APPENDIX E:

Craig HydroGeoLogic Report

CRAIG HYDROGEOLOGIC INC.

Groundwater and Soil Contamination
Groundwater Protection
Resource Development
Site Remediation
Site Professional

Grand Lake Timber, Limited
Proposed Wood Waste and Ash Disposal Site
Groundwater Assessment
Kings Mines N.B.

Submitted To: **Roy Consultants**
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Fredericton, NB
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Prepared by: **Craig HydroGeoLogic Inc.**
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Date: February 21, 2017

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Grand Lake Timber, Limited
Proposed Wood Waste and Ash
Disposal Site
Groundwater Assessment
Kings Mines N.B.

1.0 INTRODUCTION

Roy Consultants, acting on behalf of Grand Lake Timber, Limited, retained Craig Hydrogeologic Inc. to perform a groundwater assessment and evaluation of the proposed wood waste and ash disposal site located in Kings Mines, NB (PID 45073913). The groundwater assessment is part of an EIA necessary to obtain regulatory approval for a new wood waste and ash site to replace an existing site that is approaching capacity.

This report presents the results of the groundwater assessment and conclusions and recommendations based on the results of that groundwater assessment.

This report was prepared by Craig HydroGeoLogic Inc. for the clients, Roy Consultants Ltd. and Grand Lake Timber, Limited and the report presents the results of a groundwater assessment, conclusions and recommendations as described in this report.

The report is based on the application of scientific principles and professional judgment to certain facts with resultant subjective interpretations. For example, but not limited to, interpolation between boreholes is an accepted industry practice, however, actual subsurface conditions may vary from that interpolated and such variation could impact observations, discussions, conclusions and recommendations in the report. Professional judgments expressed herein are based on the facts currently available within the existing data, scope of work, budget and schedule. The material and information in the report reflects Craig HydroGeoLogic Inc.'s best judgment in light of the information available at the time of report preparation. Any use which a third party makes of this report, or any reliance on or decision(s) to be made based on this report are the responsibility of the third party(ies). Craig HydroGeoLogic Inc. accepts no responsibility for damages, if any, suffered by any third party because of decisions made or actions taken based on this report.

2.0 SCOPE

The scope of the assessment is as follows:

1. To conduct a groundwater assessment of the proposed wood waste site, and;
2. based on the results of that information, perform a risk assessment of potential groundwater impacts on potential human and environmental receptors, and;
3. consider the need for a liner at the site, and,
4. produce a report with the findings of the groundwater risk assessment and recommendations based on those findings.

3.0 SITE DESCRIPTION

General

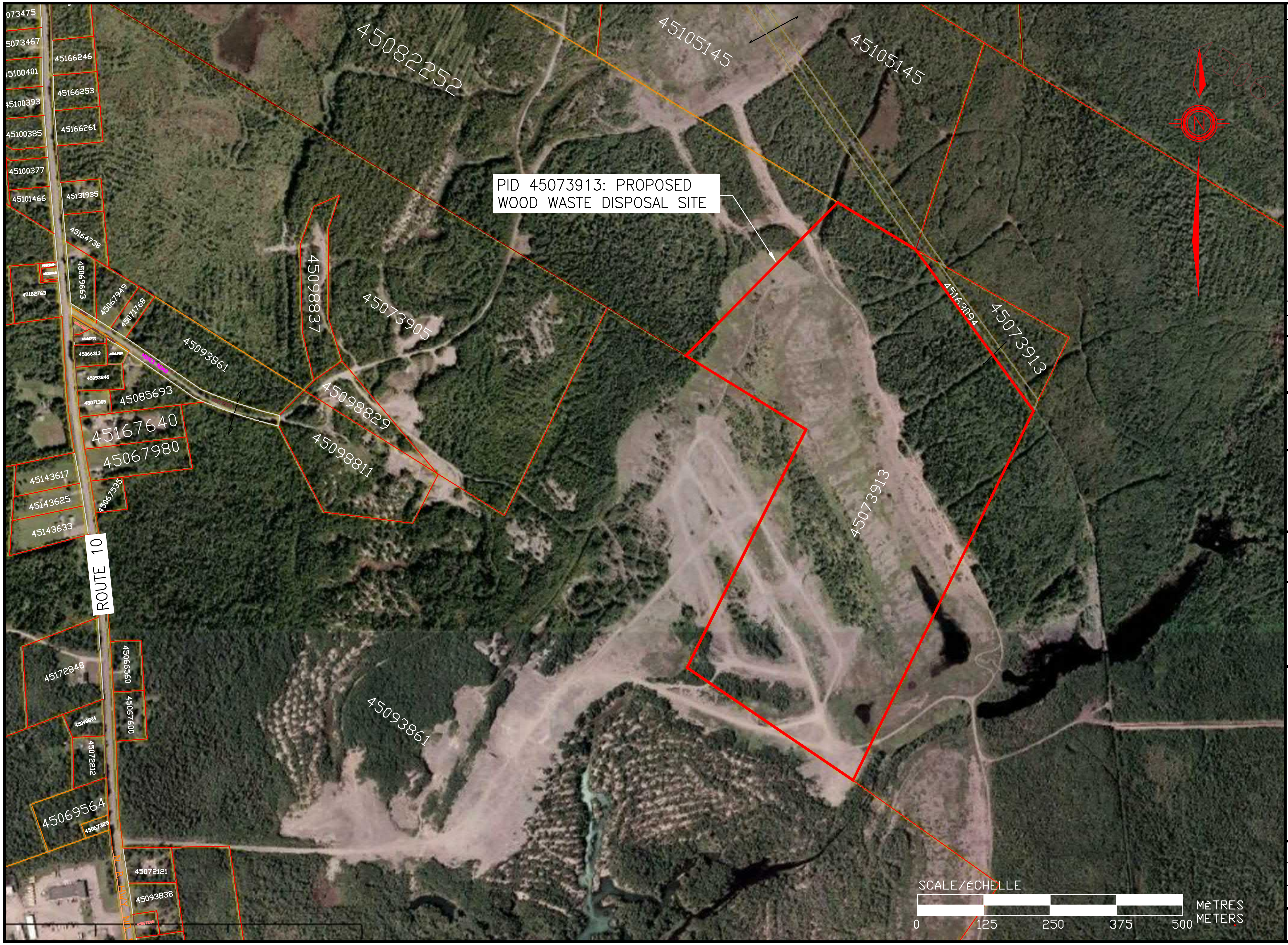
The site is located on former surface strip mined land south of Chipman, NB, in Kings Mines, NB (PID 45073913) (Figure 1). The historical coal mining operations have left the ground as a series of sub-parallel, sinuous ridges and valleys. Local surface and ground water drainage is modified and obscured by the old mine cuts. Surface waters are present as a series of unconnected ponds contained within the low areas and as defined streams. Ground water flow is difficult to predict with any degree of assurance if based only on topography. It is expected that groundwater will preferentially flow through the mine spoils, as they generally have higher hydraulic conductivities than the undisturbed bedrock in this area.

Topography, and Surface Drainage

The proposed disposal site is a linear depression trending downwards in a south – southeast direction from the northern boundary. The groundwater table outcrops south of the proposed site

Drawing Number 316–16–L1 Numero du Plan

Plot date Date du tracage



NOTES

Drawing status Etat de dessin

Client Client

J.D. IRVING, LIMITED

Project Projet

GRAND LAKE TIMBER
WOOD WASTE SITE

CHIPMAN, NB

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Drawing Title Titre du Plan

FIGURE 1:
SITUATION PLAN

Design by: Design par:	Drawn by: Dessine par: A. LEE
Checked by: Verifie par:	Date: JANUARY 10, 2017
Scale: Echelle: AS SHOWN	Sheet: Feuille: 1 of/de 1
Drawing Number: Numero du Plan: 316–16–L1	Rev. 0

as a linear pond which drains into Wilson Brook to the south. There is no obvious surface drainage in or over the proposed disposal site itself as all surface water is assumed to infiltrate into the mine spoils.

Area Geology

The undisturbed surficial overburden at the site is red clay till of variable thickness. In some areas, this is overlain by a relatively thin veneer of sand. Based on local private well logs, the overburden in the area ranges in thickness from 1.2 to approximately 4.3 meters (4 to 14 feet)**.**

The bedrock in the area is mapped as Pennsylvanian sandstone and shale which forms the local aquifer. Seams of coal are present in the area. The bedrock is known to be relatively transmissive (readily conducts the flow of ground water). The bedrock units or layers tend to be lenticular (i.e. of variable lateral extent and thickness) and are thought to have formed because of sedimentary particles deposited from flowing water (alluvial deposition). The sediments were deposited by meandering river systems, the river channel deposits being, in general, characterized by sands and gravels and the floodplain deposits being fine grained silts or clays. Many of the stratigraphic sub-units are of limited horizontal extent. It is not possible to extrapolate continuous sedimentary beds or layers over distances greater than 10 to 100 meters, except in general terms. The beds dip gently eastward. This mechanism of deposition has apparently resulted in locally (10 to 100 meters) variable well yields; however, over larger scales (1000 meters) the bedrock aquifer is quite uniform.

It is known that local groundwater quality may be compromised by the presence of coal seams, with relatively high concentrations of iron/or manganese being common in the area.

Area Hydrogeology

Private Water Supplies: Private wells are developed in the bedrock aquifer along Route 10 (Figure 1). The closest private well to the site is located at approximately 1,500 meters from the proposed wood waste disposal site. A search of the New Brunswick Department of Environment and Local Government (NBDELG) well log database for a 1,500 meter radius around the proposed development (PID 45073913) yielded a total of eight well logs. A summary of the information contained in the well logs is provided in Table 1, which follows. Copies of the well logs are provided in Appendix 1, at the back of this report.

Table 1: Summary of hydrogeologic information derived from search of NBDELG well log database (1500 meter search radius).

Bedrock Aquifer			
Well Depth (feet)	**Estimated Yield (igpm)**	**Depth to Bedrock (feet)**	**Casing Length (feet)**
Average: 97.6	**Average: 9.8**	**Average: 8.0**	**Average: 21.3**
Median: 64	**Median: 7**	**Median: 7.5**	**Median: 20**
Minimum: 40	**Minimum: 3**	**Minimum: 40**	**Minimum: 20**
Maximum: 285	**Maximum: 20**	**Maximum: 14**	**Maximum: 30**

As can be seen from the above information and the private well logs provided in Appendix 1, the eight private well logs found in the database for this general area have depths ranging from 40 to 285 feet with an average depth of 97.6 feet. The estimated safe yields range from 3 to 20 igpm with an average of 9.8 igpm. The minimum yield observed was 3.0 igpm in a 145-foot-deep well and the maximum yield observed was 20 igpm in a 65 feet deep well. The average well yield in the area is 9.8 igpm. All the private well logs for this area show that it is the undisturbed bedrock that forms the local water supply aquifer.

A search of the NBDELG well chemistry database for wells located within a 1,500 meter radius of the proposed wood waste disposal site provided results from a total of five wells for which groundwater inorganic chemistry was available. The precise locations of the wells from which the ground water chemistry was obtained are not available due to right to privacy considerations. The analytical results for the samples are provided in Table 2, which follows. In Table 2 any result that exceeds the Canadian Drinking Water Quality Guidelines (CDWQG) is bolded and shaded for ease of recognition. The water samples for the groundwater chemistry data in Table 2 were collected and analyzed using the water analysis certificate provided by the well driller when the well is new. The water samples are usually collected by the homeowner shortly thereafter in order to provide confidence that they can use the water. As a result the well from which the water sample was collected typically has not had enough time or use for the water to clear sufficiently prior to the water sample being collected. The result of this is that the chemistry data in Table 2 may overestimate the long term turbidity and some trace metal concentrations as most wells will clear naturally with use and time. Elevations in concentrations were observed for arsenic, chloride, iron, manganese, pH, turbidity and TDS (total Dissolved Solids).

Out of the five well chemistry records, two wells exceeded the CDWQG for arsenic of 10 μg/L. The presence of elevated concentrations of arsenic in some waters from this aquifer is due to natural conditions.

Out of the five chemistry records available, two wells exceeded the CDWQG for chloride. The same wells also exceeded the CDWQG for TDS, possibly indicating relict seawater. In light of no information as to the potential source of this material, it is assumed that the elevated concentrations are of natural origin.

Out of the five records a total of two exceed the CDWQG for Iron and two exceed the CDWQG for manganese. The standard for both iron and manganese is based on esthetic considerations, not health. The presence of Iron and/or Manganese in the groundwater from this aquifer is not uncommon and is the result of natural conditions.

Table 2

CDWQG = Canadian Drinking Water Quality Guideline

NB DELG Groundwater Chemistry Database

Parameter	ALK_T (mg/L)	Al (mg/L)	As (µg/L)	B (mg/L)	Ba (mg/L)	Br (mg/L)	COND (µSIE/cm)	Ca (mg/L)	Cd (µg/L)
	101	0.025	1.5	0.01	0.477	0.1	1250	117	0.5
	105	0.025	1.5	0.01	0.422	0.1	1280	115	0.5
	152	0.33	**49**	0.04	0.112	0.1	870	7.91	0.5
	114	0.25	**25**	0.048	0.116	0.1	318	8.78	0.5
	54.6	0.025	2.78	0.01	0.046	0.1	639	98	0.5
Mean	**105.3**	**0.131**	**16.0**	**0.024**	**0.235**	**0.1**	**871**	**69.3**	**0.5**
CDWQG			**<10**	**<5.0**	**<1.0**				**<5.0**

Parameter	Cl (mg/L)	Cr (µg/L)	Cu (µg/L)	E_coli P/A (P/A)	F (mg/L)	Fe (mg/L)	HARD (mg/L)	K (mg/L)	Mg (mg/L)
	376	10	10	Ab	0.111	0.016	326	1.04	8.26
				Ab					
	296	16	10	Ab	0.15	0.034	321	1	8.3
	182	20	10	Ab	0.1	**0.315**	21.5	0.7	0.41
	27.9	11	10	Ab	1.08	0.193	23.7	0.6	0.44
	40.4	10	25	Ab	0.132	**3.96**	280.2	1.07	8.61
Mean	**184.5**	**13**	**13**		**0.31**	**0.904**	**194.5**	**0.88**	**5.20**
CDWQG	**<250**	**<50**	**<1000**		**<1.5**	**<0.3**		.	

Table 2

CDWQG = Canadian Drinking Water Quality Guideline

NB DELG Groundwater Chemistry Database

Parameter	Mn (mg/L)	NO2 (mg/L)	NO3 (mg/L)	NOX (mg/L)	Na (mg/L)	PH (pH)	Pb (µg/L)	SO4 (mg/L)	Sb (µg/L)
	0.035	0.05	0.05	0.05	98	7.64	1.5	15.3	1
	0.21	0.05	0.05	0.05	107	7.54	1	14.4	1
	0.01	0.05	0.05	0.06	178	**8.79**	3.3	15	2.8
	0.012	0.05	0.05	0.05	58.3	**8.68**	1.4	8.7	1.7
	3.61	0.05	0.05	0.05	16.6	6.91	1	193	1
Mean	**0.775**	**0.05**	**0.05**	**0.05**	**91.58**	**7.91**	**1.6**	**49.28**	**1.50**
CDWQG	**<0.05**	**<10**	**<10**	**<10**	**<200**	**6.5-8.5**	**<10**	**<500**	**6**

Parameter	Se (µg/L)	TC-P/A (P/A)	TURB (NTU)	Tl (µg/L)	U (µg/L)	Zn (µg/L)	TDS (mg/L)
	1.5	**Pr**	0.44	1	0.5	18	**677**
		Pr					
	1.5	Ab	0.28	1	0.5	5	**605**
	8	Ab	**80**	1	2.6	5	476
	1.5	Ab	**73**	1	0.5	5	175
	1.5	**Pr**	**14**	1	0.5	102	399
Mean	**2.8**		**33.5**	**1**	**0.9**	**27**	**466**
CDWQG			**<1.0**		**<20**	**<5000**	**<500**

Out of the five records, a total of two slightly exceed the CDWQG for pH. The variations observed are minimal and for practical purposes it is doubtful that these variations in pH would impact the usability of the water in a private well or water source. The pH of water is important in determining water treatment methods; however, it is not a health-related water quality standard. The pH of water may be adjusted to prevent or reduce corrosion in the distribution system and this is easily accomplished using commercially available water treatment equipment.

Out of the five records, a total of three exceed the CDWQG for turbidity. The elevated levels of turbidity may be related to the relative newness of the wells and they may not have had sufficient time, or use to clear naturally. Most new wells clear naturally with time and use.

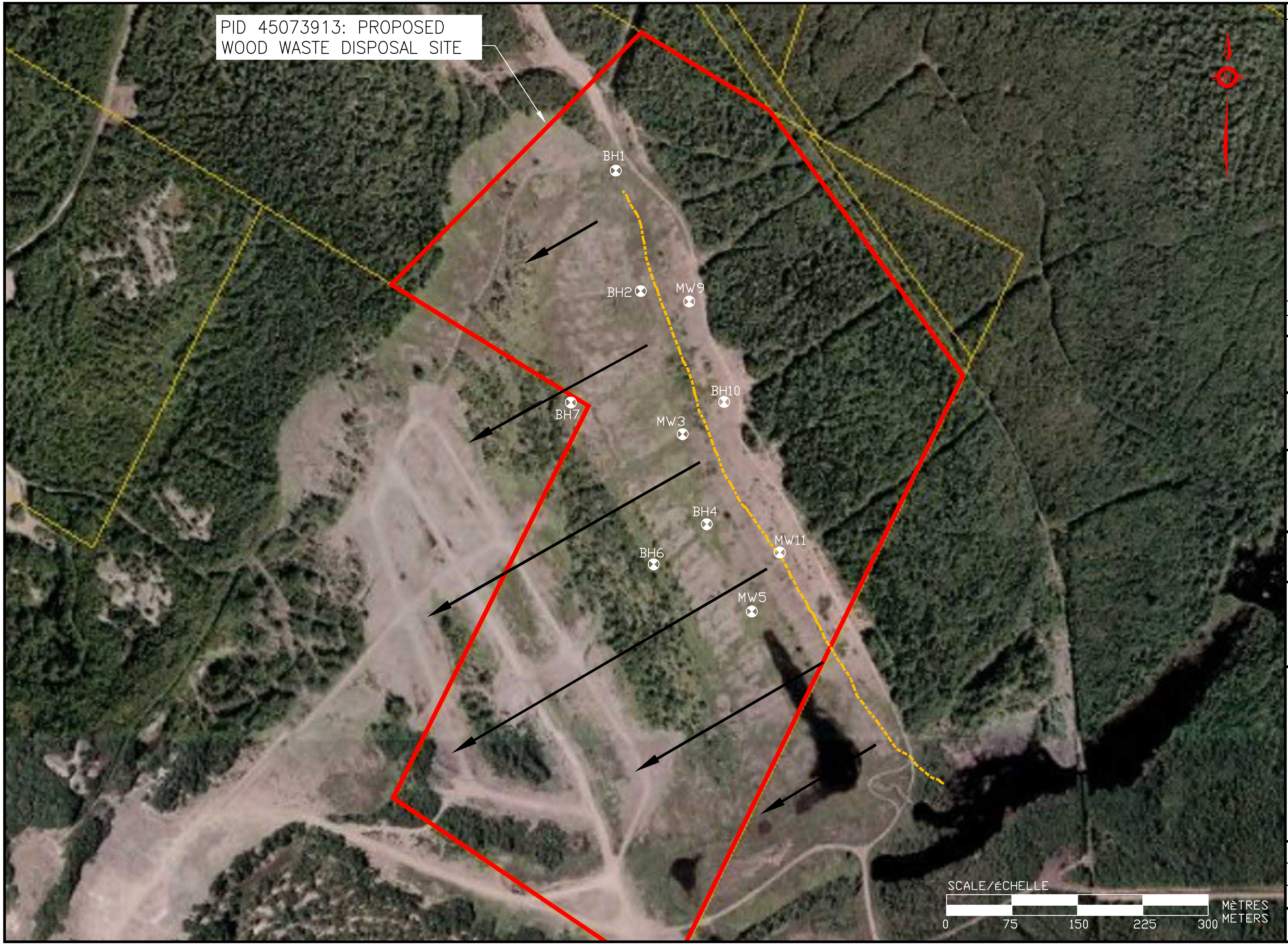
The NBDELG well chemistry database provided results from a total of six wells for E coli analysis. Out of the six wells there were no detections of E. coli. A total of six wells had data for total coliforms and there were three detection of total coliforms. Total coliforms are natural soil bacteria and are commonly present in private well water systems, particularly associated with elevated turbidities.

In summary, the groundwater chemistries found in the NBDELG database are not unusual for this area and reflect natural aquifer conditions in this specific area. Specific groundwater chemistry problems are evident in the area. Exceedances of arsenic, chloride, iron, manganese, pH, turbidity, and TDS are observed.

Site Specific Geology and Hydrogeology

A site visit was carried out December 15, 2016, coincident with staff from Roy Consultants supervising the installation of monitoring wells and boreholes. The observations made during the site visit were consistent with the available background information. A total of four monitoring wells and six boreholes were constructed at the locations shown in Figure 2. The well and borehole logs are provided in Appendix 1, at the back of this report.

Drawing Number ___316-16-L2___ Numero du Plan
Plot date________________ Date du tracage



NOTES

LEGEND

- ⊗ BOREHOLE AND MONITORING WELL LOCATION
- — — APPROXIMITE LIMIT OF OPEN MINE (UNCONFIRMED)
- ← APPROXIMITE LIMIT OF OPEN MINE (UNCONFIRMED)

Drawing status Etat de dessin

Client Client
J.D. IRVING, LIMITED

Project Projet
GRAND LAKE TIMBER
WOOD WASTE SITE
CHIPMAN, NB

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Drawing Title Titre du Plan
FIGURE 2:
LOCATION PLAN

Design by: Design par:
Drawn by: Dessine par: A. LEE
Checked by: Verifie par:
Date: JANUARY 19, 2017
Scale: Echelle: AS SHOWN
Sheet: Feuille: 1 of/de 1
Drawing Number: Numero du Plan: 293-16-L2
Rev. 0

Hydrogeology and Flow Direction: The proposed wood waste disposal site is located on former strip mined land. The boundary with undisturbed rock (not strip mined) is immediately east of the site and is shown in Figure 2 as a dotted yellow line. East of the dotted yellow line is undisturbed rock, west of the dotted yellow line are the spoils of the past strip mining operation. Well and borehole logs (MW9, MW11, and BH10) located in the undisturbed bedrock all display a similar stratigraphy. A relatively thin (0.28 to 2.77 meter thick) layer of unconsolidated intermixed dirty sand and gravel overlies consolidated sandstone. Well and borehole logs (MW3, MW5, BH1, BH2, BH4, BH6 and BH7) also display a similar stratigraphy within the group. A thick layer of unconsolidated mine spoils, described variously as varying fractions of gravel, sand, silt and clay in the well and borehole logs. Consolidated bedrock is encountered in MW5, which as a 6.58 meters of mine spoils overlying consolidated sandstone bedrock. MW5 is located at the lowest topographic elevation of all of the wells and boreholes. The rest of the wells and boreholes in this group do not intersect consolidated bedrock in any of these holes with a maximum depth of 9.14 meters.

Four soil samples of the unconsolidated mine spoils were selected for grain size analysis. The samples were located as follows:

Sample 214-16 BH2 SS-10 at a depth of approximately 5.75 meters below ground surface in unconsolidated material described as silty sand.

Sample 215-16 BH1 SS-4 at a depth of approximately 2.2 meters below ground surface in unconsolidated material described as sand, some gravel.

Sample 216-16 BH6 SS-6 at a depth of approximately 3.3 meters below ground surface in unconsolidated material described as sand and gravel.

Sample 217-16 MW3 SS-2 at a depth of approximately 0.9 meters below ground surface in unconsolidated material described as silty gravelly sand.

The results of the grain size analysis are provided in Appendix 2 at the back of this report. The sieve analysis was used to calculate hydraulic conductivities (*K*) for the four soil samples to represent the general condition of the mine spoils. This was done using the excel macro utility HydrogeoSieveXL. HydrogeoSieveXL is a utility that facilitates a quick means of obtaining hydraulic conductivity (*K*) estimates from grain size analyses. The utility tend to be most accurate in handling the coarser fractions of material common to aquifers, i.e., sand and gravel, although the values of *K* that are generated are generally only approximate. The presence of significant fractions of fines further degrades the quality of the *K* estimates. The output from HydrogeoSieveXL is provided in Appendix 2, at the back of this report. The *K* estimates are provided below in Table 3.

Table 3: Estimated hydraulic conductivity of soil samples (mine spoils).

Sample ID	K (cm/s)	Soil Classification
Sample 214-16	0.0092	Poorly Sorted Gravelly Sand Low in Fines
Sample 215-16	0.013	Poorly Sorted Gravelly Sand Low in Fines
Sample 216-16	0.017	Poorly Sorted Sandy Gravel Low in Fines
Sample 217-16	0.0050	Poorly Sorted Gravelly Sand Low in Fines
Geometric Mean	0.01	

Based on the soils analysis the estimated *K* of the mine spoils is10^{-2} cm/sec. A report by GEMTEC [1], dealing with a similar site nearby reported measured values of hydraulic conductivity for the undisturbed bedrock in the range of 10^{-4} to 10^{-2} cm/s and for the mine spoils approximately 10^{-1} cm/s. Given these values it is probable that a hydraulic conductivity contrast of at least 1 to 2

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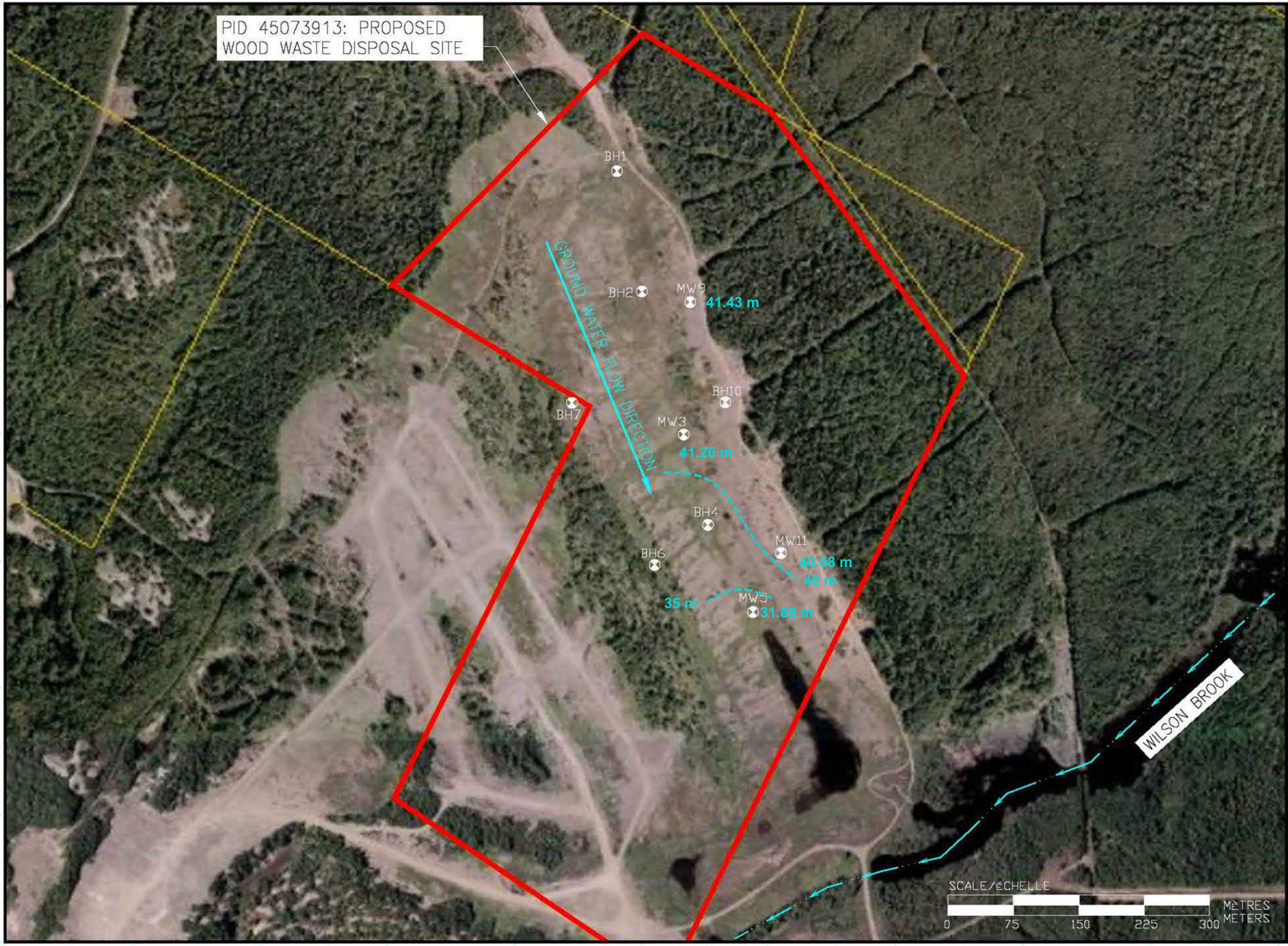
[1] GEMTEC, 1988: Surface and Groundwater Hydrology of The Fire Road Mine Site, Minto, N.B.

orders of magnitude will exist between the natural bedrock and the more conductive mine spoils. The net result of this will be a tendency for ground water flow to follow the mine spoils areas. Groundwater levels were measured in the monitoring wells prior to the samples being collected and the resulting groundwater flow direction is shown in Figure 3. The direction of shallow groundwater flow from the proposed disposal area is south southeast, towards the pond. It appears, based on the measured direction of groundwater flow, that the groundwater beneath the proposed footprint of the wood waste site does indeed follow the preferential flow path through the mine spoils in a southerly direction.

Groundwater Chemistry: Groundwater samples were collected from the four monitoring wells (Figure 2) on December 22, 2016. The samples were analyzed for general chemistry and the results are provided in Table 4 which follows. Monitoring wells MW3 and MW5 are constructed in the mining spoils while MW9 and MW11 are constructed in undisturbed bedrock. The difference in inorganic chemistry of the groundwater from the two units is pronounced and significant. The sample analysis from the mine spoils (shaded pink in Table 4) shows that the groundwater in the spoils is much more acidic than the groundwater in the background or undisturbed setting (shaded grey in Table 4). As a result of this acidity, the spoils groundwater has greatly elevated concentrations of calcium, magnesium, iron, manganese, ammonia, alkalinity, sulfate, conductivity, and hardness. Trace metal results are provided in Table 5. In Table 5 it can be seen that the measured concentration of mercury in the mine spoils exceeds the OMoE Table 9 Non-Potable Groundwater Standard within 30 m of a Waterbody. In Tables 6 and 7, the inorganic chemistry results are compared to the Canadian Drinking Water Quality Guidelines and the CCME Guidelines for the Protection of Aquatic Life. Comparison to the potable water guideline is for the purpose of comparison only, as the monitoring wells are not potable water wells. Comparison to the Guidelines for the Protection of Aquatic Life is carried out as it is Wilson Brook, a surface water, to which shallow groundwater flow (and any leachate) will ultimately discharge. It is apparent from Tables 6 and 7 that the groundwater from the mine spoils has elevated concentrations of iron, manganese, and sulfate when compared to the potable drinking water guidelines.

Drawing Number ___316-16-L3___ Numero du Plan
Plot date __________ Date du tracage



NOTES

LEGEND

● BOREHOLE AND MONITORING WELL LOCATION

Drawing status Etat de dessin

Client Client
J.D. IRVING, LIMITED

Project Projet
GRAND LAKE TIMBER
WOOD WASTE SITE
CHIPMAN, NB

ROY CONSULTANTS

Drawing Title Titre du Plan
FIGURE 3:
GROUNDWATER FLOW
DIRECTION

Design by: Design par:
Drawn by: Dessine par: A. LEE
Checked by: Verifie par:
Date: FEBRUARY 22, 2017
Scale: Echelle: AS SHOWN
Sheet: Feuille: 1 of/de 1
Drawing Number: Numero du Plan: 316-16-L3
Rev. 0

Report ID: 223255-IAS
Report Date: 10-Jan-17
Date Received: 22-Dec-16

CERTIFICATE OF ANALYSIS

for
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Table 4: Inorganic

Project #: 316-16
Location: Chipman
Analysis of Water

RPC Sample ID:				223255-1	223255-2	223255-3	223255-4	223255-5
Client Sample ID:				316-16 MW-3	316-16 MW-5	316-16 MW-5	316-16 MW-9	316-16 MW-11
Ontario Ministry of Environment Table 9 Non-Potable Groundwater Standards within 30m of a Waterbody						Duplicate		
Exceedance								
Date Sampled:				22-Dec-16	22-Dec-16	22-Dec-16	22-Dec-16	22-Dec-16
Analytes	**Units**	**RL**	**OMoE**					
Sodium	mg/L	0.05	1800	12.6	3.73	3.54	8.77	17.8
Potassium	mg/L	0.02		5.17	4.82	4.51	6.16	2.35
Calcium	mg/L	0.05		198.	276.	265.	21.5	18.8
Magnesium	mg/L	0.01		24.6	32.9	31.1	2.96	1.94
Iron	mg/L	0.02		0.82	1.08	1.74	0.05	0.18
Manganese	mg/L	0.001		12.1	23.1	20.1	0.095	0.195
Copper	mg/L	0.001	0.069	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	0.001	0.89	0.003	0.004	0.004	0.001	0.002
Ammonia (as N)	mg/L	0.05		0.26	0.45	0.39	< 0.05	< 0.05
pH	units	-		6.7	6.5	6.6	8.7	8.2
Alkalinity (as $CaCO_3$)	mg/L	2		250	200	200	73	98
Chloride	mg/L	0.5	1800	2.4	2.7	2.8	4.1	2.1
Sulfate	mg/L	1		440	670	620	19	5
Nitrate + Nitrite (as N)	mg/L	0.05		0.05	< 0.05	< 0.05	< 0.05	0.16
o-Phosphate (as P)	mg/L	0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
r-Silica (as SiO_2)	mg/L	0.1		6.2	6.4	6.2	5.8	7.5
Carbon - Total Organic	mg/L	0.5		1.6	1.9	1.8	1.7	1.1
Turbidity	NTU	0.1		> 1000	> 1000	> 1000	> 1000	> 1000
Conductivity	µS/cm	1	N/A	1110	1430	1400	196	194
Calculated Parameters								
Bicarbonate (as $CaCO_3$)	mg/L	-		250.	200.	200.	69.5	96.5
Carbonate (as $CaCO_3$)	mg/L	-		0.118	0.059	0.075	3.27	1.44
Hydroxide (as $CaCO_3$)	mg/L	-		0.003	0.002	0.002	0.251	0.079
Cation Sum	meq/L	-		13.1	17.7	16.9	1.86	1.95
Anion Sum	meq/L	-		14.2	18.0	17.0	1.97	2.13
Percent Difference	%	-		-4.17	-0.91	-0.23	-2.82	-4.51
Theoretical Conductivity	µS/cm	-	N/A	1260	1640	1560	191	187
Hardness (as $CaCO_3$)	mg/L	0.2		596	825	790	65.9	54.9
Ion Sum	mg/L	-		855	1140	1080	113	116
Saturation pH (5°C)	units	-		7.1	7.0	7.1	8.4	8.3
Langelier Index (5°C)	-	-		-0.36	-0.55	-0.46	0.29	-0.12

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit; Organic Carbon and ion chemistries for turbid samples are determined on filtered aliquots.

Tailings Un-mined

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Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 223255-IAS
Report Date: 10-Jan-17
Date Received: 22-Dec-16

CERTIFICATE OF ANALYSIS

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Table 5: Metals

Project #: 316-16
Location: Chipman

Analysis of Metals in Water

RPC Sample ID:				223255-1	223255-2	223255-3	223255-4	223255-5
Client Sample ID:				316-16 MW-3	316-16 MW-5	316-16 MW-5	316-16 MW-9	316-16 MW-11
Ontario Ministry of Environment Table 9 Non-Potable Groundwater Standards within 30m of a Waterbody						Duplicate		
Exceedance								
Date Sampled:				22-Dec-16	22-Dec-16	22-Dec-16	22-Dec-16	22-Dec-16
Analytes	**Units**	**RL**	**OMoE**					
Aluminum	µg/L	1		2	2	2	129	161
Antimony	µg/L	0.1	16000	0.2	0.1	< 0.1	0.7	0.1
Arsenic	µg/L	1	1500	13	5	4	< 1	1
Barium	µg/L	1	23000	34	23	27	327	382
Beryllium	µg/L	0.1	53	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bismuth	µg/L	1		< 1	< 1	< 1	< 1	< 1
Boron	µg/L	1	36000	14	14	13	19	18
Cadmium	µg/L	0.01	2.1	0.02	0.17	0.14	< 0.01	< 0.01
Calcium	µg/L	50		198000	276000	265000	21500	18800
Chromium	µg/L	1	640	< 1	< 1	< 1	1	< 1
Cobalt	µg/L	0.1	52	6.6	10.7	6.9	< 0.1	0.1
Copper	µg/L	1	69	< 1	< 1	< 1	< 1	< 1
Iron	µg/L	20		820	1080	1740	50	180
Lead	µg/L	0.1	20	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Lithium	µg/L	0.1		2.6	3.0	2.7	8.0	8.0
Magnesium	µg/L	10		24600	32900	31100	2960	1940
Manganese	µg/L	1		12100	23100	20100	95	195
Mercury	µg/L	0.05	0.29	1.73	1.28	1.22	< 0.05	0.20
Molybdenum	µg/L	0.1	7300	3.9	1.7	1.2	6.1	0.8
Nickel	µg/L	1	390	5	6	3	< 1	< 1
Potassium	µg/L	20		5170	4820	4510	6160	2350
Rubidium	µg/L	0.1		4.7	5.5	5.1	3.5	2.2
Selenium	µg/L	1	50	< 1	< 1	< 1	< 1	< 1
Silver	µg/L	0.1	1.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	µg/L	50	1800000	12600	3730	3540	8770	17800
Strontium	µg/L	1		2660	2670	2670	586	556
Tellurium	µg/L	0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	µg/L	0.1	400	< 0.1	0.1	< 0.1	< 0.1	< 0.1
Tin	µg/L	0.1		< 0.1	< 0.1	< 0.1	0.4	0.1
Uranium	µg/L	0.1	330	1.8	1.6	1.5	1.7	0.5
Vanadium	µg/L	1	200	< 1	< 1	< 1	3	1
Zinc	µg/L	1	890	3	4	4	1	2

Tailings
Un-mined

This report relates only to the sample(s) and information provided to the laboratory.
RL = Reporting Limit; Organic Carbon and ion chemistries for turbid samples are determined on filtered aliquots.

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Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Table 6: Inorganic Chemistry data for monitoring wells developed in undisturbed bedrock, proposed wood waste site.

Parameter			Guidelines	
Date	22-Dec-16	22-Dec-16	Canadian Drinking Water (2)	CCME F.W.A.L.(1)
Sample ID	316-16 MW-9	316-16 MW-11		
Sodium (mg/L)	8.77	17.8	≤200	
Potassium (mg/L)	6.16	2.35		
Calcium (mg/L)	21.5	18.8		
Magnesium (mg/L)	2.96	1.94		
Iron (mg/L)	0.05	0.18	≤0.3	0.3
Manganese (mg/L)	0.095	**0.195**	≤0.05	
Copper (mg/L)	< 0.001	< 0.001	≤1	0.002 - 0.004(2)
Zinc (mg/L)	0.001	0.002	≤5.0	
Ammonia (as N) (mg/L)	< 0.05	< 0.05		2.2(3)
pH	8.7	8.2	6.5-8.5	6.5-9.0
Alkalinity (as $CaCO_3$) (mg/L)	73	98		
Chloride (mg/L)	4.1	2.1	≤250	
Sulphate (mg/L)	19	5	≤500	
Nitrate + Nitrite (as N) (mg/L)	< 0.05	0.16	10.0	0.06
o-Phosphate (as P) (mg/L)	< 0.01	< 0.01		
r-Silica (as SiO_2) (mg/L)	5.8	7.5		
Carbon - Total Organic	1.7	1.1		
Turbidity (NTU)	**> 1000**	**> 1000**	1.0	
Conductivity (µS/cm)	196	194		
Hardness (calc) mg/l as $CaCO_3$	65.9	54.9		
Cation Sum (meq/L)	1.86	1.95		
Anion Sum (meq/L)	1.97	2.13		
% Difference	-2.82	-4.51%		

(1)Canadian water quality guidelines, to protect freshwater aquatic life.

(2) 0.002 mg/L if hardness = 0-120 mg/L as $CaCO_3$; 0.003 mg/L if hardness = 120-180 mg/L as $CaCO_3$; 0.004 mg/L if hardness = >180 mg/L as $CaCO_3$.

(3) 2.2 mg/L if pH = 6.5 - 7.5 and temperature = 10 -15^{0} C.

Table 7: Inorganic chemistry data from monitoring wells developed in mine spoils, proposed wood waste site.

Parameter	Sample Result			Guidelines	
Date	22-Dec-16	22-Dec-16	22-Dec-16 Duplicate	Canadian Drinking Water (2)	CCME F.W.A.L. (1)
Sodium (mg/L)	12.6	3.73	3.54	≤200	
Potassium (mg/L)	5.17	4.82	4.51		
Calcium (mg/L)	198.	276.	265.		
Magnesium (mg/L)	24.6	32.9	31.1		
Iron (mg/L)	**0.82**	**1.08**	**1.74**	≤0.3	0.3
Manganese (mg/L)	**12.1**	**23.1**	**20.1**	≤0.05	
Copper (mg/L)	< 0.001	< 0.001	< 0.001	≤1	0.002 - 0.004(2)
Zinc (mg/L)	0.003	0.004	0.004	≤5.0	
Ammonia (as N) (mg/L)	0.26	0.45	0.39		2.2(3)
pH	6.7	6.5	6.6	6.5-8.5	6.5-9.0
Alkalinity (as $CaCO_3$) (mg/L)	250	200	200		
Chloride (mg/L)	2.4	2.7	2.8	≤250	
Sulphate (mg/L)	440	**670**	**620**	≤500	
Nitrate + Nitrite (as N) (mg/L)	0.05	< 0.05	< 0.05	10.0	0.06
o-Phosphate (as P) (mg/L)	< 0.01	< 0.01	< 0.01		
r-Silica (as SiO_2) (mg/L)	6.2	6.4	6.2		
Carbon - Total Organic	1.6	1.9	1.8		
Turbidity (NTU)	**> 1000**	**> 1000**	**> 1000**	1.0	
Conductivity (µS/cm)	1110	1430	1400		
Hardness (calc) mg/l as $CaCO_3$	596	825	790		
Cation Sum (meq/L)	13.1	17.7	16.9		
Anion Sum (meq/L)	14.2	08.0	17.0		
% Difference	-4.17%	-0.91%	-0.23%		

(1)Canadian water quality guidelines, to protect freshwater aquatic life.

(2) 0.002 mg/L if hardness = 0-120 mg/L as $CaCO_3$; 0.003 mg/L if hardness = 120-180 mg/L as $CaCO_3$; 0.004 mg/L if hardness = >180 mg/L as $CaCO_3$.

(3) 2.2 mg/L if pH = 6.5 - 7.5 and temperature = 10 -15^0 C.

4.0 DISCUSSION

Potential human or environmental exposure to contaminants is considered in a risk assessment framework. In its simplest form the risk assessment can be broken down into the following components

- Potential **receptors**; and
- Characteristics and quantities of potential **contaminants** present within the site; and
- Potential exposure **pathways** for contaminants to leave the site.

The general methodology involves collecting existing background data and conducting a visual inspection of the site. The level of effort put into examining each site is limited in the initial stages. Should the initial assessment indicate potential significant exposure of receptors to contaminants then further assessment work would be recommended.

Potential Receptors

In terms of human receptors there are a number of private wells located adjacent to Route 10 which is west of the proposed site (Figure 1). The closest of this group of receptors approximately 1,500 meters from the proposed wood waste disposal area. Potential environmental receptors are a pond located south of the site, approximately 20 meters from the southern limit of the proposed site. This pond drains to Wilsons Brook via a small surface stream.

Potential Contaminants: Wood waste is commonly not suspected as a source of significant ground water contamination. It is known; however, that decomposing wood waste break-down products can potentially contaminate ground water with concentrations of tannin-lignin, BOD, COD, phenols, colour, odour and some metals in the ground water. A number of these potential contaminants are oxygen demanding and their presence can result in significantly increasing the concentration of iron and manganese in the groundwater.

The current existing wood waste disposal site for the Grand Lake Timber, Limited operation has been in place for years and the shallow groundwater chemistry below the site is monitored. This disposal site is also located in an area of former strip mine spoils. The results of the 2016 monitoring are presented in Table 8, which follows. In Table 8, the downgradient monitoring wells are represented by MW1-S, MW2-S, and MW4-S. As can be seen in Table 8, for the downgradient wells, the pH is low (acidic groundwater), with elevated concentrations of iron, manganese, and sulfate. The downgradient groundwater chemistry shown in Table 8 (below the existing wood waste site) is quite similar to the sample results for the groundwater samples collected within the mine spoils at the new proposed wood waste site. In other words, the principal groundwater chemistry impacts observed downgradient of the current operating site are principally the same as the impacts observed in the proposed new site, within the strip-mined area, which has not received any wood waste yet. The principal ground water impacts observed are due to the former strip mining activities and not the deposition of wood waste, in any significant way.

Potential Pathways

The potential pathways by which contaminants could leave the site are air, surface water, and groundwater.

Air Pathway: The air pathway is insignificant in terms of the materials present at a wood waste disposal site and the contaminants identified above. In the event that some wood dust or small particles is mobilized by wind there are no receptors close by and the wood dust would be deposited locally, in the surrounding woodland area, where its impact would be inconsequential.

Surface Water Pathway: There is no stream draining the south trending depression that holds the proposed wood waste disposal facilities footprint. The closest surface water is the pond located south of the proposed disposal area which drains to Wilson Brook. To prevent significant amounts of wood waste from reaching this potential pathway, the southernmost extension of the waste footprint should be kept a minimum of 10 meters from the high water point of the pond.

Groundwater Pathway: The groundwater pathway is the principal pathway via which potential contaminants can migrate off site. Precipitation and snowmelt will infiltrate through the wood waste and into the mine spoils below it. The measured groundwater flow direction is generally south, towards the existing pond which subsequently flows into Wilson Brook.

Potential human receptors (the private wells along Hwy 10) will not be impacted due to distance from the site (approximately 1.5 km) and the groundwater flow direction (south, eventually to Wilson Brook), not in the direction of the potential human receptors. In addition, the old Chipman dump site (PIDs 45098811, 45098829) is situated approximately midway between the proposed site and the closest private wells. When that dump site was closed in 1998, the closure included investigations and private well sampling to attempt to determine if the dump site was potentially impacting the closest private wells along Hwy

10. No discernable impacts were found. As the proposed new site is approximately twice as far away and in the same direction, it is very unlikely that human receptor impacts would occur.

The measured groundwater flow path, to the pond and into Wilson Brook indicates the potential for environmental aquatic impacts. Any potential environmental impact will be insignificant compared to the existing impacts from the historic strip mining activity. The comparison of the downgradient impacts from the existing wood waste site clearly showed minimal impacts due to the presence of the wood waste, compared to the impacts from the strip mine spoils.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following is concluded based on the site assessment;

1. Potential air transport of significant contamination from the proposed wood waste disposal site is not a significant concern.
2. Surface water transport is not a likely pathway for contaminant migration and in any event the surface water drainage from the proposed wood waste site is towards the south, away from the human receptors and in the general direction of Wilson Brook, located in that direction. In addition, there is no existing surface stream in the depression that forms the proposed footprint of the wood waste site.
3. Shallow groundwater transport is the most likely potential pathway for contaminant migration from the proposed wood waste site; however, groundwater flow was determined to be towards the south, in the general direction of the pond and Wilson Brook.
4. Potential Human receptors represented by private wells are not located in the directions of surface and ground water flow. Groundwater flow from the area of the proposed wood waste site will be within the mine spoils into the pond and eventually Wilson Brook.
5. The shallow groundwater flow beneath the wood waste footprint will slow and somewhat reduce the rate of contaminant migration to the pond and Wilson Brook through natural attenuation.
6. Ecological impacts from the discharge of the shallow groundwater into the pond/Wilson Brook will be of acceptable magnitude as demonstrated by the groundwater quality data. The magnitude of potential impacts from the wood waste is overwhelmed by existing acid mine drainage from the mine spoils.
7. A liner is not necessary at this site as a consequence of the existing state of conditions at the proposed wood waste site. The potential environmental impacts from the proposed wood waste site are inconsequential when compared to the existing environmental impacts from the previous strip mining activity and the acid mine drainage from the mine spoils. A liner would simply move the potential leachate from the wood waste into the pond and Wilson Brook faster than the shallow groundwater flow path.

The following is recommended, based on the results of the risk assessment to date.

1. It is recommended that the southern toe of the wood waste footprint be kept a minimum of 10 meters north of the pond high water mark.

Report Prepared By:

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Douglas Craig, M.Sc., P.Geo.
Hydrogeologist, Site Professional NB

Appendix 1

Well and Borehole Logs

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16, 2016
WATER DEPTH 3.66m
PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-3

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▨

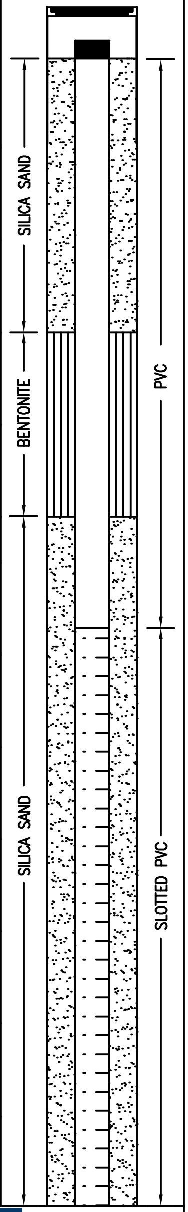
FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
45.59 (PVC)															
44.87	0 – 0.61	ORGANIC SOIL AND SILTY SAND, SOME CLAY, BROWN		☒	SS-1	2 3 3 2	6	0							
	0.61 – 1.22	SILTY GRAVELLY SAND, TRACES OF CLAY, BROWN		☒	SS-2	1 3 2 3	5	50	SA						
	1.22 – 1.83	SILTY GRAVELLY SAND, TRACES TO SOME CLAY, BROWN; PRESENCE OF COBBLES		☒	SS-3	4 9 6 9	15	13							
	1.83 – 2.44			☒	SS-4	6 3 3 2	6	0							
	2.44 – 2.74			▨	AU-1										
	2.74 – 3.35	SILTY GRAVELLY SAND, TRACES TO SOME CLAY, BROWN; PRESENCE OF ORGANIC MATTER IN SS-5 GREY SANDSTONE FRAGMENTS IN SS-6		☒	SS-5	3 2 3 4	5	25							
	3.35 – 3.96			☒	SS-6	5 2 2 2	4	25	▽						
	3.96 – 4.57			☒	SS-7	3 3 5 3	8	25	SA						
	4.57 – 5.18	SILTY SAND, SOME GRAVEL, TRACES OF CLAY, BROWN		☒	SS-8	3 3 8 6	11	33							
	5.18 – 5.79			☒	SS-9	5 11 7 5	18	29							
	5.79 – 6.40			☒	SS-10	4 4 5 5	9	96							
	6.40 – 7			☒	SS-11	5 3 5 4	8	25							



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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16, 2016 WATER DEPTH 3.66m

PAGE 2 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-3

SAMPLE TYPE
- SS : SPLIT SPOON
- CB : CORE BARREL
- AU : AUGER

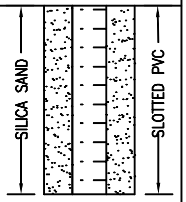
STATE OF SAMPLE
- DISTURBED ☒
- CORE ◧
- LOST ■
- NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS
- N : STANDARD PENETRATION
- ▼ : HYDROCARBON LEVEL
- ▽ : WATER LEVEL

ELEVATION
- ☒ GEODETIC
- ☐ LOCAL GRID

LABORATORY ANALYSIS
- a : MODIFIED TPH
- b : BTEX
- c : PAH
- d : METALS
- SA : SIEVE ANALYSIS
- o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
- N : NON-EXISTANT
- O : ODOUR
- S : STAINED
- FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
38.37	6.50	CONTINUED FROM PAGE 1													
		SILTY SAND, SOME GRAVEL, TRACES OF CLAY BROWN		☒	SS-11										
	7 7.01	SILTY SAND, SOME GRAVEL, TRACES OF CLAY BROWN; PRESENCE OF COBBLES		☒	SS-12	5 11 6 6	17	75							
	7.62			☒	SS-13	9 50	>50	100							
	7.75 8	END OF BOREHOLE AT 7.75 METERS ON BOULDER OR FRACTURED SANDSTONE													
	9														
	10														
	11														
	12														
	13														
	14														

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ROY CONSULTANTS
ENGINEERING SERVICES D'INGÉNIERIE

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 3.66m

PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-5

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ░

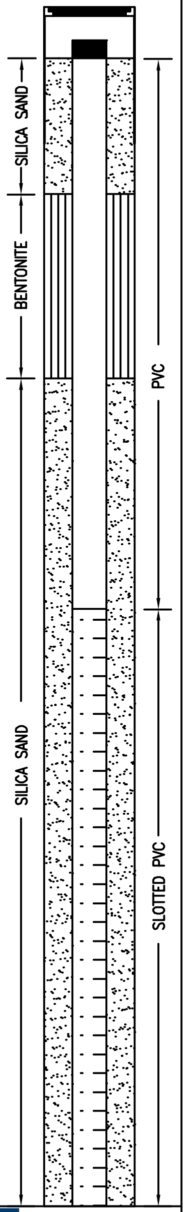
FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
36.69 (PVC)															
35.84	0	SAND, SOME GRAVEL, SOME SILT, TRACES OF CLAY, BROWN; TRACES OF ORGANIC MATTER		☒	SS-1	2 3 4 3	7	71							
	0.61 1	SAND, SOME GRAVEL, SOME SILT, TRACES OF CLAY, BROWN		☒	SS-2	3 3 3 2	6	42							
	1.22			☒	SS-3	3 3 5 5	8	54							
	1.83 2			☒	SS-4	4 3 1 1	4	42							
	2.44			☒	SS-5	1 2 1 1	3	42							
	3 3.05			☒	SS-6	3 2 2 3	4	54							
	3.66 4			☒	SS-7	3 2 3 4	5	38	▽						
	4.27			☒	SS-8	3 3 2 2	5	33							
	4.88 5			☒	SS-9	2 3 5 5	8	25							
	5.49			☒	SS-10	4 4 5 9	9	13							
	6 6.10			☒	SS-11	2, 3 12 50	15	42							
	6.58	BEDROCK: SANDSTONE, BROWN AND GREY		░											
	7														



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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 3.66m

PAGE 2 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-5

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

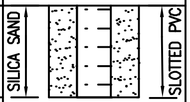
STATE OF SAMPLE
DISTURBED ☒ CORE ◨ LOST ■ NOT SAMPLED ░

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
37.87	7	CONTINUED FROM PAGE 1													
		BEDROCK: SANDSTONE, REDDISH BROWN AND GREY	▨	░											
	7.62	END OF BOREHOLE AT 7.62 METERS													
	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														

supervised by J.B. drawn by A.L. checked by J.B. date 10/01/17 rev. 0

ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16 AND 17, 2016 WATER DEPTH 7.32m (DECEMBER 17, 2016)

PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-9

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ░

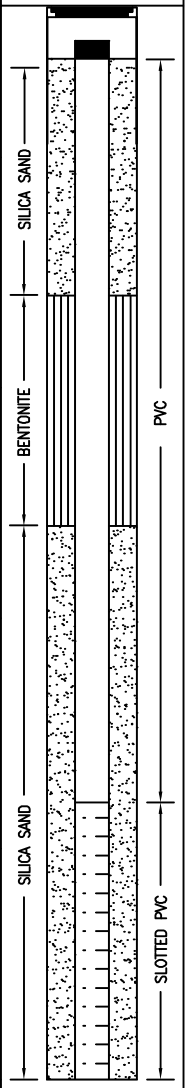
FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
49.44 (PVC)															
48.63	0	GRAVELLY SAND, SOME SILT, GREY		☒	SS–1	50	>50	100							
	0.28	BEDROCK: SANDSTONE, BROWN		░	AU–1										
	1.52			☒	AU–2										
	3.05			░	AU–3										
	4.57	BEDROCK: SANDSTONE, BROWN AND/OR GREY		░	AU–4										
	6.10			░	AU–5										
	7														



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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16 AND 17, 2016 WATER DEPTH 7.32m (DECEMBER 17, 2016)

PAGE 2 OF 2
PROJECT No. 316-16
BOREHOLE No. MW-9

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▒

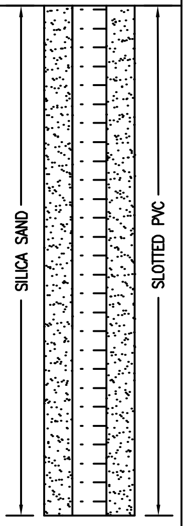
FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
∇ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
41.63	7	CONTINUED FROM PAGE 1													
	7.62	BEDROCK: SANDSTONE, BROWN AND/OR GREY	▨	▒	AU-5				∇						
	8 9 9.14		▨	☒	AU-6										
	10 13.11		▨	▒	AU-7										
	11 12 13 14 15	END OF BOREHOLE AT 13.11 METERS													



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ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 2.44m
PAGE 1 OF 3
PROJECT No. 316-16
BOREHOLE No. MW-11

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
☒ DISTURBED ◧ CORE ■ LOST ░ NOT SAMPLED

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR
45.59 (PVC)														
44.87	0	SAND AND GRAVEL, SOME SILT, GREYISH BROWN		☒	SS-1	7 15	N/A	63						
				░	AU-2									
	0.62			☒	SS-3	50	>50	17						
	0.72	GRAVELLY SAND, SOME SILT, GREYISH BROWN		░	AU-4									
	1.52	SILTY SAND, SOME GRAVEL, REDDISH BROWN		☒	SS-5	9 10 17 30	27	83	SA					
	2.13			░	AU				▽					
	2.74 2.77	BEDROCK: SANDSTONE, REDDISH BROWN AND GREY		░	SS-6	50	>50	0						

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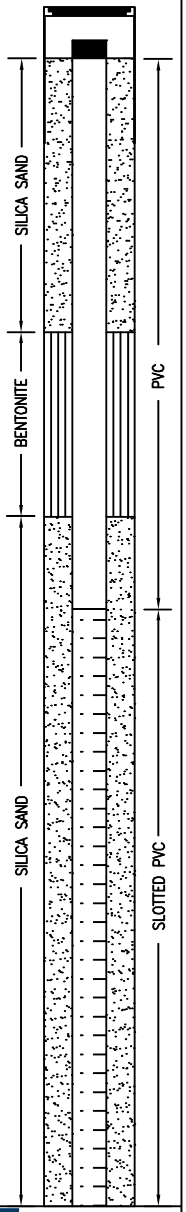
OBSERVATIONS



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ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 2.44m

PAGE 2 OF 3
PROJECT No. 316-16
BOREHOLE No. MW-11

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▨

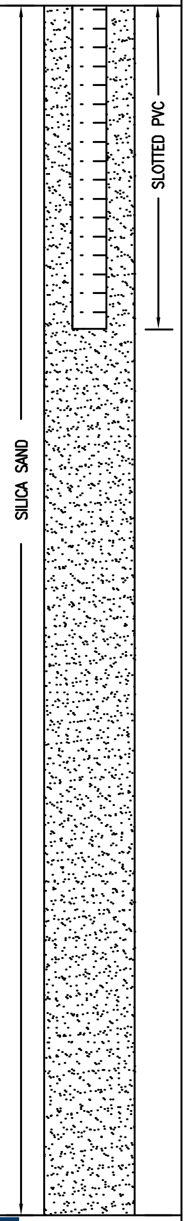
FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
37.87	7	CONTINUED FROM PAGE 1													
		BEDROCK: SANDSTONE, REDDISH BROWN AND GREY	▨	▨											
	8														
	9 9.14														
	10														
	11														
	12														
	13														
	14														
	15	CONTINUED ON PAGE 3													



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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 2.44m

PAGE 3 OF 3
PROJECT No. 316-16
BOREHOLE No. MW-11

SAMPLE TYPE

SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE

DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▒

FIELD TESTS AND OBSERVATIONS

N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION

☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS

a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS

N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON				OBSERVATIONS
											N	O	S	FR	
29.87	15	CONTINUED FROM PAGE 2													
		BEDROCK: SANDSTONE, BROWN AND GREY	▨	▒											SILICA SAND
		END OF BOREHOLE AT 15.24 METERS													
	16														
	17														
	18														
	19														
	20														
	21														
	22														
	21														

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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 17, 2016 WATER DEPTH NO WATER

PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. BH-1

SAMPLE TYPE

SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE

DISTURBED	CORE	LOST	NOT SAMPLED
☒	◧	■	▨

FIELD TESTS AND OBSERVATIONS

N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION

☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS

a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS

N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	PRESENCE OF HYDROCARBON O	PRESENCE OF HYDROCARBON S	PRESENCE OF HYDROCARBON FR	OBSERVATIONS
51.74	0	SILTY GRAVELLY SAND WITH ORGANIC SOIL, BROWN		☒	SS-1	2 10 7 7	17	71							
	0.61	SILTY GRAVELLY SAND, BROWN		☒	SS-2	7 8 8 7	16	79							
	1.22	SAND, SOME GRAVEL, SOME SILT, TRACES OF CLAY, BROWN; PRESENCE OF COBBLES		☒	SS-3	4 8 9 10	17	100							
	1.83			☒	SS-4	11 10 19 18	29	67	SA						
	2.44	GRAVELLY SAND, SOME SILT, BROWN AND GREY; PRESENCE OF COBBLES		☒	SS-5	22 25 16 17	41	79							
	3.05			☒	SS-6	15 8 14 9	22	46							
	3.66			☒	SS-7	10 12 12 10	24	21							
	4.27			☒	SS-8	15 13 8 19	21	29							
	4.88			☒	SS-9	19 21 15 8	36	33							
	5.49			☒	SS-10	7 5 4 6	9	88							
	6.10			☒	SS-11	4 3 2 2	5	8							
	6.71	CONTINUED ON PAGE 2													

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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED

LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB

DATE DECEMBER 17, 2016 WATER DEPTH NO WATER

PAGE 2 OF 2

PROJECT No. 316-16

BOREHOLE No. BH-1

SAMPLE TYPE
- SS : SPLIT SPOON
- CB : CORE BARREL
- AU : AUGER

STATE OF SAMPLE

DISTURBED	CORE	LOST	NOT SAMPLED
☒	◧	■	▒

FIELD TESTS AND OBSERVATIONS
- N : STANDARD PENETRATION
- ▼ : HYDROCARBON LEVEL
- ▽ : WATER LEVEL

ELEVATION
- ☒ GEODETIC
- ☐ LOCAL GRID

LABORATORY ANALYSIS
- a : MODIFIED TPH
- b : BTEX
- c : PAH
- d : METALS
- SA : SIEVE ANALYSIS
- o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
- N : NON-EXISTANT
- O : ODOUR
- S : STAINED
- FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON				OBSERVATIONS
											N	O	S	FR	
	6.50	CONTINUED FROM PAGE 1													
45.03	6.71 7	GRAVELLY SAND, SOME SILT, BROWN AND GREY; PRESENCE OF COBBLES	▒	☒	SS-12	6 18 21 10	39	33							
	7.32		▒	☒	SS-13	9 9 14 17	23	42							
	7.92 8	END OF BOREHOLE AT 7.92 METERS													
	9														
	10														
	11														
	12														
	13														
	14														

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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED

LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB

DATE DECEMBER 16, 2016 WATER DEPTH 7.01m

PAGE 2 OF 2

PROJECT No. 316-16

BOREHOLE No. BH-2

SAMPLE TYPE

SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE

DISTURBED ☒ CORE ◨ LOST ■ NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS

N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION

☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS

a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS

N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
	6.50	CONTINUED FROM PAGE 1													
31.98	6.71 7	SILTY SAND, SOME GRAVEL, TRACES TO SOME CLAY, BROWN; PRESENCE OF COBBLES	▨	☒	SS-12	6 7 12 7	19	88	▽						
	7.32		▨	☒	SS-13	5 9 6 15	15	42							
	7.92 8		▨	☒	SS-14	6 6 21 20	27	38							
	8.53 9		▨	☒	SS-15	33 10 7 11	17	50							
	9.14	END OF BOREHOLE AT 9.14 METERS													
	10 11 12 13 14														

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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16, 2016 WATER DEPTH 7.01m

PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. BH-2

SAMPLE TYPE

SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE

DISTURBED ⊠ CORE ◧ LOST ■ NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS

N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION

☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS

a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS

N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
38.69	0	SILTY SAND, SOME GRAVEL, TRACES TO SOME CLAY, BROWN	▨	⊠	SS-1	2 3 6 3	9	46							
	0.61 1	SILTY SAND, SOME GRAVEL, TRACES TO SOME CLAY, BROWN; PRESENCE OF COBBLES (SANDSTONE FRAGMENTS)	▨	⊠	SS-2	4 2 2 2	4	33							
	1.22		▨	⊠	SS-3	4 20 10 7	30	21							
	1.83 2		▨	⊠	SS-4	8 6 4 37	10	63							
	2.44		▨	⊠	SS-5	11 6 5 12	11	33							
	3.05 3	SILTY SAND, SOME GRAVEL, TRACES TO SOME CLAY, BROWN; PRESENCE OF COBBLES	▨	⊠	SS-6	5 5 2 4	7	71							
	3.65 4		▨	⊠	SS-7	5 4 4 3	8	25							
	4.27		▨	⊠	SS-8	5 5 8 4	13	71							
	4.88 5		▨	⊠	SS-9	5 4 3 3	7	71							
	5.49 6		▨	⊠	SS-10	6 4 5 5	9	100	SA						
	6.01		▨	⊠	SS-11	4 5 5 7	10	58							
	6.71 7	CONTINUED ON PAGE 2													

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BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 15, 2016 WATER DEPTH 3.35m

PAGE 1 OF 1
PROJECT No. 316-16
BOREHOLE No. BH-4

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◨ LOST ■ NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
∇ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
38.02	0	SILTY GRAVELLY SAND, TRACES TO SOME CLAY, BROWN; TRACES OF ORGANIC MATTER		☒	SS-1	2 2 3 4	5	50							
	0.61 1			☒	SS-2	3 2 3 2	5	17							
	1.22	SAND, SOME GRAVEL, SOME SILT, TRACES OF CLAY, BROWN; TRACES COBBLES		☒	SS-3	2 3 10 9	13	46							
	1.83 2			☒	SS-4	5 4 4 3	5	50							
	2.44 3			☒	SS-5	2 3 5 8	8	33							
	3.05			☒	SS-6	8 2 6 5	8	21	∇						
	3.66 4			☒	SS-7	4 5 6 5	11	46							
	4.27			☒	SS-8	2 3 3 4	6	75							
	4.88 5			☒	SS-9	2 3 3 4	6	58							
	5.49 6			☒	SS-10	3 3 3 10	6	75							
	6.10			☒	SS-11	33 50	>50	0							
	6.38 7	END OF BOREHOLE AT 6.38 METERS													

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ENGINEERING SERVICES D'INGÉNIERIE

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 17, 2016 WATER DEPTH NO WATER

PAGE 1 OF 1
PROJECT No. 316-16
BOREHOLE No. BH-6

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON				OBSERVATIONS
											N	O	S	FR	
48.98	0	SAND AND GRAVEL, SOME SILT, BROWN AND GREY; TRACES OF ORGANIC MATTER AND PRESENCE OF COBBLES		☒	SS-1	2 4 9 9	13	58							
	0.61 1			☒	SS-2	6 7 12 14	19	88							
	1.22			☒	SS-3	6 10 6 5	16	42							
	1.83 2	SAND AND GRAVEL, SOME SILT, BROWN AND GREY; TRACES OF COBBLES		☒	SS-4	4 4 5 6	9	63							
	2.44 3			☒	SS-5	5 4 5 8	9	83							
	3.05			☒	SS-6	6 6 6 5	12	75	SA						
	3.66 4			☒	SS-7	7 10 6 5	16	63							
	4.27			☒	SS-8	7 7 4 7	11	71							
	4.88 5			☒	SS-9	7 50	>50	57							
	5.05 6 7	END OF BOREHOLE AT 5.05 METERS ON POSSIBLE BOULDER													

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ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 17, 2016
WATER DEPTH NO WATER
PAGE 1 OF 2
PROJECT No. 316-16
BOREHOLE No. BH-7

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▒

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
52.12	0	SAND AND GRAVEL, SOME SILT, REDDISH BROWN; PRESENCE OF COBBLES		☒	SS-1	2 6 7 7	13	67							
	0.61			☒	SS-2	4 4 6 4	10	63							
	1 1.22			☒	SS-3	4 4 3 2	7	50							
	1.83 2			☒	SS-4	3 2 2 3	4	29							
	2.44	SILTY GRAVELLY SAND, SOME CLAY, BROWN		☒	SS-5	3 4 2 2	5	58							
	3 3.05		3.71	☒	SS-6	3 3 1 2	4	88	▽						
	3.66 4	GRAVELLY SAND, SOME SILT, TRACES OF CLAY, GREY AND/OR BROWN; TRACES OF COBBLES		☒	SS-7	7 6 6 8	12	100							
	4.27			☒	SS-8	10 8 5 6	13	96							
	4.88 5			☒	SS-9	5 5 7 11	12	92							
	5.49 6			☒	SS-10	7 12 10 10	22	67							
	6.10			☒	SS-11	7 12 1 14	13	88							
	6.71 7														

CONTINUED ON PAGE 2

supervised by J.B. drawn by A.L. checked by J.B. date 12/01/17 rev. 0

ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 17, 2016 WATER DEPTH NO WATER

PAGE 2 OF 2
PROJECT No. 316-16
BOREHOLE No. BH-7

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▨

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON-EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON				OBSERVATIONS
											N	O	S	FR	
	6.50	CONTINUED FROM PAGE 1													
45.41	6.71 7	GRAVELLY SAND, SOME SILT, TRACES OF CLAY, GREY AND/OR BROWN; TRACES OF COBBLES	▨	☒	SS-12	7 10 8 8	18	100							
	7.32		▨	☒	SS-13	7 8 8 7	16	75							
	7.93 8		▨	☒	SS-14	7 6 7 7	13	100							
	8.53 9		▨	☒	SS-15	5 6 9 8	15	83							
	9.14	END OF BOREHOLE AT 9.14 METERS													
	10														
	11														
	12														
	13														
	14														

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ROY CONSULTANTS

BOREHOLE LOG REPORT

CLIENT J.D. IRVING, LIMITED
LOCATION GRAND LAKE WOOD WASTE DISPOSAL SITE (PID 45073913), CHIPMAN, NB
DATE DECEMBER 16, 2016 WATER DEPTH NO WATER

PAGE 1 OF 1
PROJECT No. 316-16
BOREHOLE No. BH-10

SAMPLE TYPE
SS : SPLIT SPOON
CB : CORE BARREL
AU : AUGER

STATE OF SAMPLE
DISTURBED ☒ CORE ◧ LOST ■ NOT SAMPLED ▒

FIELD TESTS AND OBSERVATIONS
N : STANDARD PENETRATION
▼ : HYDROCARBON LEVEL
▽ : WATER LEVEL

ELEVATION
☒ GEODETIC
☐ LOCAL GRID

LABORATORY ANALYSIS
a : MODIFIED TPH
b : BTEX
c : PAH
d : METALS
SA : SIEVE ANALYSIS
o : OTHER

PRESENCE OF HYDROCARBONS IN SOILS
N : NON–EXISTANT
O : ODOUR
S : STAINED
FR : FREE PHASE PRODUCT

ELEV. (M)	DEPTH (M)	SOIL DESCRIPTION	STRATA PLOT	STATE OF SAMPLE	SAMPLE TYPE/NO.	BLOW / 0.15m	R.Q.D. or N	RECUPARATION (%)	TESTS / ANALYSIS	HYDROCARBON VAPOURS	PRESENCE OF HYDROCARBON N	O	S	FR	OBSERVATIONS
48.14	0	SAND AND GRAVEL, SOME SILT, BROWN TO GREY; TRACES OF ORGANIC MATTER	▒	☒	SS–1	9 35 19 50	54	36							BEDROCK AT 0.41 METERS
	0.56	BEDROCK: SANDSTONE, GREY AND BROWN	▨	▒	AU–1										
	1														
	1.52			☒	SS–2	50	>50	0							
	1.60	END OF BOREHOLE AT 1.60 METERS													
	2														
	3														
	4														
	5														
	6														
	7														

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Kings Mines

1500 meter radius around PID 45073913

Well Depth (Feet)	**Estimated Yield** (igpm)	**Depth to Bedrock** (Feet)	**Casing Length** (Feet)
53	20	6	30
63	4	8	20
285	10	10	20
145	3	10	20
65	20	14	20
40	7	7	20
60	7	4	20
Well Depth (Feet)	**Estimated Yield** (igpm)	**Depth to Bedrock** (Feet)	**Casing Length** (Feet)

Median	63	7	8	20	Median
average	101.6	10.1	8.4	21.4	AVERAG
max	285	20	14	30	max
min	40	3	4	20	min
count	7				

New Nouveau Brunswick

Environment

Report Number **3011**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Cable Tool**	**06/18/2003**

Casing Information

Casing above ground **2ft**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
3011	Steel	6 inch	0ft	30ft	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**5ft**	**0 igpm**	**0hr**	**0ft**	**20 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
Chlorine Pucks

Qty **0 ig**

Pump Installed
Submersible

Intake Setting (BTC)
40ft

Driller's Log

Well Log	From	End	Colour	Rock Type
3011	0ft	6ft	Brown	Overburden
3011	6ft	53ft	Grey	Conglomerate

Overall Well Depth
53ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
3011	45ft	20 igpm

Setbacks

Well Log	Distance	Setback From
3011	55ft	Septic Tank
3011	80ft	Leach Field

New Nouveau Brunswick

Environment

Report Number **6251**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Rotary**	**09/10/2003**

Casing Information

Casing above ground **1ft 6in** Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
6251	**Steel**	**8 inch**	**0ft**	**20ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**0 igpm**	**0hr**	**0ft**	**4 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
N/A

Qty **0 ig**

Pump Installed
N/A

Intake Setting (BTC)
55ft

Driller's Log

Well Log	From	End	Colour	Rock Type
6251	**0ft**	**8ft**	**Brown**	**Topsoil**
6251	**8ft**	**55ft**	**Grey**	**Sandstone**
6251	**55ft**	**63ft**	**Brown and red**	**Shale**

Overall Well Depth
63ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
6251	**55ft**	**4 Igpm**

Setbacks

There is no Setback information.

New Nouveau Brunswick

Environment

Report Number **6272**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Rotary**	**11/22/2004**

Casing Information

Casing above ground **2ft**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
6272	**Steel**	**10 inch**	**0ft**	**2ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**0.35 igpm**	**2hrs**	**0ft**	**10 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

Well Log	Grout Type	From	End
6272	**Clay(cuttings)**	**0ft**	**10ft**

Drilling Fluids Used
None

Disinfectant
Chlorine Pucks

Qty **0 ig**

Pump Installed
N/A

Intake Setting (BTC)
0ft

Driller's Log

Well Log	From	End	Colour	Rock Type
6272	**0ft**	**10ft**	**Tan**	**Sand**
6272	**10ft**	**100ft**	**Red**	**Shale**
6272	**100ft**	**285ft**	**Grey**	**Shale and Slate**

Overall Well Depth
285ft

Bedrock Level
10ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
6272	**100ft**	**10 Igpm**
6272	**180ft**	**10 igpm**

Setbacks

Well Log	Distance	Setback From
6272	**50ft**	**Septic Tank**
6272	**75ft**	**Leach Field**

Environment

Report Number **6273**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Rotary (Hammer)**	**11/22/2004**

Casing Information

Casing above ground **1ft 6in**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
6273	**Steel**	**6 inch**	**0ft**	**20ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**3 igpm**	**2hrs**	**0ft**	**3 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
N/A

Qty **0 ig**

Pump Installed
Submersible
Intake Setting (BTC)
125ft

Driller's Log

Well Log	From	End	Colour	Rock Type
6273	**0ft**	**10ft**	**Tan**	**Sand**
6273	**10ft**	**95ft**	**Red**	**Shale**
6273	**95ft**	**145ft**	**Grey**	**Shale and Slate**

Overall Well Depth
145ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
6273	**30ft**	**0.5 Igpm**
6273	**100ft**	**2 igpm**
6273	**145ft**	**3 igpm**

Setbacks

Well Log	Distance	Setback From
6273	**75ft**	**Septic Tank**
6273	**100ft**	**Leach Field**
6273	**300ft**	**Right of any Public Way Road**

Report Number **16536**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Cable Tool**	**08/22/2007**

Casing Information

Casing above ground **2ft**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
16536	**Steel**	**6 inch**	**0ft**	**20ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Bailer	**39ft**	**20 igpm**	**1hr 35min**	**39ft**	**20 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
N/A

Qty **0 ig**

Pump Installed
N/A

Intake Setting (BTC)
0ft

Driller's Log

Well Log	From	End	Colour	Rock Type
16536	**0ft**	**14ft**	**Brown**	**Mud**
16536	**14ft**	**65ft**	**Grey**	**Sandstone**

Overall Well Depth
65ft

Bedrock Level
14ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
16536	**45ft**	**2 igpm**
16536	**55ft**	**5 Igpm**
16536	**60ft**	**13 igpm**

Setbacks

Well Log	Distance	Setback From
16536	**72ft**	**Septic Tank**
16536	**92ft**	**Leach Field**
16536	**37ft**	**Right of any Public Way Road**

New Nouveau Brunswick

Environment

Report Number **90670600**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well (NEW WELL)**	**Rotary (ROTARY)**	**07/29/1996**

Casing Information

Casing above ground **1ft 7in**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
90670600	**Steel**	**6 inch**	**0ft**	**20ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**7 igpm**	**1hr**	**5ft**	**7 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
Bleach (Javex)

Qty **1.0 ig**

Pump Installed
N/A

Intake Setting (BTC)
35ft

Driller's Log

Well Log	From	End	Colour	Rock Type
90670600	**0ft**	**7ft**	**Brown**	**Sand**
90670600	**7ft**	**40ft**	**Grey**	**Sandstone**

Overall Well Depth
40ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
90670600	**30ft**	**7 Igpm**

Setbacks

There is no Setback information.

New Nouveau Brunswick

Environment

Report Number **90739800**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well (NEW WELL)**	**Rotary (ROTARY)**	**10/22/1996**

Casing Information

Casing above ground **1ft 5in**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
90739800	Steel	6 inch	0ft	20ft	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**7 igpm**	**1hr**	**17ft**	**7 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
Bleach (Javex)

Qty **1.0 ig**

Pump Installed
N/A

Intake Setting (BTC)
45ft

Driller's Log

Well Log	From	End	Colour	Rock Type
90739800	0ft	4ft	Brown	Gravel
90739800	4ft	27ft	Grey	Sandstone
90739800	27ft	28ft	Brown	Sandstone
90739800	28ft	49ft	Brown	Sandstone
90739800	49ft	52ft	Brown	Sandstone
90739800	52ft	60ft	Brown	Sandstone

Overall Well Depth
60ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
90739800	40ft	2 Igpm
90739800	50ft	5 igpm

Setbacks

There is no Setback information.

New Nouveau Brunswick

Environment

Report Number **92195000**

Well Driller's Report

Date printed **2016/12/09**

Drilled by

Well Use	Work Type	Drill Method	Work Completed
Drinking Water, Domestic	**New Well**	**Rotary**	**07/04/2001**

Casing Information

Casing above ground **1ft 5in**

Drive Shoe Used? **Yes**

Well Log	Casing Type	Diameter	From	End	Slotted?
92195000	**Steel**	**6 inch**	**0ft**	**20ft**	

Aquifer Test/Yield

Method	Initial Water Level (BTC)	Pumping Rate	Duration	Final Water Level (BTC)	Estimated Safe Yield	Flowing Well?	Rate
Air	**0ft**	**7 igpm**	**1hr**	**12ft**	**7 igpm**	**No**	**0 igpm**

(BTC - Below top of casing)

Well Grouting

There is no Grout information.

Drilling Fluids Used
None

Disinfectant
Bleach (Javex)

Qty **1.0 ig**

Pump Installed
N/A

Intake Setting (BTC)
55ft

Driller's Log

Well Log	From	End	Colour	Rock Type
92195000	**0ft**	**5ft**	**Brown**	**Gravel**
92195000	**5ft**	**26ft**	**Grey**	**Sandstone**
92195000	**26ft**	**26ft**	**Brown**	**Sandstone**
92195000	**26ft**	**60ft**	**Grey**	**Sandstone**
92195000	**60ft**	**60ft**	**Brown**	**Sandstone**
92195000	**60ft**	**70ft**	**Grey**	**Sandstone**

Overall Well Depth
70ft

Bedrock Level
0ft

Water Bearing Fracture Zone

Well Log	Depth	Rate
92195000	**26ft**	**3 igpm**
92195000	**60ft**	**4 Igpm**

Setbacks

There is no Setback information.

Appendix 2

Grain Size Analysis and K Output

ROY CONSULTANTS
ENGINEERING SERVICES D'INGÉNIERIE

Laboratory report: Soils and Aggregates

Client Grand Lake Timber (JD Irving) Chipman	Lot-Station	Project Number 316-16
Nature of Sample Silty sand, some gravel, traces to some clay	Proposed Use Geotechnical study	Sample Number 214-16
Pit or Quarry Name	Location	Reference
Municipality, County Chipman, NB	Sampled by: Jon Burtt Date: 17-Dec-16	Contract
Sampling Site BH-2 SS-10	Tested by: Daniel Albert Date: 11-Jan-17	

Sieve Analysis

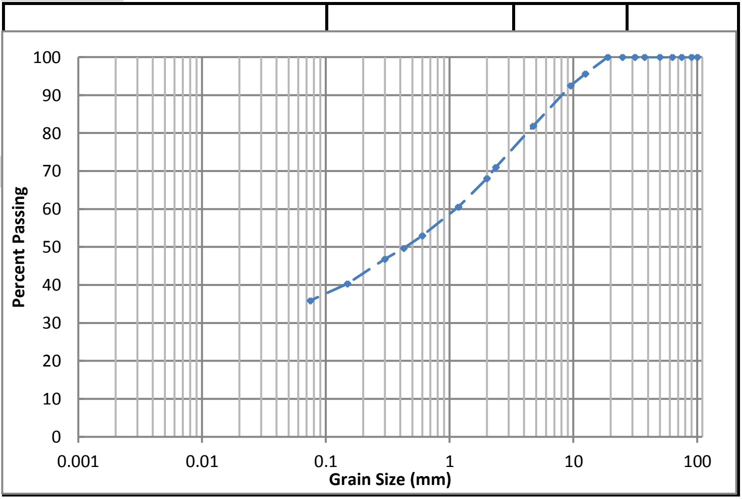
Sieve Size	% Passing Separated	% Passing Combined	Requirements Low	Requirements High
100 mm		100.0		
90 mm		100.0		
75 mm		100.0		
63 mm		100.0		
50 mm		100.0		
37.5 mm		100.0		
31.5 mm		100.0		
25 mm		100.0		
19 mm		100.0		
12.5 mm		95.6		
9.5 mm		92.5		
4.75 mm	100.0	81.9		
2.36 mm	86.6	71.0		
2.00 mm	83.2	68.1		
1.18 mm	73.9	60.6		
600 µm	64.7	53.0		
425 µm	60.7	49.7		
300 µm	57.1	46.8		
150 µm	49.2	40.3		
75 µm	43.8	35.9		

Hydrometer Analysis

Various Tests

		Requirements Low	Requirements High
% Gravel	18.1		
% Sand	46.0		
% Silt and Clay	35.9		
Atterberg Limits			
Liquid Limit			
Plastic Limit			
Plasticity Index			
Natural Water Content	14.4%		

Proctor	Hammer	
	Test	
	Preparation	
	Method	
	Maximum Dry Density	
	Optimum Water Content	



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Calculated by Pierre Lanteigne, P.Eng.
Reviewed by: Daniel Albert, P.Tech.
Date: 18-01-2017

ROY CONSULTANTS
ENGINEERING SERVICES D'INGÉNIERIE

Laboratory report: Soils and Aggregates

Client Grand Lake Timber (JD Irving) Chipman	Lot-Station		Project Number 316-16
Nature of Sample Sand, some gravel, some silt, traces of clay	Proposed Use Geotechnical study		Sample Number 215-16
Pit or Quarry Name	Location		Reference
Municipality, County Chipman, NB	Sampled by Jon Burtt	Date 17-Dec-16	Contract
Sampling Site BH-1 SS-4	Tested by Daniel Albert	Date 12-Jan-17	

Sieve Analysis

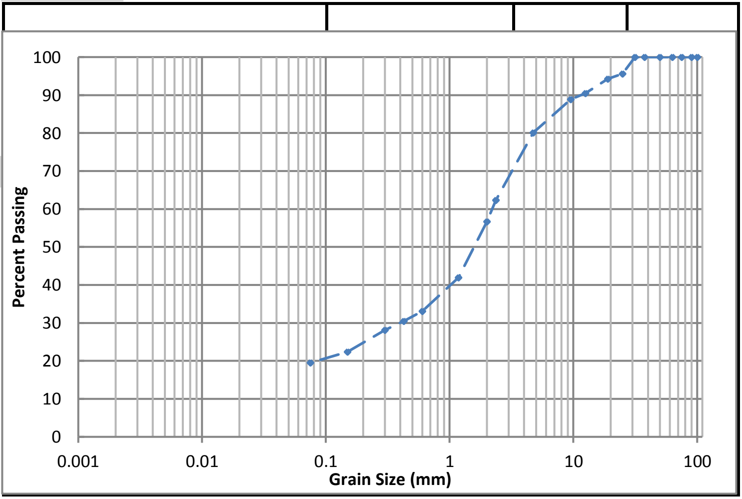
Sieve Size	% Passing Separated	% Passing Combined	Requirements	
			Low	High
100 mm		100.0		
90 mm		100.0		
75 mm		100.0		
63 mm		100.0		
50 mm		100.0		
37.5 mm		100.0		
31.5 mm		100.0		
25 mm		95.6		
19 mm		94.3		
12.5 mm		90.5		
9.5 mm		88.9		
4.75 mm	100.0	80.1		
2.36 mm	81.1	62.3		
2.00 mm	75.3	56.7		
1.18 mm	59.5	41.9		
600 µm	50.1	33.1		
425 µm	47.4	30.5		
300 µm	44.9	28.1		
150 µm	38.8	22.4		
75 µm	35.7	19.5		

Hydrometer Analysis

Various Tests

		Requirements	
		Low	High
% Gravel	19.9		
% Sand	60.6		
% Silt and Clay	19.5		
Atterberg Limits			
Liquid Limit			
Plastic Limit			
Plasticity Index			
Natural Water Content	7.5%		

Proctor	
Hammer	
Test	
Preparation	
Method	
Maximum Dry Density	
Optimum Water Content	



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ROY CONSULTANTS
ENGINEERING SERVICES D'INGÉNIERIE

Laboratory report: Soils and Aggregates

Client Grand Lake Timber (JD Irving) Chipman	Lot-Station		Project Number 316-16
Nature of Sample Gravel and Sand, some silt	Proposed Use Geotechnical study		Sample Number 216-16
Pit or Quarry Name	Location		Reference
Municipality, County Chipman, NB	Sampled by Jon Burtt	Date 17-Dec-16	Contract
Sampling Site BH-6 SS-6	Tested by Daniel Albert	Date 11-Jan-17	

Sieve Analysis

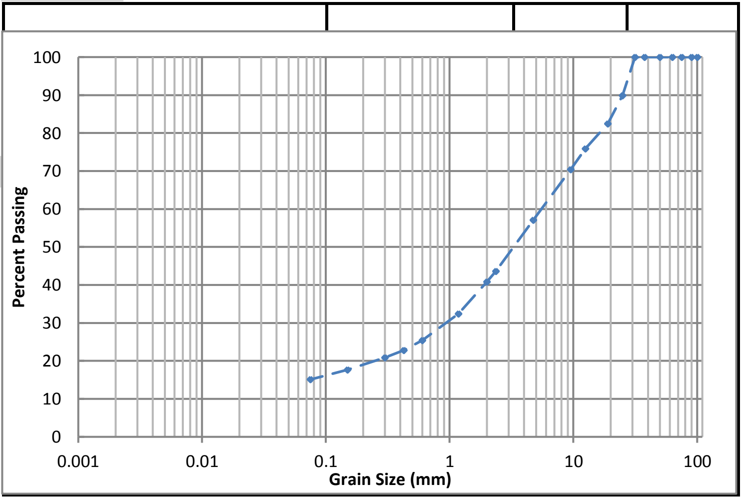
Sieve Size	% Passing Separated	% Passing Combined	Requirements	
			Low	High
100 mm		100.0		
90 mm		100.0		
75 mm		100.0		
63 mm		100.0		
50 mm		100.0		
37.5 mm		100.0		
31.5 mm		100.0		
25 mm		89.9		
19 mm		82.5		
12.5 mm		75.9		
9.5 mm		70.4		
4.75 mm	100.0	57.1		
2.36 mm	76.4	43.6		
2.00 mm	71.5	40.8		
1.18 mm	56.7	32.4		
600 µm	44.4	25.4		
425 µm	40.0	22.8		
300 µm	36.7	20.9		
150 µm	31.0	17.7		
75 µm	26.5	15.1		

Hydrometer Analysis

Various Tests

		Requirements	
		Low	High
% Gravel	42.9		
% Sand	42.0		
% Silt and Clay	15.1		
Atterberg Limits			
Liquid Limit			
Plastic Limit			
Plasticity Index			
Natural Water Content	5.9%		

Proctor	Hammer	
	Test	
	Preparation	
	Method	
	Maximum Dry Density	
	Optimum Water Content	



Remarks

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Calculated by Pierre Lanteigne, P.Eng.
Reviewed by: Daniel Albert, P.Tech.
Date: 18-01-2017

Laboratory report: Soils and Aggregates

Client Grand Lake Timber (JD Irving) Chipman	Lot-Station	Project Number 316-16
Nature of Sample Silty gravelly sand, traces to some clay	Proposed Use Geotechnical study	Sample Number 015-17
Pit or Quarry Name	Location	Reference
Municipality, County Chipman, NB	Sampled by: Jon Burtt Date: 17-Dec-16	Contract
Sampling Site MW3 SS-7	Tested by: Pierre Lanteigne Date: 7-Feb-17	

Sieve Analysis

Sieve Size	% Passing Separated	% Passing Combined	Requirements Low	Requirements High
100 mm				
90 mm				
75 mm				
63 mm				
50 mm				
37.5 mm				
31.5 mm				
25 mm		100.0		
19 mm		94.6		
12.5 mm		82.6		
9.5 mm		80.1		
4.75 mm	100.0	72.7		
2.36 mm	89.3	65.0		
2.00 mm	86.2	62.7		
1.18 mm	78.3	57.0		
600 µm	70.1	51.0		
425 µm	66.4	48.3		
300 µm	63	45.8		
150 µm	55.1	40.1		
75 µm	48.6	35.3		

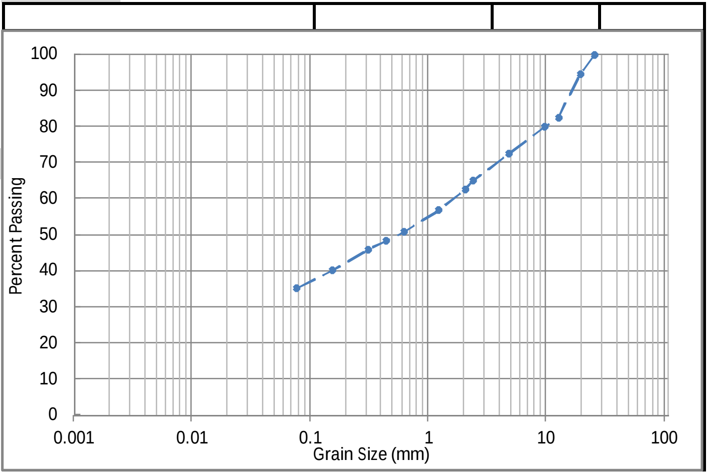
Hydrometer Analysis

Various Tests

		Requirements Low	Requirements High
% Gravel	27.3		
% Sand	37.4		
% Silt and Clay	35.3		
Atterberg Limits			
Liquid Limit			
Plastic Limit			
Plasticity Index			
Natural Water Content	17.1%		

Proctor

Hammer	
Test	
Preparation	
Method	
Maximum Dry Density	
Optimum Water Content	



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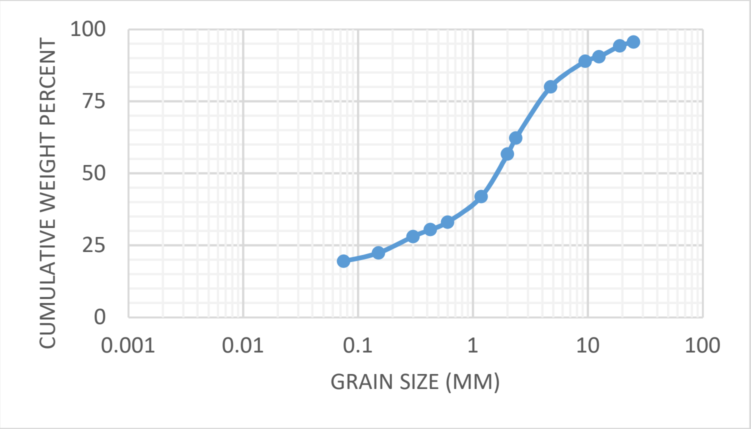
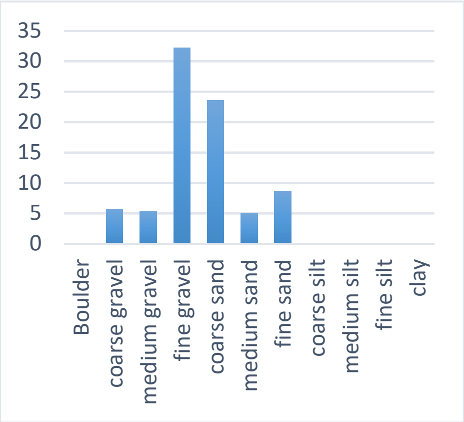
Grain Size Analysis Report Date: 30-1-16

Sample Name: BH1 SS-4 215-16

Mass Sample (g): 500 T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
25	22	0.044	95.6
19	6.5	0.013	94.3
12.5	19	0.038	90.5
9.5	8	0.016	88.9
4.75	44	0.088	80.1
2.36	89	0.178	62.3
2	28	0.056	56.7
1.18	74	0.148	41.9
0.6	44	0.088	33.1
0.425	13	0.026	30.5
0.3	12	0.024	28.1
0.15	28.5	0.057	22.4
0.075	14.5	0.029	19.5

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.038	Uniformity Coef.	57.52
d17	0.065	n computed	0.26
d20	0.088	g (cm/s^2)	980.00
d50	1.629	ρ (g/cm^3)	0.9981
d60	2.212	μ (g/cm s)	0.0098
de (Kruger)	1.096	$\rho g/\mu$ (1/cm s)	9.9327E+04
de (Kozeny)	0.993	tau (Sauerbrei)	1.053
de (Zunker)	1.026	$d_{geometric\ mean}$	1.585
de (Zamarin)	1.061	σ_ϕ	3.242
Io (Alyameni)	-0.359		

mm	0	% in sample
>64	Boulder	
16 - 64	coarse gravel	5.7
8 - 16	medium gravel	5.4
2 - 8	fine gravel	32.2
0.5 - 2	coarse sand	23.6
0.25 - 0.5	medium sand	5
0.063 - 0.25	fine sand	8.6
0.016 - 0.063	coarse silt	
0.008 - 0.016	medium silt	
0.002 - 0.008	fine silt	
<0.002	clay	

K from Grain Size Analysis Report

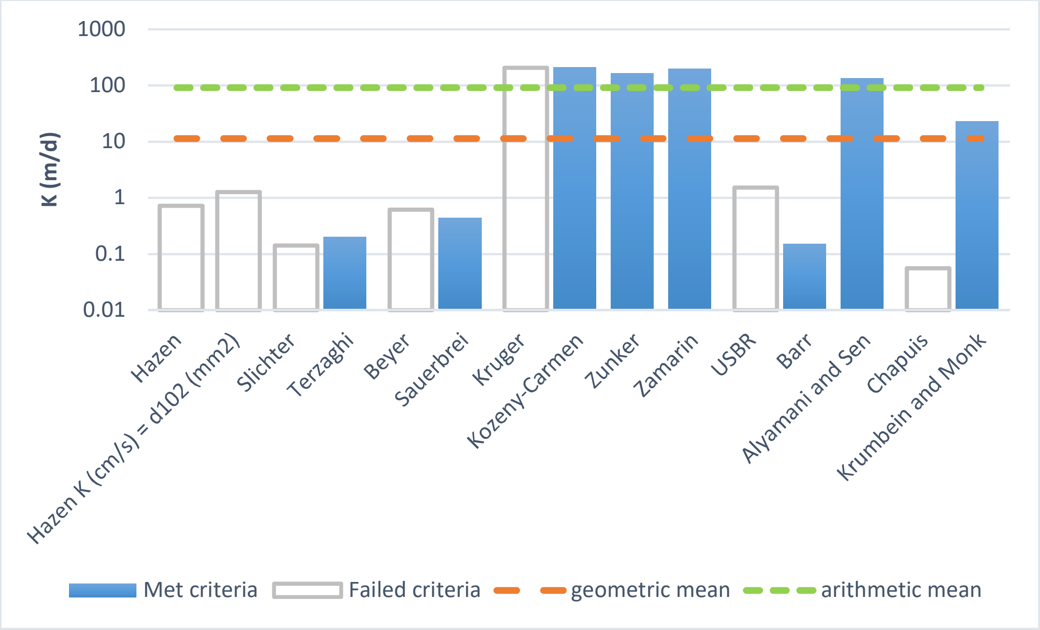
Date: 30-01-2017

Sample Name: BH1 SS-4 215-16

Mass Sample (g): 500

T (oC) 20

Poorly sorted gravelly sand low in fines



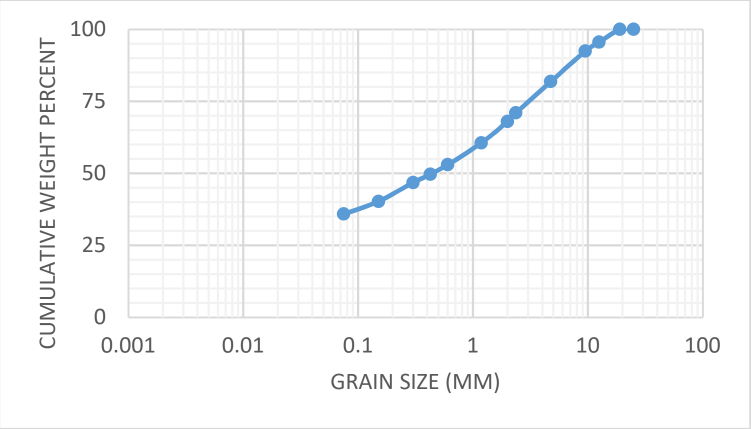
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.838E-03	.838E-05	0.72	
Hazen K (cm/s) = d_{10} (mm)	.148E-02	.148E-04	1.28	
Slichter	.165E-03	.165E-05	0.14	
Terzaghi	.235E-03	.235E-05	0.20	
Beyer	.718E-03	.718E-05	0.62	
Sauerbrei	.501E-03	.501E-05	0.43	
Kruger	.238E+00	.238E-02	205.96	
Kozeny-Carmen	.243E+00	.243E-02	210.02	
Zunker	.190E+00	.190E-02	164.16	
Zamarin	.230E+00	.230E-02	198.85	
USBR	.178E-02	.178E-04	1.54	
Barr	.176E-03	.176E-05	0.15	
Alyamani and Sen	.153E+00	.153E-02	132.59	
Chapuis	.648E-04	.648E-06	0.06	
Krumbein and Monk	.268E-01	.268E-03	23.16	
geometric mean	.132E-01	.132E-03	11.38	
arithmetic mean	.106E+00	.106E-02	91.20	

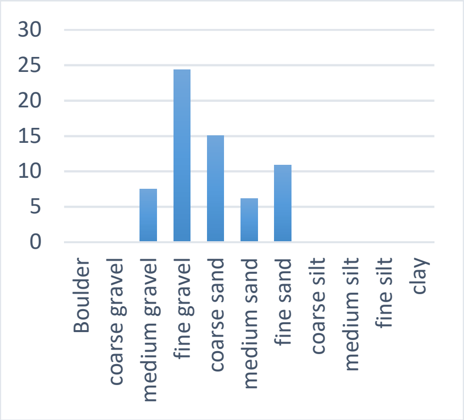
Grain Size Analysis Report Date: ______________________

Sample Name: BH2 SS-10 214-16

Mass Sample (g): 500 T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
25	0	0	100
19	0	0	100
12.5	22	0.044	95.6
9.5	15.5	0.031	92.5
4.75	53	0.106	81.9
2.36	54.5	0.109	71
2	14.5	0.029	68.1
1.18	37.5	0.075	60.6
0.6	38	0.076	53
0.425	16.5	0.033	49.7
0.3	14.5	0.029	46.8
0.15	32.5	0.065	40.3
0.075	22	0.044	35.9

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.021	Uniformity Coef.	54.29
d17	0.036	n computed	0.26
d20	0.042	g (cm/s^2)	980.00
d50	0.441	ρ (g/cm^3)	0.9981
d60	1.134	μ (g/cm s)	0.0098
de (Kruger)	0.979	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.885	tau (Sauerbrei)	1.053
de (Zunker)	0.915	$d_{geometric\ mean}$	1.374
de (Zamarin)	0.947	σ_ϕ	3.392
Io (Alyameni)	-0.084		

mm	0	% in sample
>64	Boulder	
16 - 64	coarse gravel	0
8 - 16	medium gravel	7.5
2 - 8	fine gravel	24.4
0.5 - 2	coarse sand	15.1
0.25 - 0.5	medium sand	6.2
0.063 - 0.25	fine sand	10.9
0.016 - 0.063	coarse silt	
0.008 - 0.016	medium silt	
0.002 - 0.008	fine silt	
<0.002	clay	

K from Grain Size Analysis Report

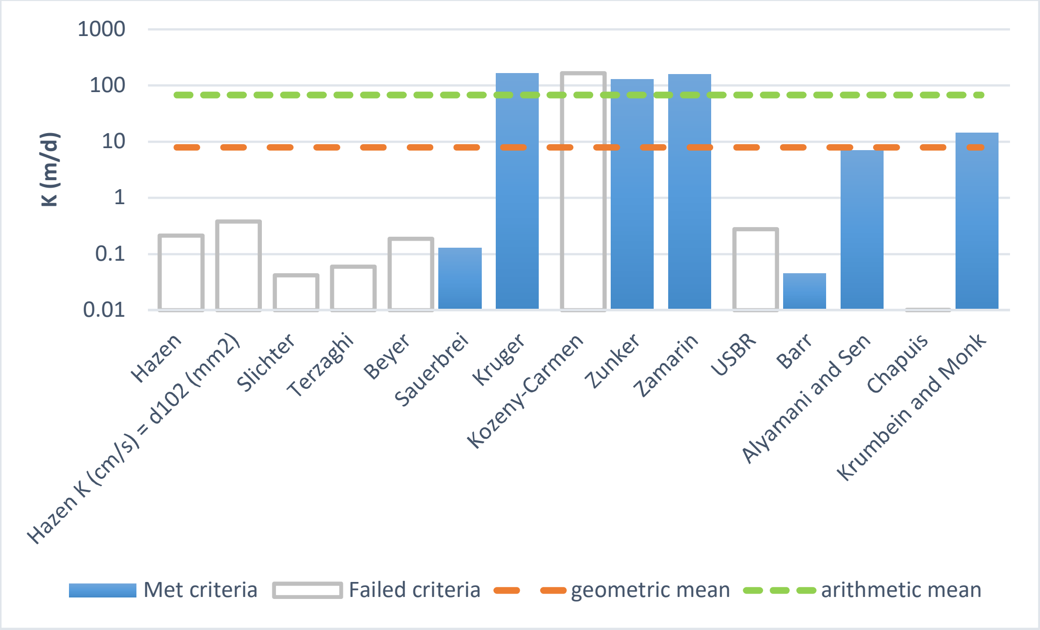
Date: 30-01-2017

Sample Name: BH2 SS-10 214-16

Mass Sample (g): 500

T (oC) 20

Poorly sorted gravelly sand low in fines



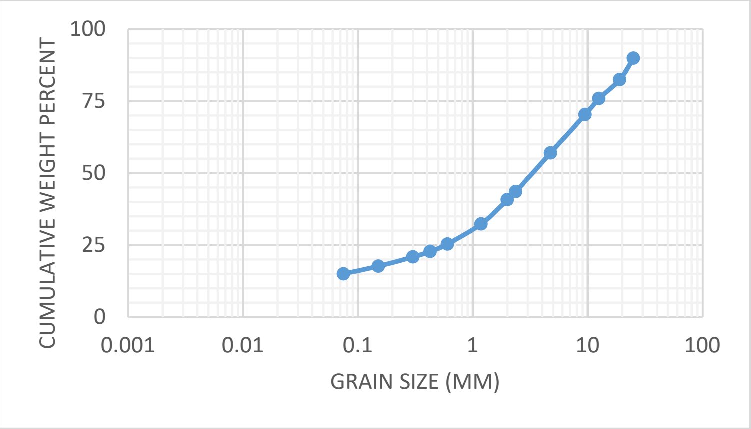
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.247E-03	.247E-05	0.21	
Hazen K (cm/s) = d_{10} (mm)	.436E-03	.436E-05	0.38	
Slichter	.486E-04	.486E-06	0.04	
Terzaghi	.692E-04	.692E-06	0.06	
Beyer	.217E-03	.217E-05	0.19	
Sauerbrei	.148E-03	.148E-05	0.13	
Kruger	.190E+00	.190E-02	164.41	
Kozeny-Carmen	.193E+00	.193E-02	166.58	
Zunker	.151E+00	.151E-02	130.48	
Zamarin	.183E+00	.183E-02	158.40	
USBR	.321E-03	.321E-05	0.28	
Barr	.521E-04	.521E-06	0.04	
Alyamani and Sen	.815E-02	.815E-04	7.04	
Chapuis	.116E-04	.116E-06	0.01	
Krumbein and Monk	.165E-01	.165E-03	14.29	
geometric mean	.917E-02	.917E-04	7.93	
arithmetic mean	.785E-01	.785E-03	67.83	

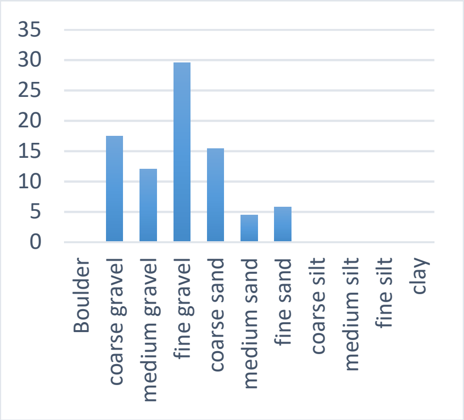
Grain Size Analysis Report Date: 30-01-2017

Sample Name: BH6 SS-6 216-16

Mass Sample (g): 500 T (oC) 20

Poorly sorted sandy gravel low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
25	50.5	0.101	89.9
19	37	0.074	82.5
12.5	33	0.066	75.9
9.5	27.5	0.055	70.4
4.75	66.5	0.133	57.1
2.36	67.5	0.135	43.6
2	14	0.028	40.8
1.18	42	0.084	32.4
0.6	35	0.07	25.4
0.425	13	0.026	22.8
0.3	9.5	0.019	20.9
0.15	16	0.032	17.7
0.075	13	0.026	15.1

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.050	Uniformity Coef.	116.49
d17	0.130	n computed	0.26
d20	0.258	g (cm/s^2)	980.00
d50	3.493	ρ (g/cm^3)	0.9981
d60	5.786	μ (g/cm s)	0.0098
de (Kruger)	1.449	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	1.315	tau (Sauerbrei)	1.053
de (Zunker)	1.358	$d_{geometric\ mean}$	2.356
de (Zamarin)	1.404	σ_ϕ	3.435
Io (Alyameni)	-0.811		

mm	0	% in sample
>64	Boulder	
16 - 64	coarse gravel	17.5
8 - 16	medium gravel	12.1
2 - 8	fine gravel	29.6
0.5 - 2	coarse sand	15.4
0.25 - 0.5	medium sand	4.5
0.063 - 0.25	fine sand	5.8
0.016 - 0.063	coarse silt	
0.008 - 0.016	medium silt	
0.002 - 0.008	fine silt	
<0.002	clay	

K from Grain Size Analysis Report

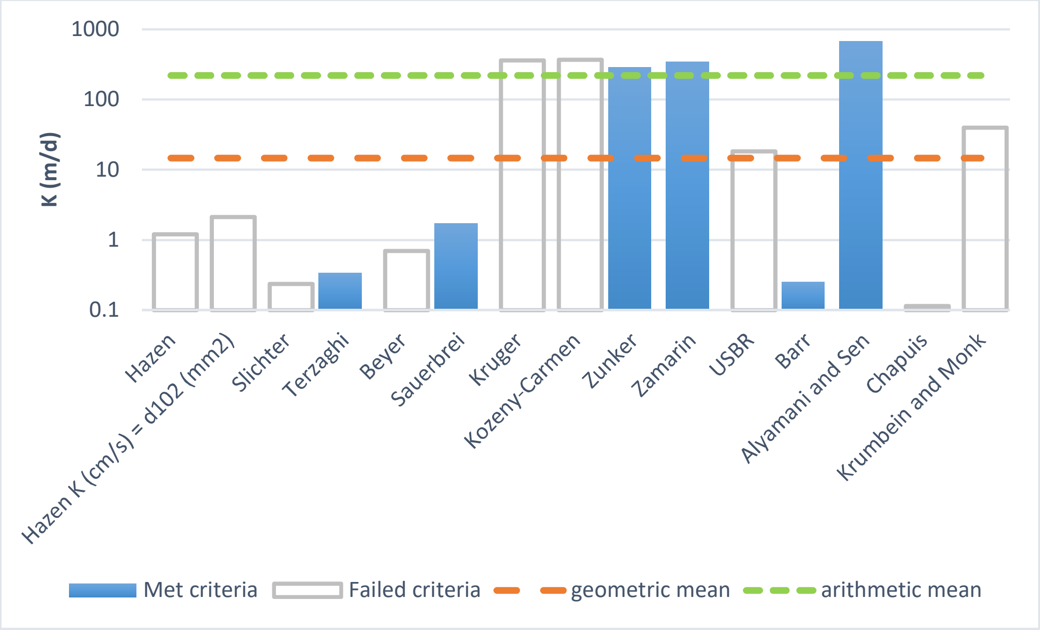
Date: 30-01-2017

Sample Name: BH6 SS-6 216-16

Mass Sample (g): 500

T (oC) 20

Poorly sorted sandy gravel low in fines



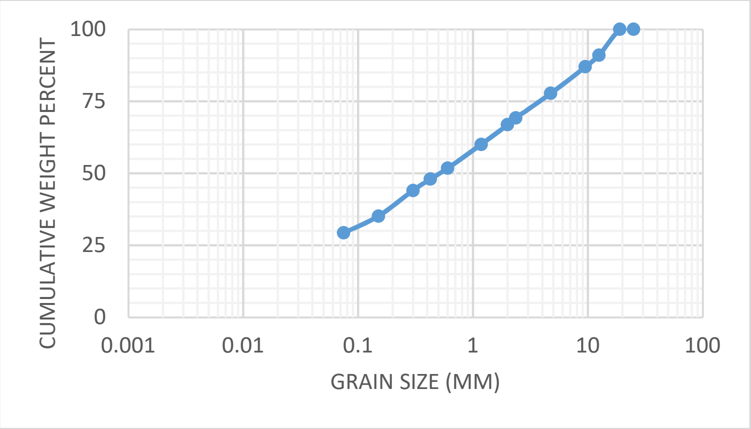
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.140E-02	.140E-04	1.21	
Hazen K (cm/s) = d_{10} (mm)	.247E-02	.247E-04	2.13	
Slichter	.274E-03	.274E-05	0.24	
Terzaghi	.391E-03	.391E-05	0.34	
Beyer	.806E-03	.806E-05	0.70	
Sauerbrei	.197E-02	.197E-04	1.71	
Kruger	.417E+00	.417E-02	360.25	
Kozeny-Carmen	.426E+00	.426E-02	367.93	
Zunker	.333E+00	.333E-02	287.45	
Zamarin	.403E+00	.403E-02	348.00	
USBR	.211E-01	.211E-03	18.23	
Barr	.294E-03	.294E-05	0.25	
Alyamani and Sen	.791E+00	.791E-02	683.48	
Chapuis	.133E-03	.133E-05	0.12	
Krumbein and Monk	.459E-01	.459E-03	39.69	
geometric mean	.170E-01	.170E-03	14.68	
arithmetic mean	.255E+00	.255E-02	220.20	

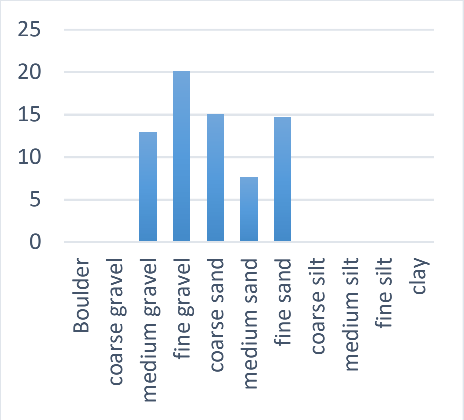
Grain Size Analysis Report Date: 30-01-17

Sample Name: MW3 SS-2 217-16

Mass Sample (g): 500 T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
25	0	0	100
19	0	0	100
12.5	44.5	0.089	91.1
9.5	20.5	0.041	87
4.75	46	0.092	77.8
2.36	42.5	0.085	69.3
2	12	0.024	66.9
1.18	34	0.068	60.1
0.6	41.5	0.083	51.8
0.425	19	0.038	48
0.3	19.5	0.039	44.1
0.15	44.5	0.089	35.2
0.075	29	0.058	29.4

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.026	Uniformity Coef.	45.98
d17	0.043	n computed	0.26
d20	0.051	g (cm/s^2)	980.00
d50	0.517	ρ (g/cm^3)	0.9981
d60	1.173	μ (g/cm s)	0.0098
de (Kruger)	0.778	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.702	tau (Sauerbrei)	1.053
de (Zunker)	0.726	$d_{geometric\ mean}$	1.375
de (Zamarin)	0.752	σ_ϕ	3.452
Io (Alyameni)	-0.097		

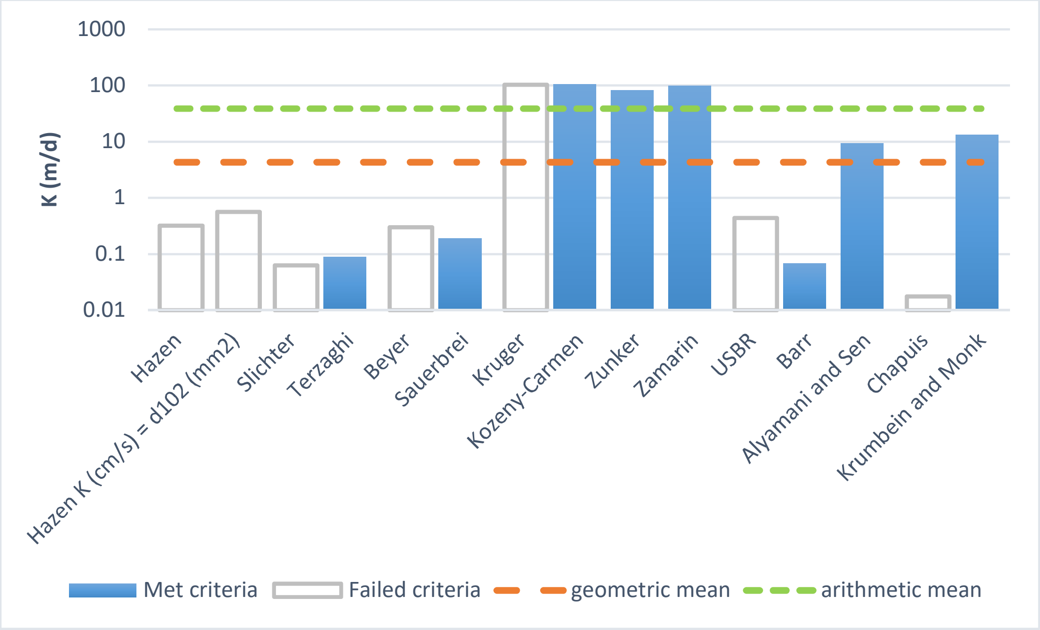
mm	0	% in sample
>64	Boulder	
16 - 64	coarse gravel	0
8 - 16	medium gravel	13
2 - 8	fine gravel	20.1
0.5 - 2	coarse sand	15.1
0.25 - 0.5	medium sand	7.7
0.063 - 0.25	fine sand	14.7
0.016 - 0.063	coarse silt	
0.008 - 0.016	medium silt	
0.002 - 0.008	fine silt	
<0.002	clay	

K from Grain Size Analysis Report | Date: 30-01-2017

Sample Name: MW3 SS-2 217-16

Mass Sample (g): 500 T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.369E-03	.369E-05	0.32	
Hazen K (cm/s) = d_{10} (mm)	.651E-03	.651E-05	0.56	
Slichter	.725E-04	.725E-06	0.06	
Terzaghi	.103E-03	.103E-05	0.09	
Beyer	.348E-03	.348E-05	0.30	
Sauerbrei	.221E-03	.221E-05	0.19	
Kruger	.120E+00	.120E-02	103.73	
Kozeny-Carmen	.121E+00	.121E-02	104.92	
Zunker	.952E-01	.952E-03	82.22	
Zamarin	.116E+00	.116E-02	99.89	
USBR	.508E-03	.508E-05	0.44	
Barr	.777E-04	.777E-06	0.07	
Alyamani and Sen	.109E-01	.109E-03	9.41	
Chapuis	.204E-04	.204E-06	0.02	
Krumbein and Monk	.153E-01	.153E-03	13.23	
geometric mean	.501E-02	.501E-04	4.33	
arithmetic mean	.449E-01	.449E-03	38.75	