 100 mL Amber Glass, NaHSO4)
	PAH (2 X100 mL Amber Glass, NaHSO4)
	LEPH/HEPH (Calc) (2 X 100 mL Amber Glass, NaHSO4)
	Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Mineral Oil & Grease (2 X 250 mL Amber Glass, 2 mL 1:1 HCl or 1:1 H2SO4)
	Organochlorine Pesticides (OCP) (2 X 500 mL Amber Glass)
	Organophosphorus Pesticides (OPP) (2 X 500 mL Amber Glass)
	Polychlorinated Biphenyls (PCBs) (2 X 500 mL Amber Glass)
	Chlorophenols (Tri, Tetra & Penta) (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenolics, Non-Chlorinated (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Phenols, Colorimetric (125 mL Amber Glass, H2SO4)
	Acid Extractable Herbicides (2 X 1 L Amber Glass, NaHSO4)
	Resin Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)
	Fatty Acids (2 X 500 mL Amber Glass, C6H8O6 & NaHSO4)

BACTERIOLOGY

	E. coli - MF
	Enterococci - MF
	Fecal coliform - MF
	Fecal coliform - MPN
	Fecal streptoc - MF
	Total coliform - MF
	Total coliform - MPN

OTHER Tests

X	Grain Size / Hydrometer
X	Moisture Content
X	Organic Carbon Content

Smpl No.	FIELD TEST Details	Method Results	Units

Paul Sep 29 @ 08:50

6.2°C

L1999662-COFC

Report ID: EMSR0900

Date: 2017-09-26 15:16

Attachment C
Permeability Tests

MEG Technical Services (MTS)

(A Division of MEG Consulting Limited)

Form Nº MTS120

Client/Project:	GHD - Cobble Hill Holdings Landfill			Project No.:	17-MTS-028
Location:	South Shawnigan Lake Area, BC			Date:	November 6, 2017
Borehole:	Test Pit 3	Sample No.:	Secondary Clay Liner	Depth (m):	Top of Shelby

Constant Head Permeability Test (ASTM D5084-00)

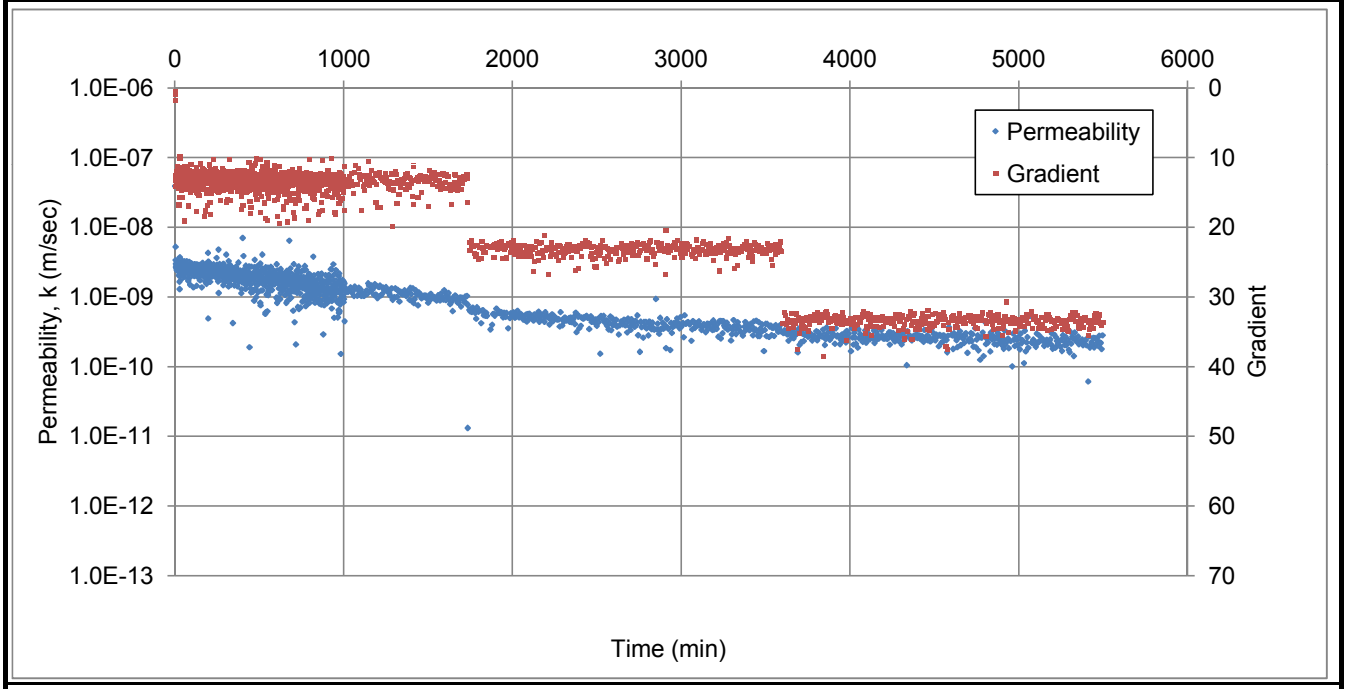
	1	2	3		
Diameter (mm):	73.60	73.48	72.98	Avgerage Diameter (mm):	73.35
Height (mm):	86.68	87.12	86.98	Avgerage Height (mm):	86.93
Weight Before Testing (g):		705.05		Volume (cm^3):	367.35
Area (cm^2):		42.26			
				Total Unit Weight (before test) (kN/m3):	18.83

Back Pressure Saturation Stage

Back Pressure (kPa):	552	Cell Pressure (kPa)	565
Temperature (°C):	22.0	Temperature Coefficient:	0.99957

Consolidation Stage

Back Pressure (kPa):	552	Cell Pressure (kPa)	652
Temperature (°C):	22.0	Effective Stress (kPa)	100



Comments: Permeability corrected to 20°C
Sample was consolidated to 100kPa prior to running permeability tests
Test scatter in the initial 1000 minutes is due to the number of readings taken. In the first 1000 minutes data is collected every minute. After that data is collected every 5 minutes

Performed by:	PC	Checked By:	PS	Approved By:	EP
Date:	November 6, 2017	Date:	November 6, 2017	Date:	November 6, 2017

MEG Technical Services (MTS)

(A Division of MEG Consulting Limited)

Form Nº MTS120

Client/Project:	GHD - Cobble Hill Holdings Landfill			Project No.:	17-MTS-028
Location:	South Shawnigan Lake Area, BC			Date:	November 6, 2017
Borehole:	Test Pit 3	Sample No.:	Secondary Clay Liner	Depth (m):	Bottom of Shelby

Constant Head Permeability Test (ASTM D5084-00)

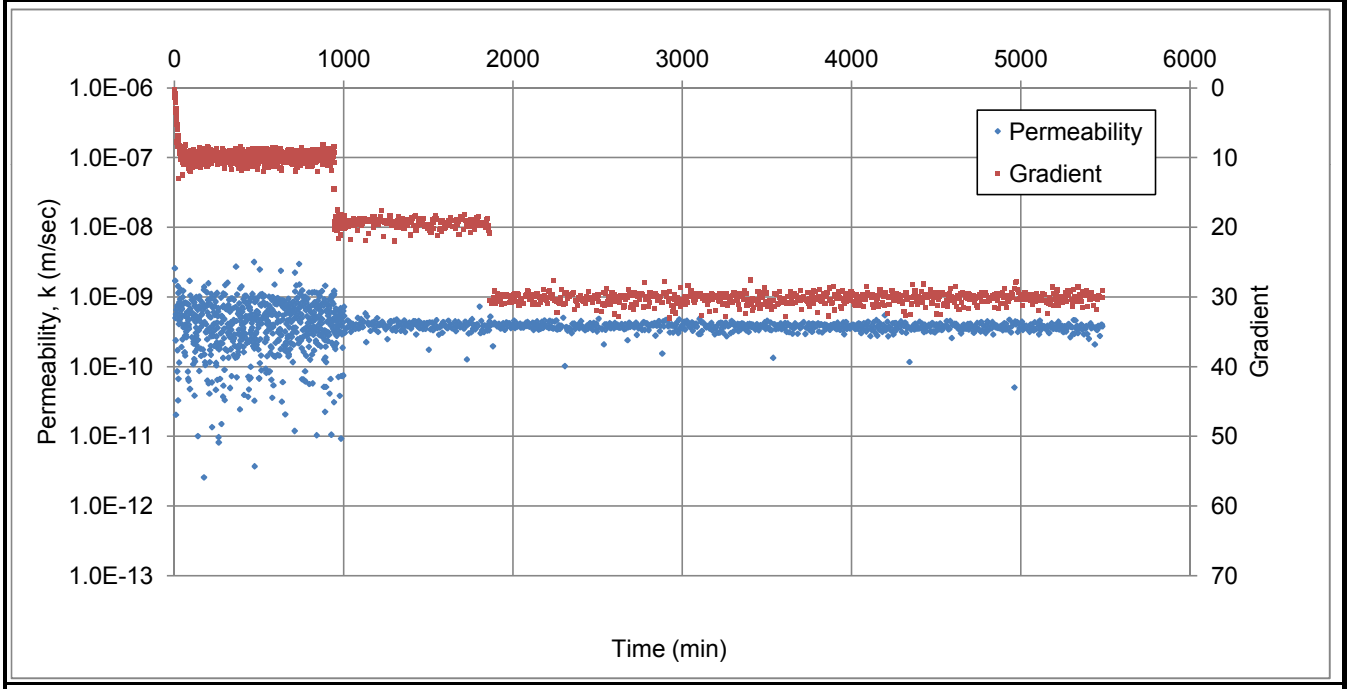
	1	2	3		
Diameter (mm):	73.08	73.85	73.95	Avgerage Diameter (mm):	73.63
Height (mm):	82.82	81.95	82.59	Avgerage Height (mm):	82.45
Weight Before Testing (g):		666.31		Volume (cm^3):	351.05
Area (cm^2):		42.58			
				Total Unit Weight (before test) (kN/m3):	18.62

Back Pressure Saturation Stage

Back Pressure (kPa):	552	Cell Pressure (kPa)	565
Temperature (°C):	22.0	Temperature Coefficient:	0.99957

Consolidation Stage

Back Pressure (kPa):	552	Cell Pressure (kPa)	652
Temperature (°C):	22.0	Effective Stress (kPa)	100



Comments: Permeability corrected to 20°C
Sample was consolidated to 100kPa prior to running permeability tests
Test scatter in the initial 1000 minutes is due to the number of readings taken. In the first 1000 minutes data is collected every minute. After that data is collected every 5 minutes

Performed by:	PC	Checked By:	PS	Approved By:	EP
Date:	November 6, 2017	Date:	November 6, 2017	Date:	November 6, 2017

Attachment D
Mineralogy Tests

Clay Speciation by X-Ray Diffraction

Report Prepared for:	*SGS Canada Inc*
Project Number/ LIMS No.	*16479-101/MI4504-OCT17*
Sample Receipt:	*October 13, 2017*
Sample Analysis:	*October 23, 2017*
Reporting Date:	*October 24, 2017*

Instrument:	BRUKER AXS D8 Advance Diffractometer
Test Conditions:	Co radiation, 40 kV, 35 mA Regular Scanning: Step: 0.02°, Step time:0.2s, 2θ range: 3-70° Clay Section Scanning: Step: 0.01°, Step time:0.2s, 2θ range: 3-40°
Interpretations :	PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva software.
Detection Limit :	0.5-2%. Strongly dependent on crystallinity.

Contents:

Kim Gibbs, H.B.Sc., P.Geo.
Senior Mineralogist

Huyun Zhou, Ph.D.
Senior Mineralogist

ACCREDITATION: SGS Minerals Services Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada - Minerals Services - Lakefield: http://palcan.scc.ca/SpecsSearch/GLSearchForm.do.

Method Summary

The Clay Speciation by XRD by XRD (ME-LR-MIN-MET-MN-D04) method used by SGS Minerals Services is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involve matching the diffraction pattern of a test sample material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) and released on software as a database of Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds. Mineral proportions are based on relative peak heights and may be strongly influenced by crystallinity, structural group or preferred orientations. Interpretations and relative proportions should be accompanied by supporting petrographic and geochemical data (Whole Rock Analysis, Inductively Coupled Plasma - Optical Emission Spectroscopy, etc.).

Clay Mineral Separation and Identification:

Clay minerals are typically fine-grained (<2 µm) phyllosilicates in sedimentary rock. Due to the poor crystallinity and fine size of clay minerals, separation of the clay fraction from bulk samples by centrifuge is required. A slide of the oriented clay fraction is prepared and scanned followed by a series of procedures (the addition of ethylene glycol and high temperature heating). Clay minerals are identified by their individual diffraction patterns and changes in their diffraction pattern after different treatments.

Bulk Sample Semi-Quantitative Analysis:

The Semi-Quantitative analysis (RIR method) is performed based on each mineral's relative peak heights and of their respective I/Icor values, which are available from the PDF database. Mineral abundances for the bulk sample (in weight %) are generated by Bruker-EVA Software. These data are reconciled with a bulk chemistry (e.g. whole rock analysis including SiO_2, Al_2O_3, Na_2O, K_2O, CaO, MgO, Fe_2O_3, Cr_2O_3, MnO, TiO_2, P_2O_5, V_2O_5 or other chemical data). A chemical balance table shows the difference between the assay results and elemental concentrations determined by XRD.

Summary of Semi-Quantitative X-ray Diffraction Results

Crystalline Mineral Assemblage (relative proportions based on peak height)

Sample	Major (>30% Wt)	Moderate (10% -30% Wt)	Minor (2% -10% Wt)	Trace (<2% Wt)
PIT #3-C				
Bulk collected from 0.35 m above the base of the clay layer	plagioclase	quartz, nontronite	potassium-feldspar, kaolinite, amphibole, chlorite, illite, pyroxene	*vermiculite, *rutile
Clay Fraction	smectite	chlorite, kaolinite	illite, vermiculite	-
PIT #3-E				
Bulk collected from 0.2 m above the base of the clay layer	plagioclase	quartz, nontronite	potassium-feldspar, kaolinite, amphibole, chlorite, illite, pyroxene	*vermiculite, *rutile
Clay Fraction	smectite	chlorite, kaolinite	illite	*vermiculite

** tentative identification due to low concentrations, diffraction line overlap or poor crystallinity*

brackets indicate non-clay minerals present in the clay fraction.

Note: The smectite clay group includes montmorillonite and nontronite.

Mineral	Composition
Amphibole	$(Na,K)Ca_2(Fe,Mg)_5(Al,Si)_8O_{22}(OH)_2$
Anorthite	$CaAl_2Si_2O_8$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Nontronite	$Fe_2(Al,Si)_4O_{10}(OH)_2Na_{0.3}(H_2O)_4$
Plagioclase	$(NaSi,CaAl)AlSi_2O_8$
Potassium-Feldspar	$KAlSi_3O_8$
Pyroxene	$(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$
Quartz	SiO_2
Rutile	TiO_2
Vermiculite	$(Mg,Al)_3(Si,Al)_4O_{10}(OH)_2*4H_2O$

Semi-Quantitative X-ray Diffraction Results

Mineral	PIT #3-C (wt %)	PIT #3-E (wt %)
Quartz	22.6	24.4
Albite	19.9	20.8
Nontronite	13.2	13.2
Anorthite	11.8	11.8
Orthoclase	7.9	6.6
Kaolinite	6.6	6.6
Actinolite	5.0	5.0
Clinochlore	4.7	4.7
Illite	3.4	3.4
Diopside	3.1	1.9
Vermiculite	0.8	0.8
Rutile	0.8	0.8
TOTAL	100	100
	collected from 0.35 m above the base of the clay layer	collected from 0.2 m above the base of the clay layer

Chemical Balance

PIT #3-C

Name	Assay[1]	SQD[2]	Delta	Status
Oxygen	44.6	49.3	-4.75	Both
Silicon	27.8	28.8	-1.05	Both
Aluminum	8.20	8.20	0.00	Both
Iron	4.98	4.91	0.07	Both
Calcium	2.52	2.69	-0.18	Both
Sodium	1.97	1.95	0.02	Both
Magnesium	1.72	1.84	-0.11	Both
Potassium	1.17	1.26	-0.09	Both
Titanium	0.49	0.51	-0.02	Both
Manganese	0.09	-	0.09	XRF
Phosphorus	0.07	-	0.07	XRF
Chromium	0.01	-	0.01	XRF
Vanadium	0.01	-	0.01	XRF
Hydrogen	-	0.48	0.48	SQD

PIT #3-E

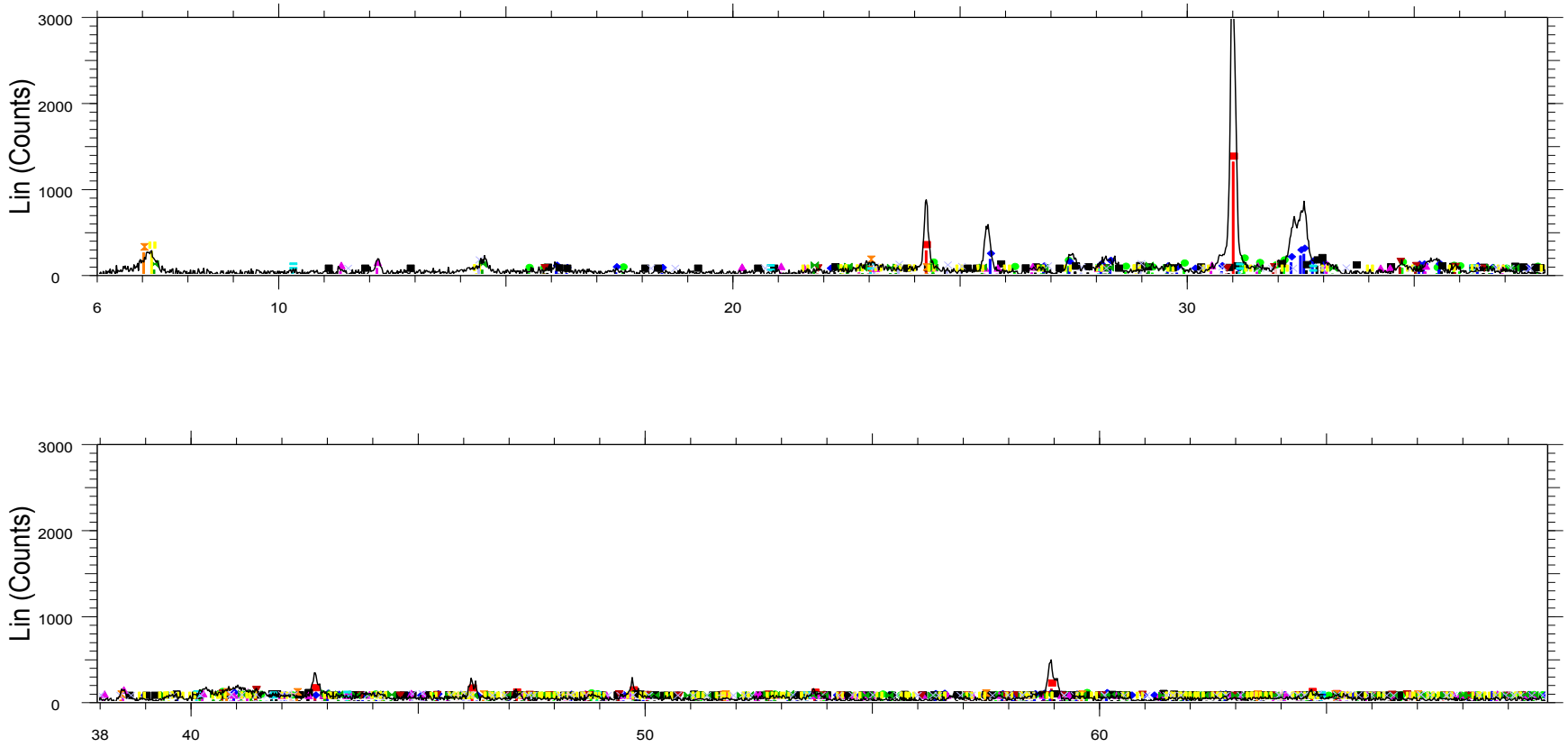
Name	Assay[1]	SQD[2]	Delta	Status
Oxygen	44.8	49.5	-4.77	Both
Silicon	28.1	29.2	-1.09	Both
Aluminum	8.10	8.14	-0.05	Both
Iron	4.76	4.76	0.01	Both
Calcium	2.46	2.49	-0.03	Both
Sodium	2.01	2.02	-0.01	Both
Magnesium	1.68	1.77	-0.09	Both
Potassium	1.15	1.08	0.07	Both
Titanium	0.47	0.50	-0.03	Both
Manganese	0.09	-	0.09	XRF
Phosphorus	0.07	-	0.07	XRF
Chromium	0.01	-	0.01	XRF
Vanadium	0.01	-	0.01	XRF
Hydrogen	-	0.48	0.48	SQD

1. Values measured by chemical assay.

2. Values calculated based on mineral/compound formulas and quantites identified by semi-quantitative XRD.

PIT #3-C

collected from 0.35 m above the base of the clay layer



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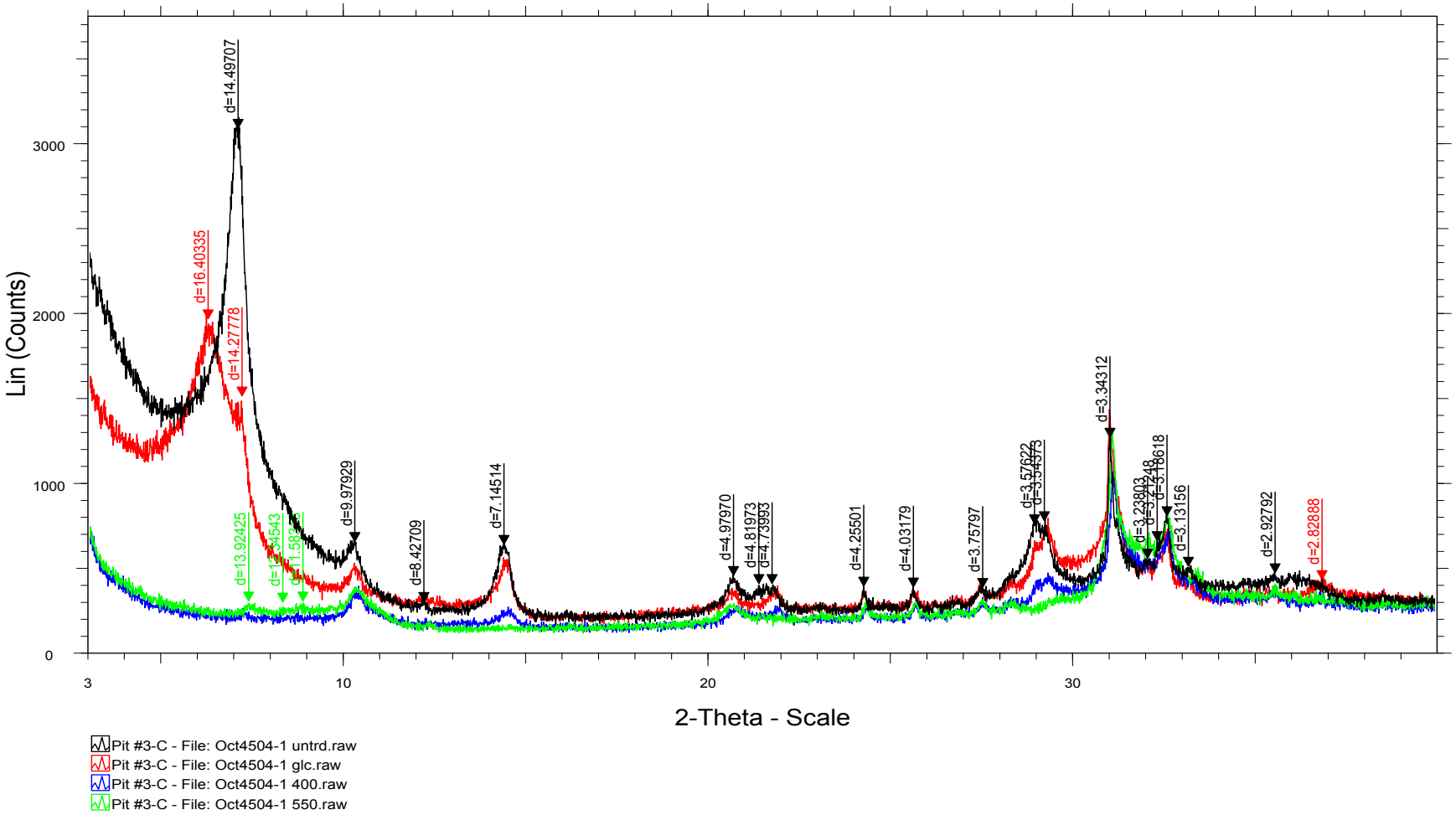
01-086-0439 (C) - Orthoclase - K(AlSi3O8)
01-084-0752 (C) - Albite low - Na(AlSi3O8)
01-086-1706 (C) - Anorthite - Ca(Al2Si2O8)
01-080-0521 (C) - Actinolite - Ca2(Mg,Fe)5Si8O22(OH)
01-087-0701 (C) - Diopside ferroan, syn - CaMg.52Fe.48(Si2O6)
00-002-0017 (D) - Nontronite - Na0.33Fe2.17(Si3.17Al0.83)O10(OH)2·4H2O
01-087-2496 (C) - Clinochlore (IIb-4) - Mg4.882Fe0.22Al1.881Si2.96O10(OH)8
00-009-0343 (D) - Illite, trioctahedral - K0.5(Al,Fe,Mg)3(Si,Al)4O10(OH)2
01-077-0022 (C) - Vermiculite - (Mg2.36Fe.48Al.16)(Al1.28Si2.72)O10(OH)2(H2O)6Mg.
01-080-0886 (C) - Kaolinite - Al2(Si2O5)(OH)4
01-087-0920 (C) - Rutile, syn - TiO2

Pit #3-C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2000
3000
3
10
20
30
2-Theta - Scale
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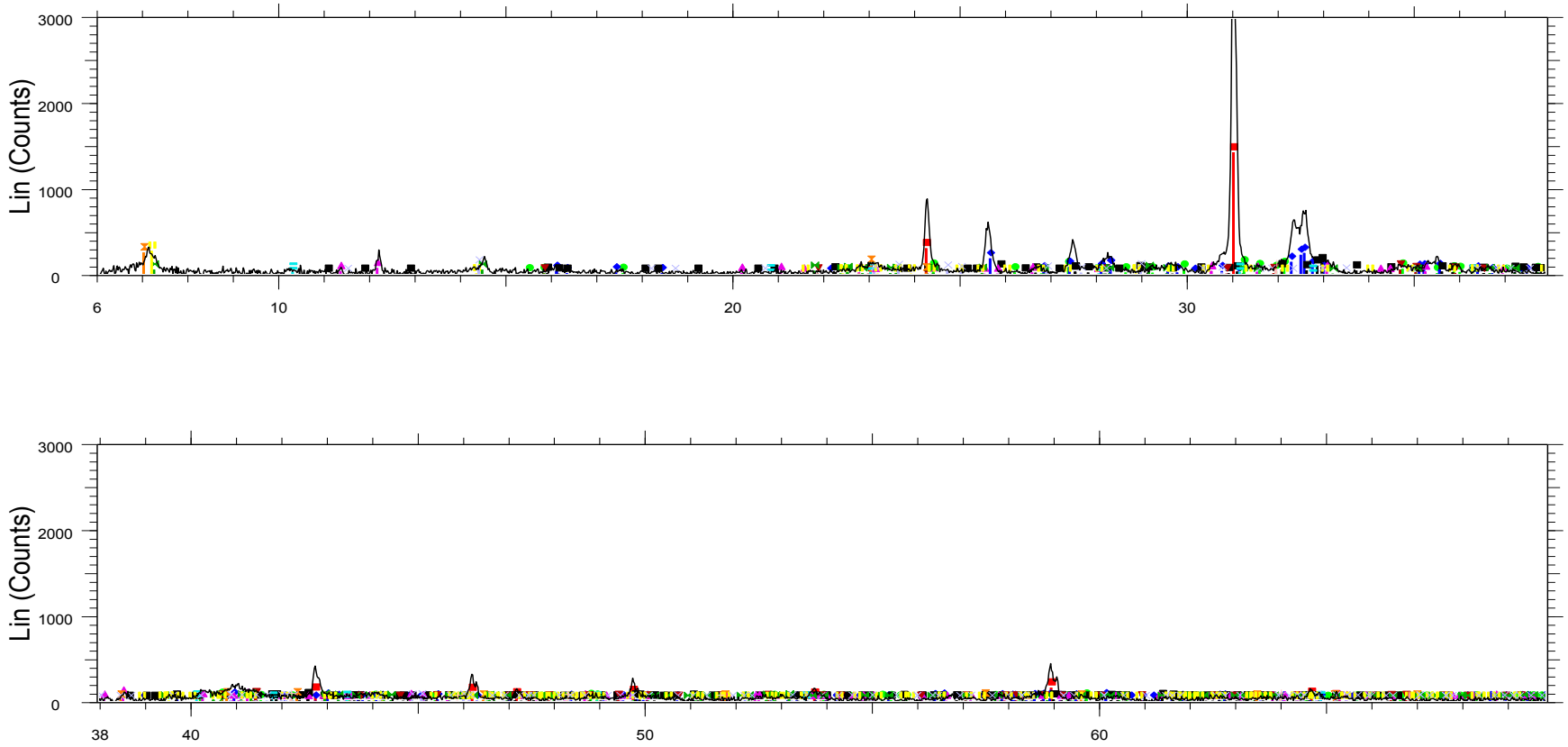
Pit #3-C - File: Oct4504-1 glc.raw
Pit #3-C - File: Oct4504-1 400.raw
Pit #3-C - File: Oct4504-1 550.raw

SGS Canada Inc
16479-101/MI4504-OCT17
24-Oct-17

PIT #3-E

collected from 0.2 m above the base of the clay layer



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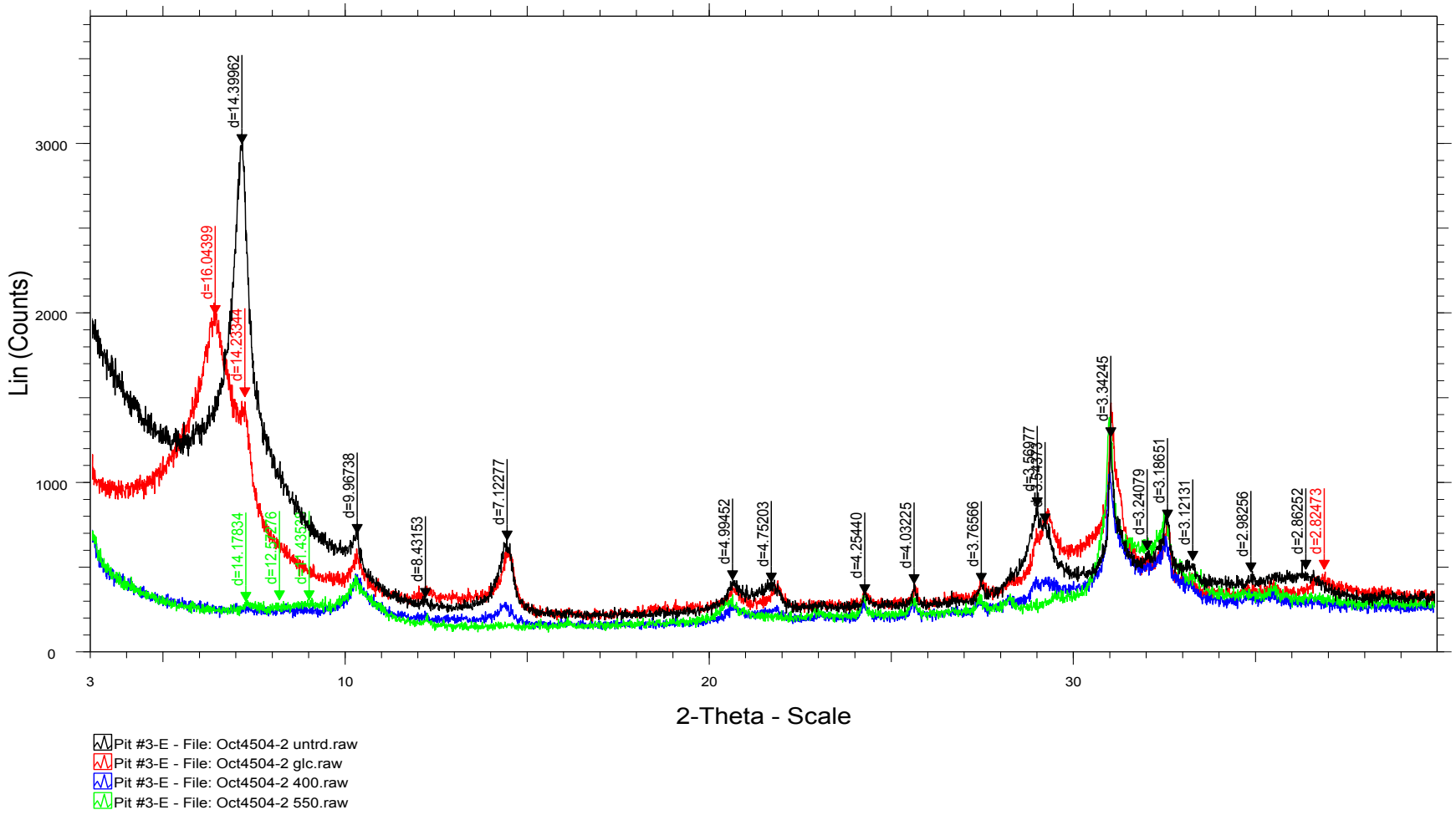
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1000
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3000
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10
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Pit #3-E - File: Oct4504-2 glc.raw
Pit #3-E - File: Oct4504-2 400.raw
Pit #3-E - File: Oct4504-2 550.raw

Attachment E
GPR Report

FRONTIER GEOSCIENCES INC.

GROUND PENETRATING RADAR SURVEY REPORT

COBBLE HILL HOLDINGS LANDFILL

SHAWNIGAN LAKE, BC

Submitted to:

GHD

November 2, 2017

Authors:

Cliff Candy, P.Geo.

Project: FGI-1516

237 St. Georges Ave.
North Vancouver, B.C.
V7L 4T4

604 987 3037

Table of Contents

Illustrations

1. Introduction

On September 26, 2017, Frontier Geosciences Inc. carried out a Ground Penetrating Radar (GPR) investigation for GHD at the Cobble Hill Holdings Landfill near Shawnigan Lake, B.C. A Survey Location Plan of the area is shown at a scale of 1:75,000 in Figure 1.

The purpose of the geophysical survey was to determine the integrity of the clay/geo-membrane basal liner beneath the landfill soils in Cell 1. As the task is near the limits of the capability of the GPR method, discussion of limitations was carried out prior to survey mobilisation, including geophysical expert input from GHD. It was decided that a range of GPR antennae would maximise the value of the survey. As a result, 400, 200, and 100 MHz antennae were mobilised.

Prior to the survey mobilisation, the lock-blocks near the leachate collection storage tank were removed, exposing the clay liner at the toe of the central north side of the facility. The initial plan was to carry out an orientation survey in this location to determine the clay liner response, and to monitor the transition from the toe area with no soils cover, onto the plastic membrane covered landfill slope. If the test showed that detection of the base of the clay liner though the soils could be achieved, at least in the thinner materials at the margins of the landfill, the full survey program would be commissioned. However, on the day of field operations, it was determined that the risk of puncturing the cover with the GPR system and crew operations was too high. As a result, no data over the landfill soils was collected.

In addition to the removal of the lock-blocks, the north side margin berm was removed. This provided the opportunity to conduct the GPR survey over the clay liner on the north side of the landfill, on lines outside the plastic cover. In addition, lines were run around the southwest and southeast perimeter of Cell 1, where access conditions permitted. A total of 240 metres of GPR data was collected over four profiles. A Site Plan showing the line locations is presented at a scale of 1:500 in Figure 2 in the Appendix.

GPR Survey, north side of landfill

2. The Ground Penetrating Radar (GPR) Survey

2.1 Principles

Ground penetrating radar entails transmitting an electrical pulse into the subsurface by discharging electromagnetic energy from a transducer antenna. The transmitted pulse travels through the subsurface until it reaches a subsurface interface or embedded object. Depending on the electrical characteristics of the interface, a portion of the transmitted pulse is reflected back to the surface where it is detected by the receiver section of the antenna. Depth of penetration is dependent upon the electrical properties of the soil and the antenna used.

2.2 Survey Equipment

The survey was carried out using a Geophysical Survey Systems Inc., SIR 3000 system, combined with three antennae operating at frequencies of 100 MHz, 200 MHz and 400 MHz. The antenna is located in a housing which is designed to slide over the ground surface without damage to the transducer. The system is operated by a portable control unit that allows visual field inspection of recorded data for field quality assessment.

2.3 Survey Procedure and Positioning

The system consists of a combined transmitter and receiver antenna that was moved along the traverses at a constant speed. When surveying, line distances were noted against known survey points in the field. Care was taken to ensure the radar antenna traversed the ground surface as smoothly as possible to ensure good coupling between the radar antenna and the ground surface. Field data were inspected for clarity and completeness before proceeding to the next survey line.

2.4 Data Post-processing Procedure

Positioning was determined by notes, geological and local features and GPS measurements obtained in the field. The GPR profiles were exported as a post-processed amplitude section with a vertical time scale and a horizontal trace scale. Converting the vertical axis to depth measurement took into account the two way time of the radar path and the expected velocity of the signals through the ground subsurface. A velocity of 25 nanoseconds per metre was used for the depth conversion. The data was bandpass filtered and an automatic gain control was applied to produce the final sections. These sections are presented in colour amplitude format.

3. Geophysical Results

The survey at the edge of the landfill was carried out to profile the margins of the clay liner. It was determined that the 400 MHz antenna provided the best combination of depth penetration and resolution for this purpose. The four GPR profiles are presented at a scale of 1:100 horizontal and 1:20 vertical, in Figures 3 to 8, in the Appendix.

GPR traverses Lines 1 and 2 are located at the toe of Cell 1, on the north side, and are shown in Figures 3 and 4, respectively. These lines show a complex of reflectors at approximately 1 metre depth that likely represents the base of the placed clay. The absence of a defined shallower reflector suggests that this layer extends to near surface, consistent with the observed presence of clays at surface. Lines 3 is located on the southeast side of Cell 1, and is shown in Figure 4. Similar to the north side lines, this traverse shows a return at a depth of approximately 1 metre. Irregularities in the subsurface boundaries result in responses that vary between a relatively horizontal ringing reflector response, and the more complex reflector package. A dashed black line shows the location of the interpreted base of the clay on these profiles.

Line 4, shown on Figures 6, 7 and 8, was located on the southwest side of the landfill. In this location, the line is reported to be beyond the extent of the clay liner. This line shows a more diffuse response with scattering diffractors present. This is consistent with the likelihood that the berm materials contain rip-rap similar to the materials exposed in the ditch.

GPR Line 4, looking south

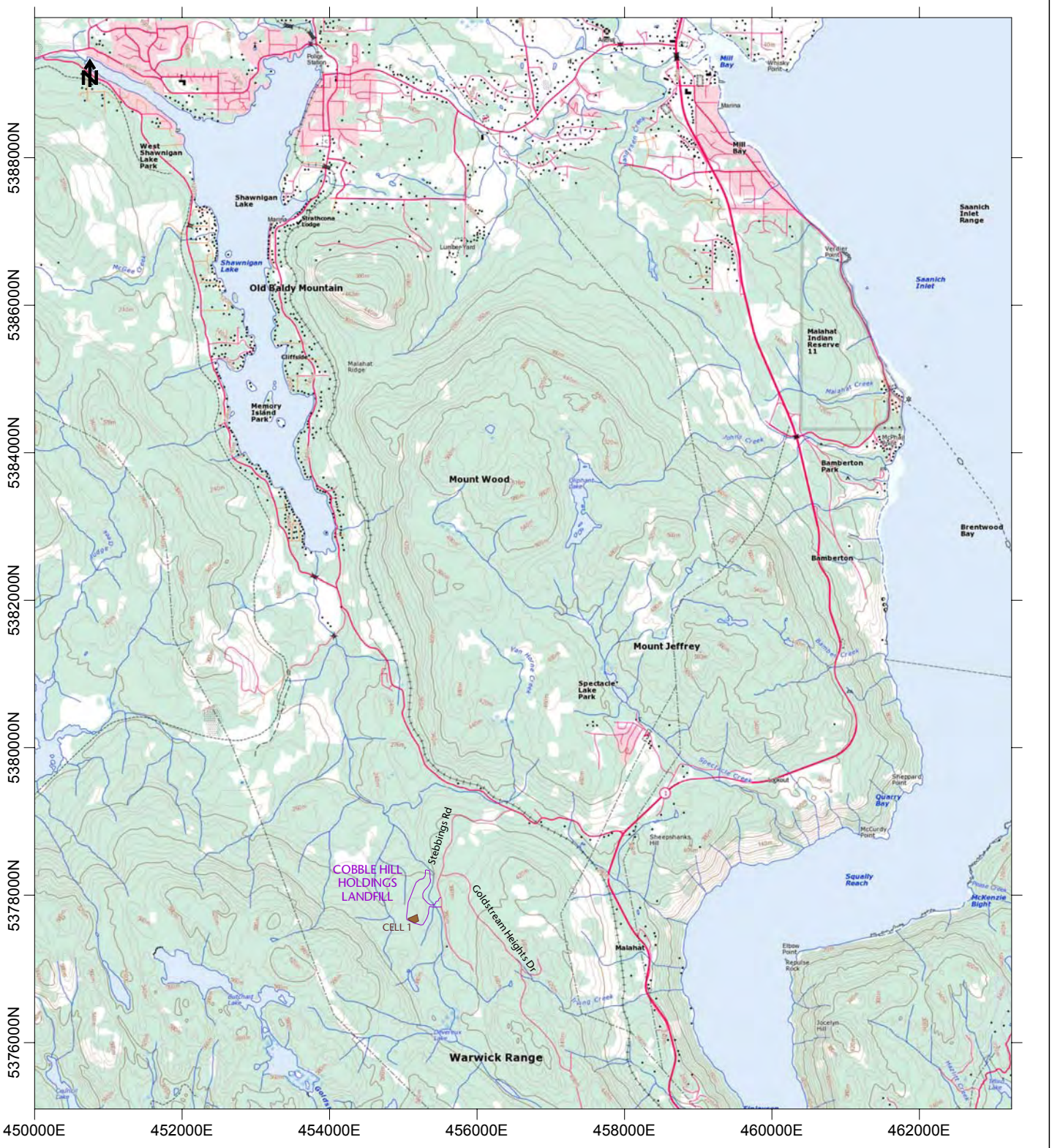
4. Limitations

The ground penetrating radar method provides an estimate of subsurface conditions only at the locations where lines were traversed and only to the depths penetrated, and within the accuracy of the method. These data are indirect and the interpreted features subjective in nature, with identified anomalies based on a visual assessment of the characteristic signatures in the data. In some cases, the presence of a very steeply dipping surface, weathering, and other geologic effects, may result in incorrect extension of an interpreted horizon from one location to another.

The information in this report is based upon geophysical measurements and field procedures and our interpretation of the data. The results are interpretive in nature and are considered to be a reasonably accurate representation of existing subsurface conditions within the limitations of the ground penetrating radar method.

For: Frontier Geosciences Inc.

Cliff Candy, P.Geo.



NATIONAL RESOURCES CANADA
TOPORAMA MAPSHEET 92B12

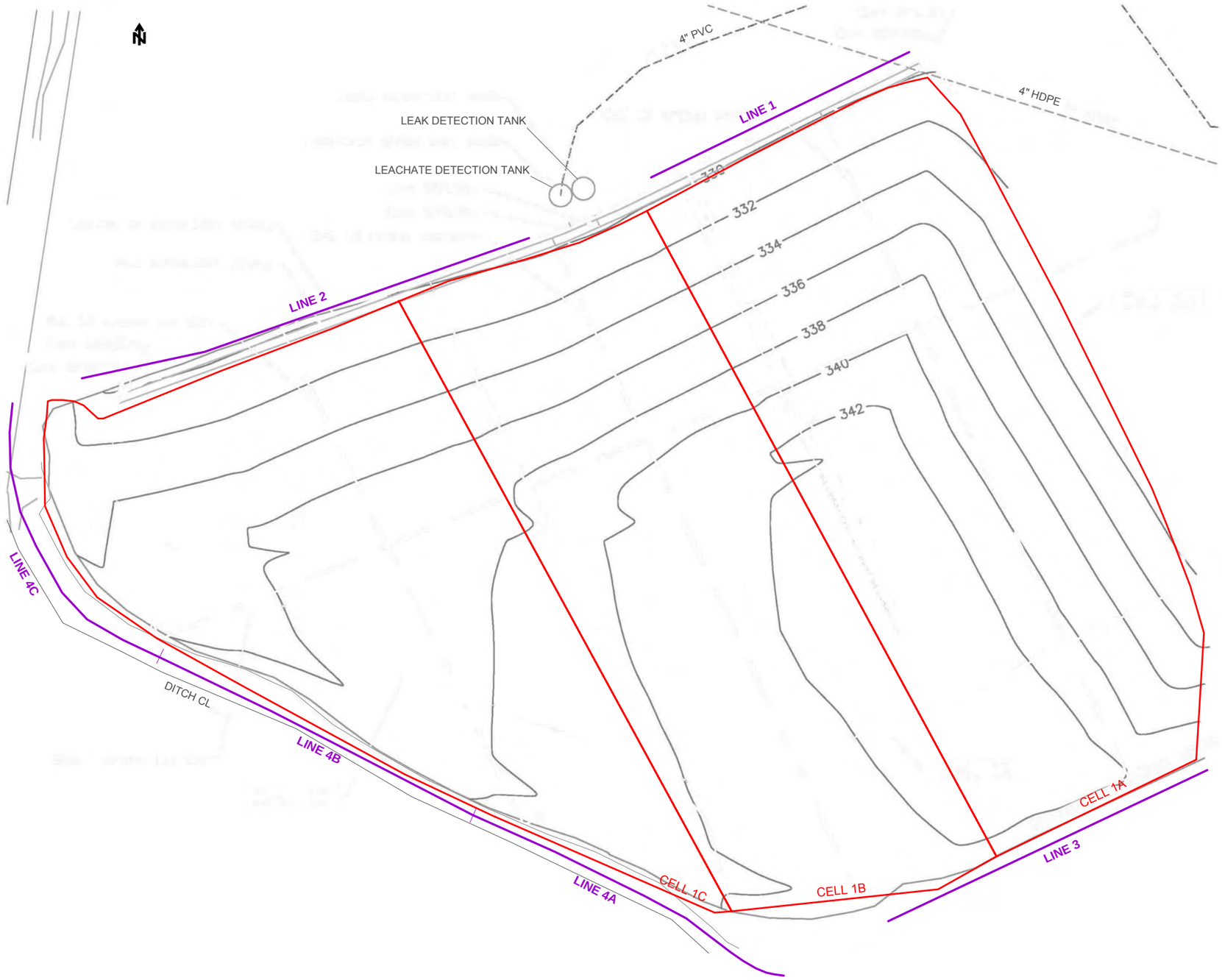
GHD
COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

SURVEY LOCATION PLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	SCALE 1:75,000	FIG. 1



0 5 10 15 20

METRES

GHD

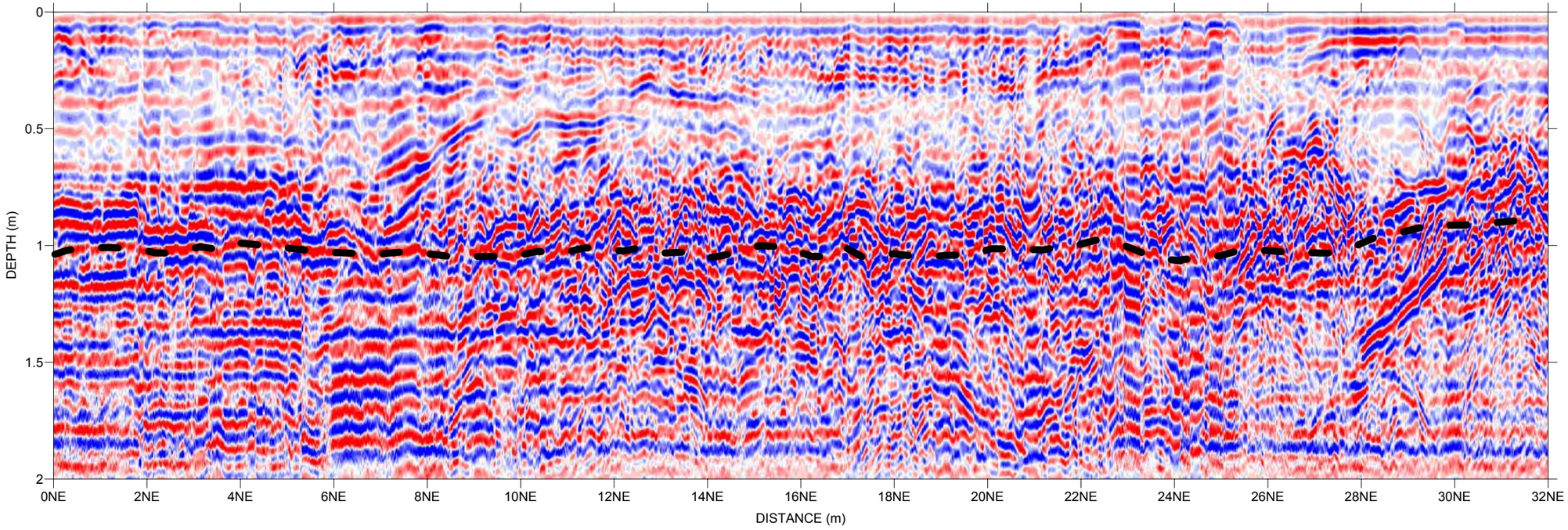
COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

SITEPLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	SCALE 1:500	FIG. 2



INTERPRETED BASE OF CLAY

0 1 2 3 4

METRES

GHD

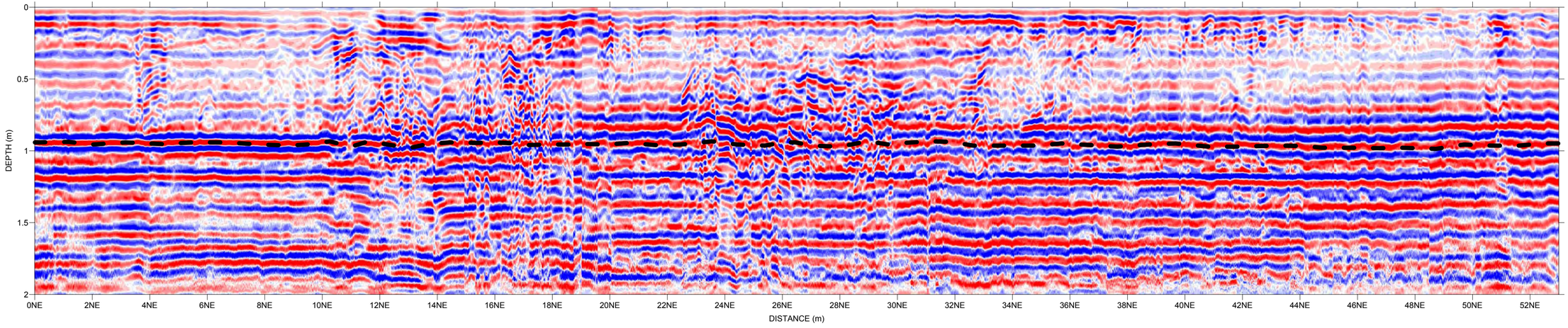
COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

LINE 1

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 3

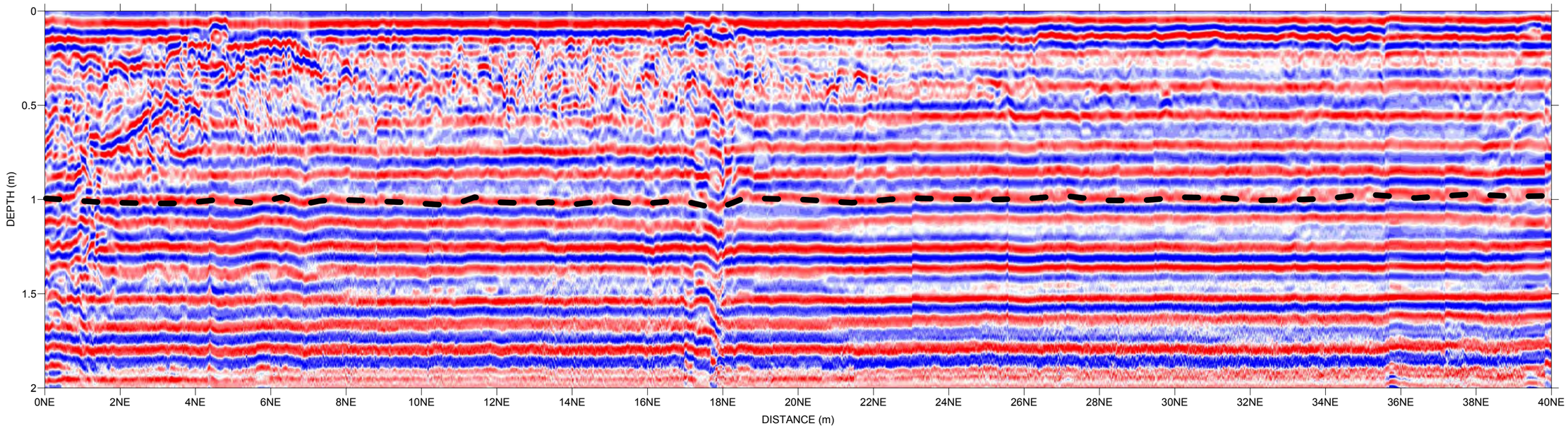


INTERPRETED BASE OF CLAY

0 1 2 3 4

METRES

GHD COBBLE HILL HOLDINGS LANDFILL		
GROUND PENETRATING RADAR SURVEY		
LINE 2		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 4



INTERPRETED BASE OF CLAY

0 1 2 3 4

METRES

GHD

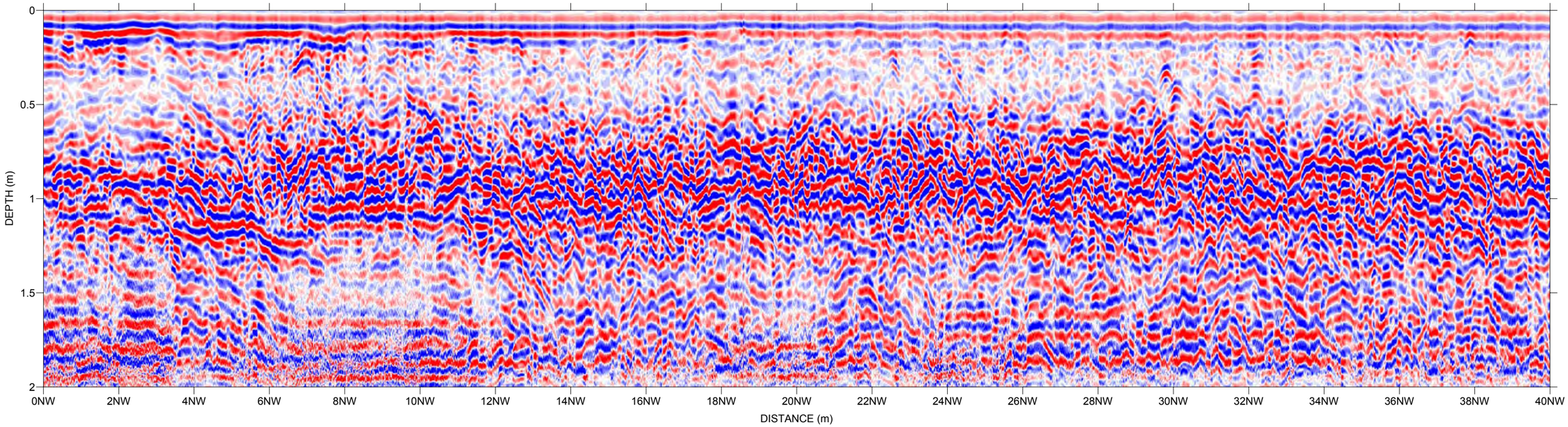
COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

LINE 3

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 5



GHD

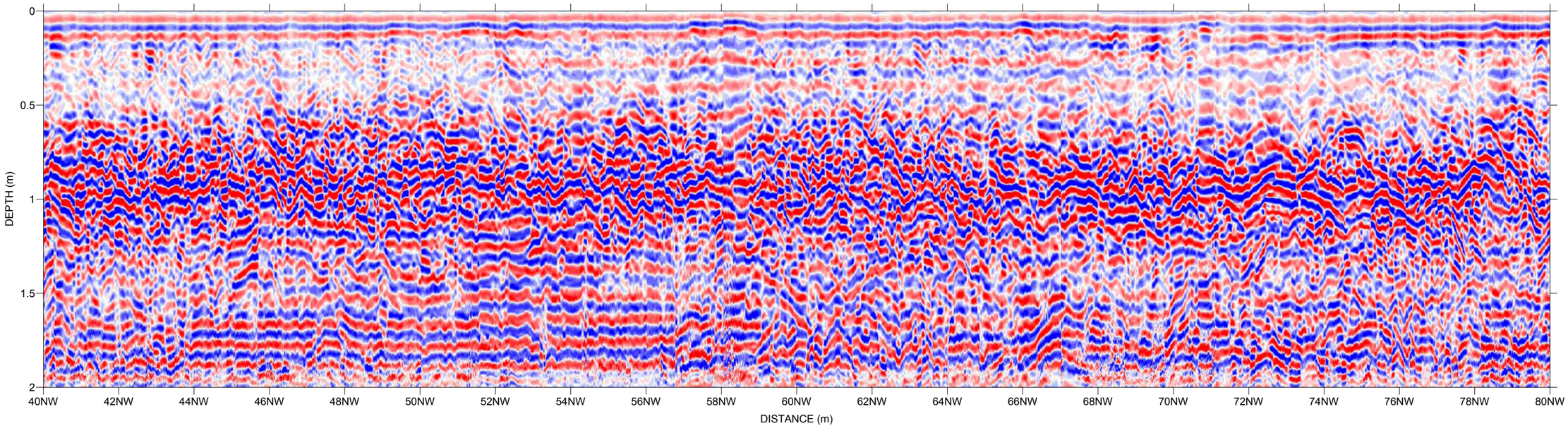
COBBLE HILL HOLDINGS LANDFILL

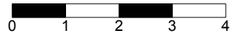
GROUND PENETRATING RADAR SURVEY

LINE 4A

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 6





METRES

GHD

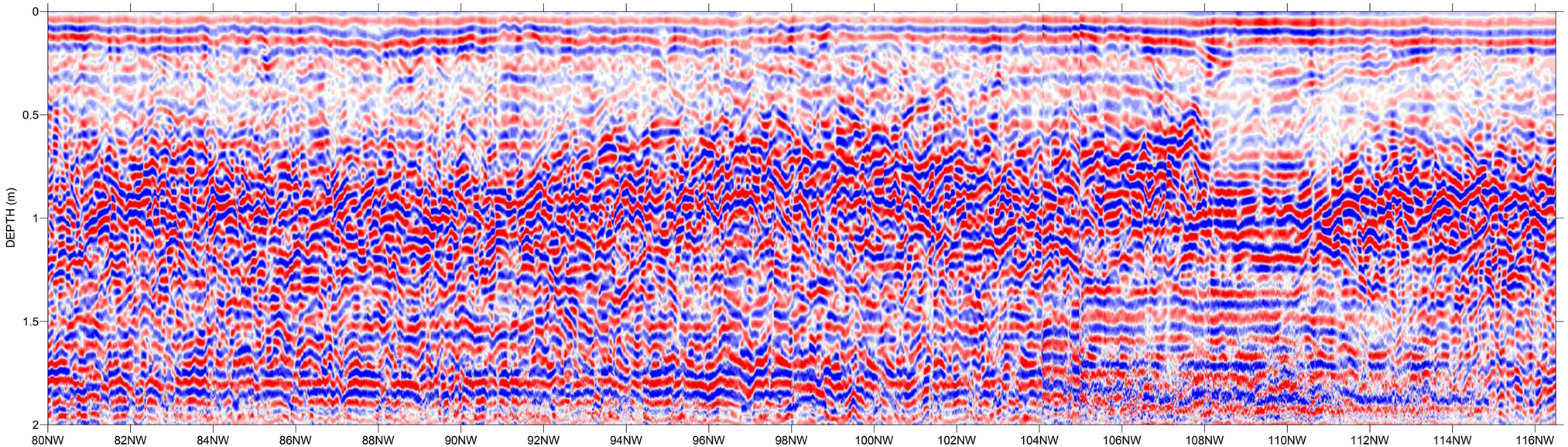
COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

LINE 4B

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 7



GHD

COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

LINE 4C

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 8

Attachment F
GPR Report Markup by GHD

APPROXIMATE LOCATIONS OF TEST PITS (ADDED BY GHD) BASED ON SPERLING HANSEN'S AS-BUILT PLAN VIEW FIGURE 1 - REFER TO ATTACHMENT A OF GHD'S LETTER

N

4" PVC

4" HDPE

LEAK DETECTION TANK

LEACHATE DETECTION TANK

TP-1

TP-2

TP-3

TP-4

LINE 1

LINE 2

LINE 3

LINE 4A

LINE 4B

LINE 4C

330

332

334

336

338

340

342

DITCH CL

CELL 1A

CELL 1B

CELL 1C

0 5 10 15 20

METRES

GHD

COBBLE HILL HOLDINGS LANDFILL

GROUND PENETRATING RADAR SURVEY

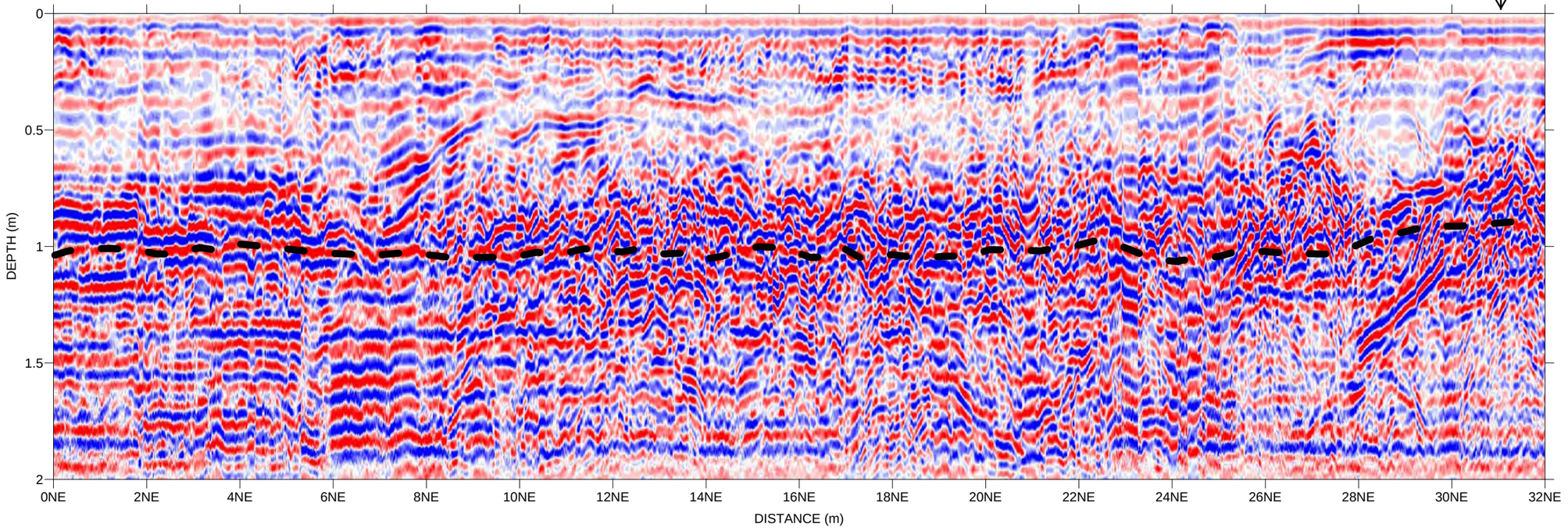
SITEPLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2017	SCALE 1:500	FIG. 2

APPROXIMATE LOCATION OF TEST PIT (ADDED BY GHD) BASED ON SPERLING HANSEN'S AS-BUILT PLAN VIEW FIGURE 1 - REFER TO ATTACHMENT A OF GHD'S LETTER

APPROXIMATE LOCATION OF TP-1

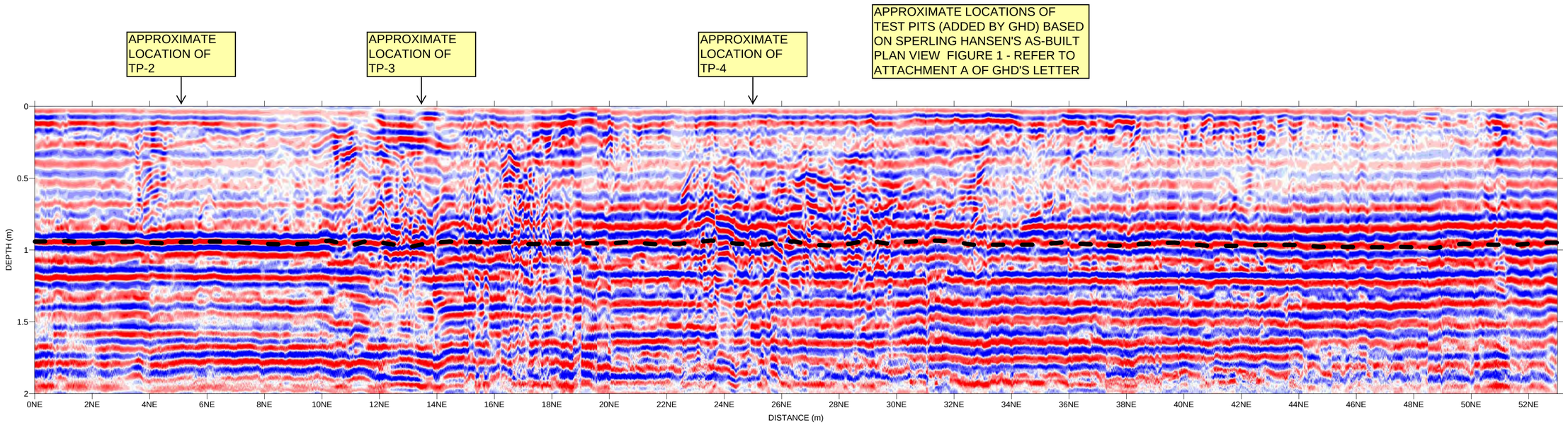


INTERPRETED BASE OF CLAY

0 1 2 3 4

METRES

GHD COBBLE HILL HOLDINGS LANDFILL		
GROUND PENETRATING RADAR SURVEY		
LINE 1		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 3



GHD COBBLE HILL HOLDINGS LANDFILL		
GROUND PENETRATING RADAR SURVEY		
LINE 2		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2017	HSCALE 1:100 VSCALE 1:20	FIG. 4