TECHNICAL MEMORANDUM

DATE	May 27, 2014	**PROJECT No.**	13-1118-0010 (5008)
TO	Alexandra Drapack Osisko Hammond Reef Gold Ltd.	**DOC No.**	0033 (Rev 1)
FROM	Devin Hannan, P.Eng.	**EMAIL**	dhannan@golder.com

OSISKO HAMMOND REEF GOLD PROJECT – TAILINGS MANAGEMENT FACILITY, 3D GROUNDWATER MODELLING

1.0 INTRODUCTION

The purpose of this technical memorandum is to report on three-dimensional (3D) groundwater modelling of the eastern portion of the proposed Tailings Management Facility (TMF) for the Hammond Reef Gold Project and the adjacent Lizard Lake catchment area (Figure 1). The objectives of the modelling analysis are as follows:

- Simulate groundwater flow within and around the eastern portion of the TMF; and
- Evaluate applicability of the design concept for seepage collection.

The seepage collection system design is currently at a conceptual level and includes perimeter ditches and collection ponds. As such, a rigorous modelling analysis is not required at this time. Instead, the model described herein is used to evaluate the applicability of the conceptual design in terms of seepage collection such that it may be considered a practical basis for future designs. This modelling will be updated in the future for the purposes of detailed engineering design and regulatory permitting as new hydrogeological data is collected following approval of the Hammond Reef Gold Project Environmental Impact Statement/Environmental Assessment (Osisko, 2013).

2.0 TAILINGS MANAGEMENT FACILITY DESIGN

The modelled TMF layout is based on the design framework put forth in the technical memorandum *Design Basis for Runoff and Seepage Collection Systems – Hammond Reef Gold Project* (Golder, 2013[1]) included in the *Hydrogeology Technical Support Document (Version 2)* (Golder, 2013[2]). The TMF is proposed to store 165 Mm^3 of thickened tailings over a footprint of approximately 800 ha throughout five stages of tailings deposition and progressive dam raise construction. The modelling focusses on the TMF at the ultimate extent, as this configuration would produce the greatest amount of groundwater flow.

The conceptual design for the TMF containment system includes rockfill dams with upstream geomembrane liners. The reclaim pond dams will be fully lined, whereas the upstream rockfill dam shells will be lined on the lower (approximate) half of their upstream flank. Runoff and water released from the tailings due to consolidation/settlement will be collected in the TMF reclaim pond (located south of the TMF). Groundwater seepage will be collected by perimeter collection ditches and conveyed to collection ponds where it will be pumped back to the TMF reclaim pond.

3.0 HYDROGEOLOGICAL DATA

The primary source of hydrogeological data for model construction is *Hydrogeology Technical Support Document (Version 2)* (Golder, 2013[2]). This TSD includes site borehole logs, hydraulic testing, and grain size analysis summaries. The following information from the TSD is pertinent to the model construction:

- The average overburden depth within the model domain is 5 m;
- Bedrock weathering is not typically observed in borehole logs within the model domain; however, where present, the weathered thickness is less than 3 m;
- The geometric mean hydraulic conductivity of the coarse grained material in the TMF area is 6E-6 m/s; and
- The geometric mean hydraulic conductivity of the upper bedrock zone in the TMF area is 2E-6 m/s.

Figure 1 shows the location of site boreholes and their respective overburden depths. The borehole logs within the model domain (and BRH-0019, which lies slightly outside of the model domain but is included in this analysis) are provided in Appendix A of this memorandum.

4.0 MODEL CONSTRUCTION

A summary of model input parameters and boundary conditions are provided in Table 1. Additional information is as follows:

- **Code:** MODFLOW-2005 (Harbaugh, 2005) is the code used to simulate groundwater flow at the site. MODFLOW is a multi-purpose three dimensional groundwater flow code developed by the United States Geological Survey. It is modular in nature and uses the finite difference formulation of the groundwater flow equation in its solution. MODFLOW has been recognized as an industry standard for general purpose groundwater flow modelling and has gained wide acceptance from academia, consultants and regulatory agencies worldwide. Visual MODFLOW® (Version 2011.1) is used as the pre and post-processor for the simulations presented in this report. SAMG (Algebraic Multigrid Methods for Systems) is used to solve the groundwater flow equations.
- **Domain:** The groundwater model domain is shown on Figure 1. The domain is limited to the eastern TMF as this is the area where seepage would be directed towards Lizard Lake; the remaining western TMF area would discharge towards Sawbill Bay. As such, the western flank of the model is ascribed according to the future topographic divide created by the tailings mound. The eastern boundary of the model is represented by Lizard Lake. The remaining model outline is delineated according to subcatchment divides.
- **Layout:** The MODFLOW representation of the TMF and surrounds is displayed on Figure 2 (model layer 1 shown).
- **Layers:** The nominal model layering is as follows: 1) Tailings and lake bathymetry (Lizard Lake depth taken from Golder, 2013[3]); 2) Dam Materials (Upper); 3) Dam Materials (Lower); 4) Overburden; 5) Weathered Bedrock; 6) Competent Bedrock. Note that it is necessary to subdivide the dam geometry as the tailings dams only have liner on the approximate lower half of their upstream shell, whereas the reclaim pond dam has liner along its entire upstream shell. For a given layer, where the nominal material is not present, the numerical layer thins out to 1 m and the underlying material property is input in its stead.
- **Hydraulic Conductivity:** A “bulk” approach to assigning hydraulic conductivities to each unit is utilized. Spatial differentiation of hydraulic conductivities within units is not considered warranted given the scope of

this model analysis. Isotropic conditions are assumed at each material with the exception of the overburden, which is assigned a K_H:K_Z of 1:0.1. This anisotropy is selected due to the presence of clayey lenses within the overburden material that would tend to impede vertical flow.

- **Geomembrane Liner:** The geomembrane liner is considered impermeable (inactive cells) in the model. However, there is the potential that future "wear and tear" of the liner may increase the effective permeability the material. This could result in some shallow seepage crossing the rockfill dams; however, this seepage would ultimately report to the perimeter seepage collection ditches and be captured.
- **Perimeter Seepage Collection Ditches:** The seepage collection ditches are represented by drain cells at a depth of 7 m below existing ground surface.
- **Cross-Section**: A west-east cross-section through the model domain is shown on Figure 3.

5.0 MODEL RESULTS

Figure 4 displays the simulated water table surface. Groundwater flows from a high at the tailings radially outward, eventually discharging to either the perimeter seepage collection ditching, drainage features upstream of Lizard Lake or to Lizard Lake itself.

Table 2 lists the model flow budget. The term "in" means into the *groundwater* system, whereas "out" means out of the *groundwater* system. The total amount of water entering and leaving the modelled groundwater system is 1,954 m^3/d.

Inflows: Most of the inflow to the model is provided by the tailings (712 m^3/d) and reclaim pond (1,240 m^3/d). Some flow occurs within the tailings themselves, a result of constant head cells at higher elevations "feeding" adjacent cells at lower elevations – this is a normal and expected numerical outcome given the representation of the tailings water table surface as sloped constant heads. It follows that the net groundwater flow emanating from the TMF is 712 m^3/d – 395 m^3/d = 317 m^3/d. Note that a small portion of inflow, 2 m^3/d, occurs from the Lizard Lake upstream drainage to Lizard Lake itself. This is a result of the drainage feature having a higher head elevation than the downstream Lizard Lake.

Outflows: For this given conceptual design the majority of the outflow reports to the perimeter collection ditches (1,409 m^3/d). The remainder of outflow reports to the Lizard Lake catchment (146 m^3/d total).

Seepage Collection: Also provided in Table 2 is a breakdown of flows as they pertain to collection ditch efficiency for the conceptual design. A total of 1,409 m^3/d of the 1,553 m^3/d of groundwater emanating from the TMF is retained. These results reflect a capture efficiency of 91%. This is consistent with the treatment efficiency used in the EIS/EA (Osisko, 2013).

6.0 CONCLUSIONS

A 3D MODFLOW groundwater model is constructed to simulate flow in and around the eastern portion of the TMF and Lizard Lake and to estimate the capture efficiency of the proposed seepage collection system conceptual design. The modelling analysis suggests that a capture efficiency of greater than 90% is achievable using a perimeter seepage collection ditch of 7 m or greater. It follows that the seepage collection system conceptualization forms a reasonable basis for future detailed design, and that values used in the EIS/EA evaluation is reasonable and appropriate.

7.0 RECOMMENDATIONS

It is recommended that, as the conceptual design is advanced during pre- construction stages, the model should in turn be refined to provide more exacting estimates of seepage and continue to assist in the design finalization. With a more refined model, a sensitivity analysis may be performed to determine an upper and lower bound on results.

8.0 REFERENCES

Golder, 2013[1]. *Design Basis for Runoff and Seepage Collection Systems – Hammond Reef Gold Project.* Document No. 011 (Rev 0). Project No. 13-1118-0010 (2010). Submitted to Osisko Hammond Reef Gold Ltd. December 3, 2013.

Golder, 2013[2]. *Hammond Reef Gold Project, Hydrogeology Technical Support Document, Version 2.* Document No. DOC017. Project No. 13-1118-0010. Submitted to Osisko Hammond Reef Gold Ltd. December 2013.

Golder, 2013[3]. *Hammond Reef Gold Project, Aquatic Environment Technical Support Document, Version 2.* Document No. DOC013. Project No. 13-1118-0010. Submitted to Osisko Hammond Reef Gold Ltd. December 2013.

Harbaugh, A.W., 2005. *MODFLOW-2005, The U.S. Geological Survey Modular Ground-Water Model - the Ground-Water Flow Process.* U.S. Geologic Survey Techniques and Methods 6-A16.

Osisko (Osisko Hammond Reef Gold Ltd.), 2013. *Hammond Reef Gold Project, Environmental Impact Statement/Environmental Assessment Report. Version 2.* Submitted to Canadian Environmental Assessment Agency and Ontario Ministry of the Environment. December 2013. Toronto, ON.

9.0 CLOSURE

We trust this meets your current requirements. If you have any questions please do not hesitate to contact the undersigned.

<Original signed by> <Original signed by>

Devin Hannan, P.Eng.
Associate, Environmental Engineer

Ken De Vos, M.Sc., P.Geo.
Principal

DAH/KD/sp

Attachments:
Table 1 – Summary of Model Construction Details
Table 2 – Model Flow Budget
Figure 1 – General Arrangement Plan Tailings Management Facility
Figure 2 – Model Layout (Layer 1)
Figure 3 – Model Cross-section
Figure 4 – Simulated Water Table (masl)
Appendix A – Borehole logs

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TABLES

TABLE 1
Summary of Model Construction Details

General Attributes	
Code	USGS MODFLOW 2000
Software	Visual MODFLOW Version 2011.1
Flow Type	Steady-State
Dimensions	3D

Domain	
Area	10 km^2
Horizontal Extents	2 km wide x 5 km long
Vertical Extents	492 masl to 400 masl
Top of Model	Ground Surface (see Figure 1)
Bottom of Model	400 masl (competent rock layer)

Grid Layout	
Grid Spacing	10 m x 10 m to 20 m x 20 m
Number of Layers	6
Number of Active Cells	538,314

Numerical Layer Details

Layer	**Nominal Description**	**Thickness**	**Notes**
1	Tailings and Lake Bathymetry	62 m to 1 m	
2	Rockfill Dam and Liner (Upper)	14 m to 1 m	Liner ~ 1 m thick.
3	Rockfill Dam and Liner (Lower)	14 m to 1 m	Liner ~ 1 m thick.
4	Overburden	5 m - 7 m	
5	Weathered Bedrock	3 m	
6	Competent Bedrock	80 m to 1 m	

Material Properties

Material	**Hydraulic Conductivity K_H (m/s)**	**K_H:K_Z**	**Source**
Tailings	6E-07	1:1	(Golder, 2012)
Water Bodies	1E-02	1:1	Assumed
Rockfill	1E-04	1:1	Assumed
Geomembrane Liner	Impermeable	1:1	Assumed
Overburden	6E-06	1:0.1	Golder, 2013[2]
Weathered Bedrock	2E-06	1:1	Golder, 2013[2]
Competent Bedrock	2E-08	1:1	Assumed

Boundary Conditions

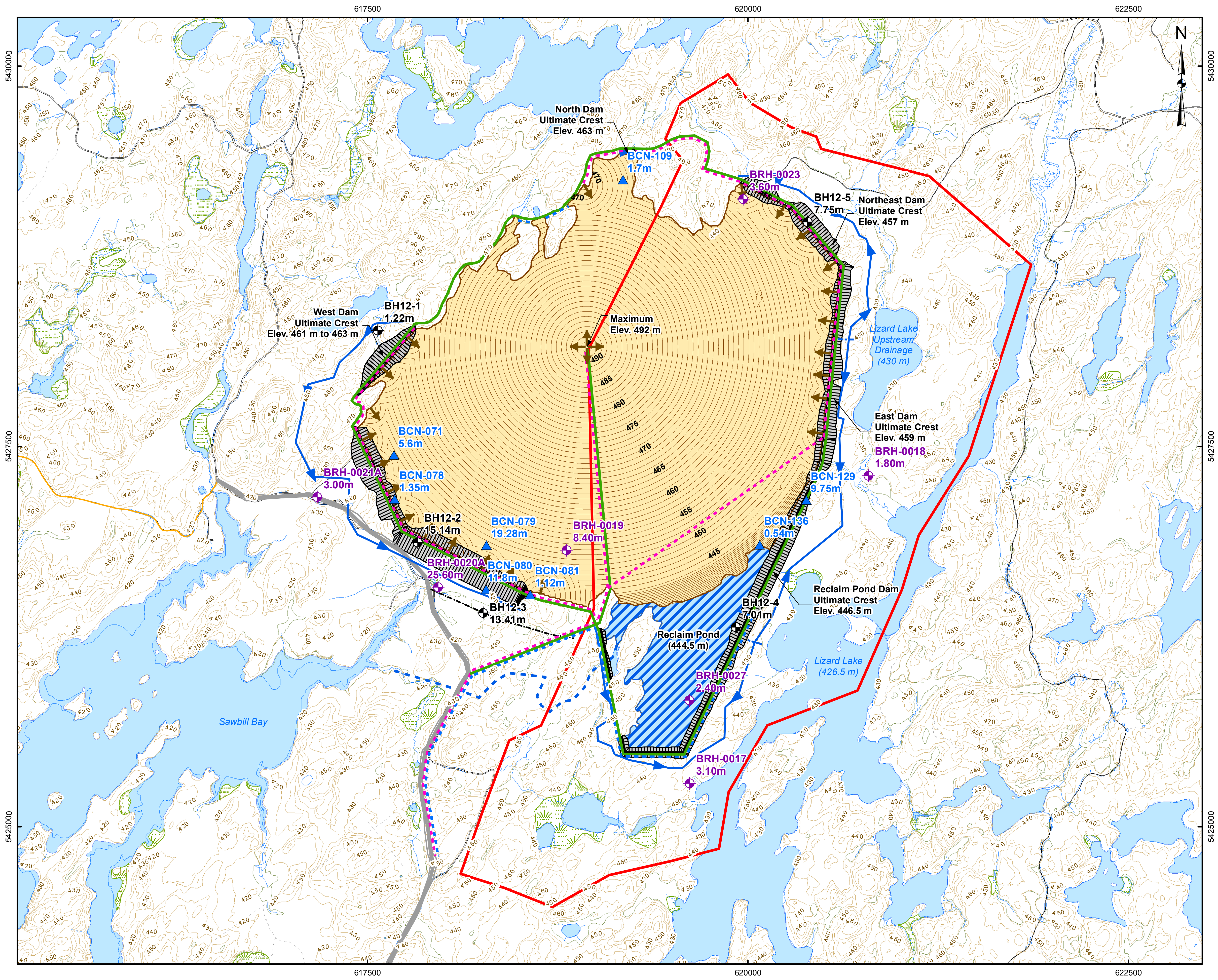
Feature	**Type**	**Assigned Head**	**Source**
Tailings Phreatic Surface	Constant Head	Ground minus 2 m	Assumed
Reclaim Pond	Constant Head	444.5 masl	Golder, 2013[2]
Seepage Collection Ditch	Drains (Conductance 500 m^2/d)	Ground minus 7 m	Iterative modelling.
Lizard Lake U/S Drainage	Constant Head	430 masl	Golder, 2013[2]
Lizard Lake	Constant Head	426.65 masl	Golder, 2013[3]
External Catchment Areas	Inactive	-	Golder, 2013[2]

TABLE 2
Model Flow Budget

Global Flow Balance				
Feature	**Boundary Type**	**Flow In (m^3/d)**	**Flow Out (m^3/d)**	**Net In (+) / Out (-)**
Tailings	CH	712	395	317
Reclaim Pond	CH	1,240	4	1,236
Northeast Dam Collection Trench	Drains	0	110	-110
East Dam Collection Trench	Drains	0	196	-196
Reclaim Pond Collection Trench	Drains	0	1,103	-1,103
Lizard Lake	CH	0	126	-126
Lizard Lake Upstream Drainage	CH	2	20	-18
	TOTAL:	1,954	1,954	0

TMF Groundwater Flow Details	
Total Groundwater Flow External To TMF (m^3/d)	1,553
Tailings Seepage Collected (m^3/d)	306
Reclaim Pond Seepage Collected (m^3/d)	1,103
Bypass to Lizard Lake and Lizard Lake Drainage (m^3/d)	144
Collection Efficiency (%)	91
Bypass to Lizard Lake Catchment (%)	9

FIGURES



LEGEND

- Index Contour (5m interval)
- Ditch
- Marsh/Swamp
- River/Stream
- Road
- Trail
- Lake
- Wetland
- ▲ Osisko Exploration Borehole (Overburden Thickness Labelled)
- Hydrogeological Borehole (Overburden Thickness Labelled)
- Geotechnical Borehole (Overburden Thickness Labelled)
- Perimeter Seepage Collection Ditch
- Pit Spillover Point
- Tailings Discharge Location
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Reclaim Pipeline
- Spillway Channel
- Tailings Pipeline
- TMF Access Road
- Model Domain
- Dam
- Tailings Management Facility
- Tailings Management Facility Reclaim Pond

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500
SCALE 1:25,000 METERS

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
GENERAL ARRANGEMENT PLAN
TAILINGS MANAGEMENT FACILITY (ULTIMATE)

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	REV. ION 2
DESIGN	CGE	14 Nov. 2008	FIGURE: 1	
GIS	SC	20 May. 2014		
CHECK	DH	20 May. 2014		
REVIEW	DH	20 May. 2014		

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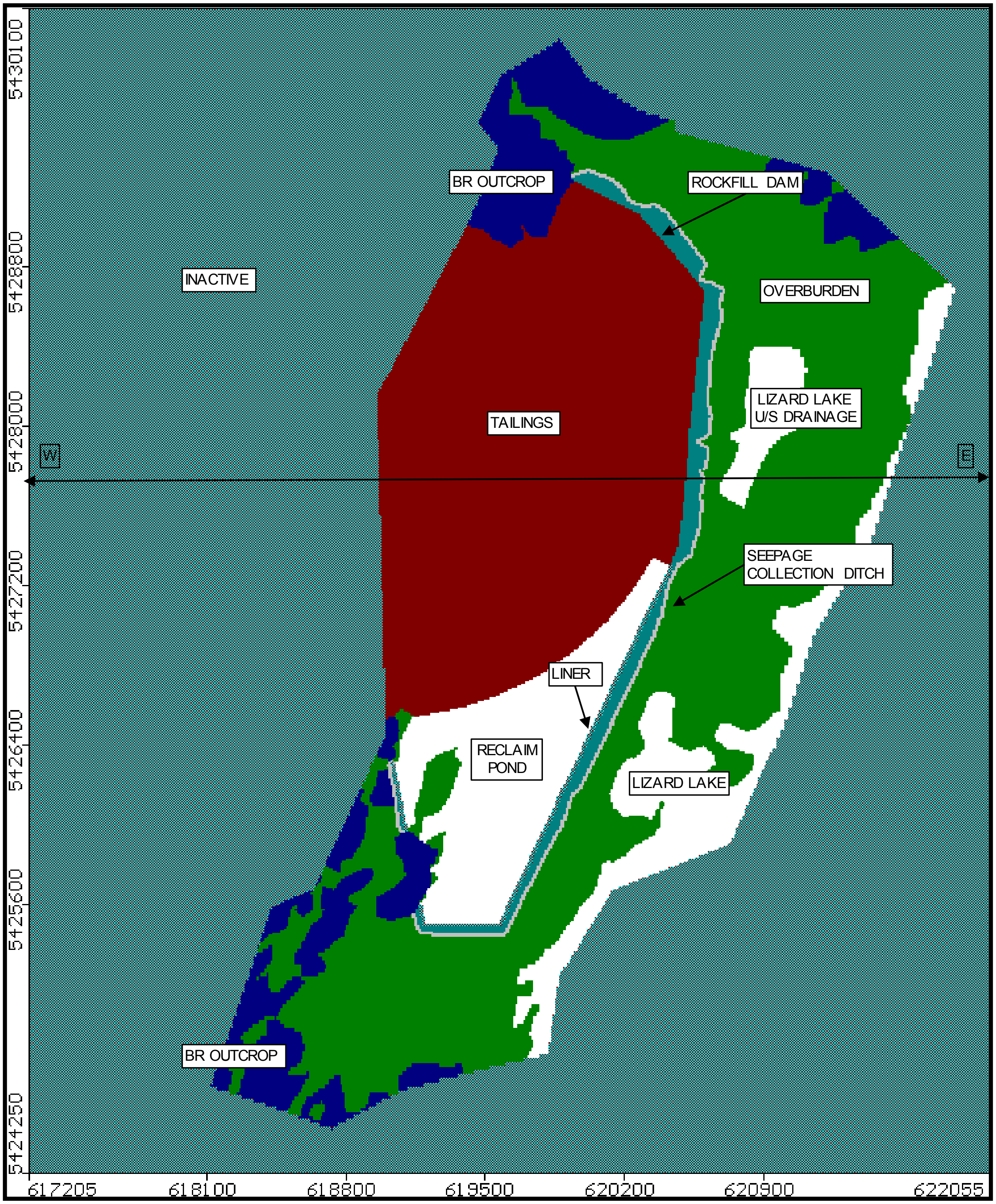

LEGEND

UNIT	DESCRIPTION
⬜	WATER BODY
🟥	TAILINGS
🟦	ROCKFILL DAM
🟩	OVERBURDEN
🟦	WEATHERED BEDROCK
◻	COLLECTION DITCH
▨	INACTIVE / NO FLOW

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
MODEL LAYOUT (LAYER 1)

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			REV. 0.0
DESIGN	SC	5 May. 2014	FIGURE: 2
GIS	SC	21 May. 2014	
CHECK	DH	21 May. 2014	
REVIEW	DH	21 May. 2014	

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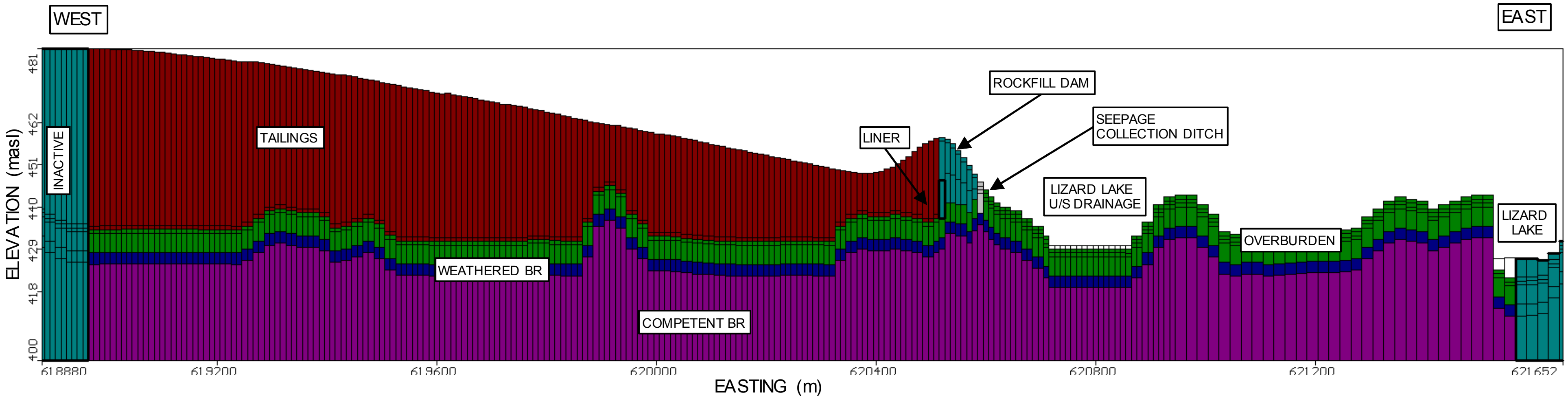

LEGEND

UNIT	DESCRIPTION
⬜	WATER BODY
🟥	TAILINGS
▨	ROCKFILL DAM
🟩	OVERBURDEN
🟦	WEATHERED BEDROCK
▒	COLLECTION DITCH
▩	INACTIVE / NO FLOW

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
MODEL CROSS-SECTION

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			REV. 0.0
DESIGN	SC	5 May. 2014	FIGURE: 3
GIS	SC	21 May. 2014	
CHECK	DH	21 May. 2014	
REVIEW	DG	21 May. 2014	

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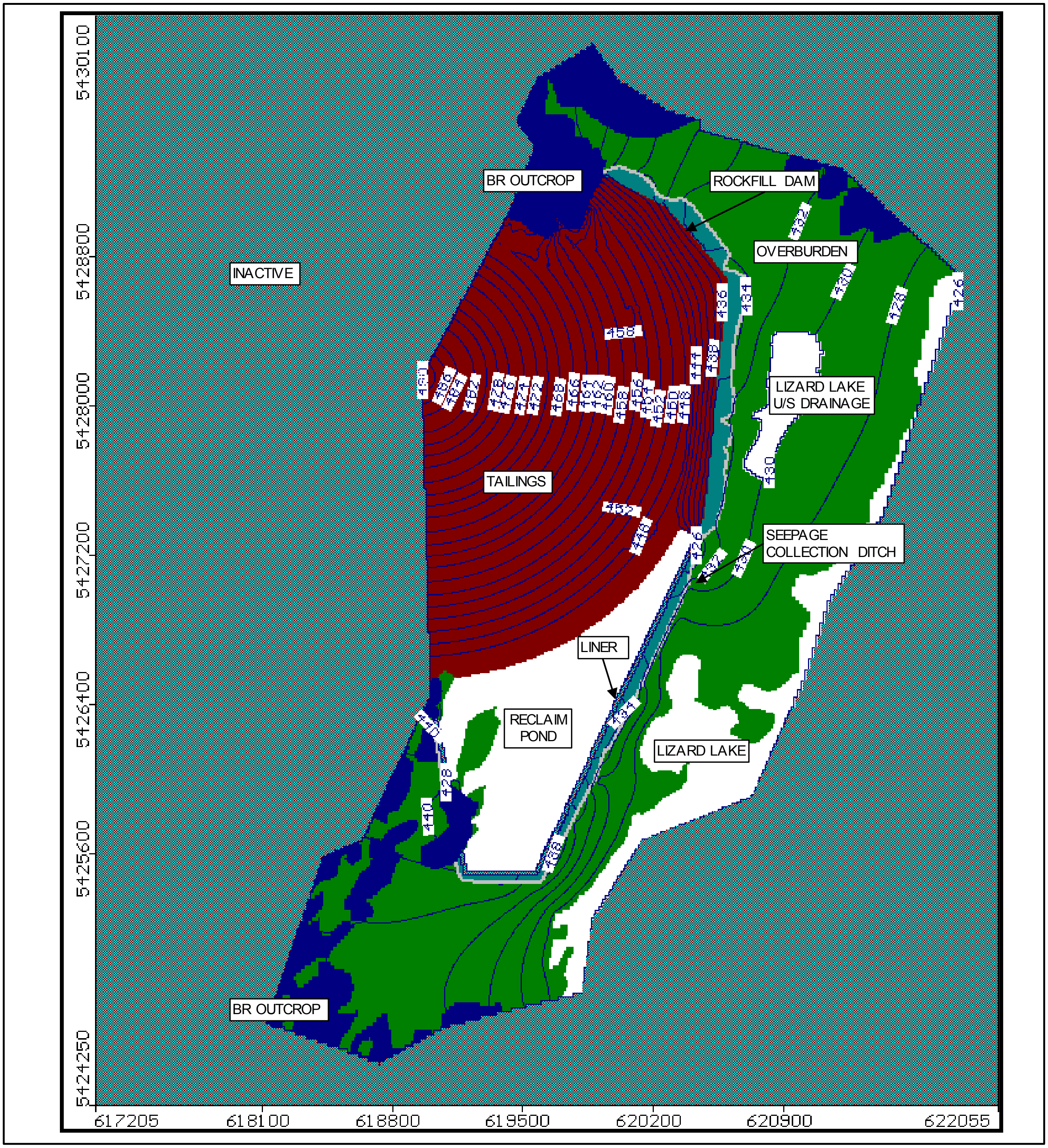

LEGEND

UNIT	DESCRIPTION
⬜	WATER BODY
🟥	TAILINGS
🟦	ROCKFILL DAM
🟩	OVERBURDEN
🟦	WEATHERED BEDROCK
⬜	COLLECTION DITCH
▨	INACTIVE / NO FLOW

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
SIMULATED WATER TABLE (masl)

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			REV. 0.0
DESIGN	SC	5 May. 2014	FIGURE: 4
GIS	SC	21 May. 2014	
CHECK	DH	21 May. 2014	
REVIEW	DH	21 May. 2014	

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APPENDIX A

Borehole logs

PROJECT: 10-1118-0020 / 4000

RECORD OF BOREHOLE: BRH-0017A

SHEET 1 OF 1

LOCATION: N 5425289.5 ;E 619623.7

BORING DATE: April 7, 2011

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

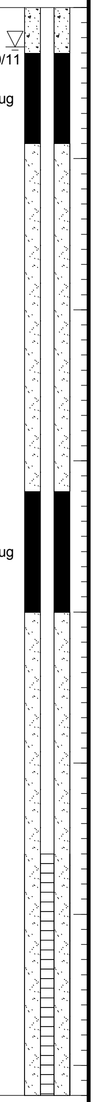
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp —○W— Wl — 16 32 48 64

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
		GROUND SURFACE	424.6				
0	CME 55 200 mm Diam. (Hollow Stem Auger)	Loose, moist to wet, brown, silty SAND, some organics.	0.0	1 2	50 DO 50 DO	- 55	
1.5		Loose to compact, wet, brown, SAND, some silt, some clay, trace gravel.	423.1 1.5	3	50 DO	20	MH
2.3		Compact, wet, brown, medium to coarse, SAND, trace to some gravel, trace silt.	422.3 2.3	4 5	50 DO 50 DO	18 50/ 0.1	
3.1	CME 55 NQ Core	Fresh bedding, grey, very coarse-grained, crystalline, strong rock (TONALITE).	421.5 3.1				
7.2		END OF BOREHOLE Note: 1. For coring details see Record of Drillhole BRH-0017A.	417.4 7.2				

PIEZOMETER OR STANDPIPE INSTALLATION



Cement

▽ 29/10/11

Bentonite Holeplug

Riser

Silica Sand

Bentonite Holeplug

Silica Sand

31.8 mm Diam. PVC #10 Slot Screen

0.84 m Riser Stickup.

SUD-BOREHOLE 10-1118-0020 (4000).GPJ GLDR_CAN.GDT 21/09/12 DATA INPUT:

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TDM
CHECKED: MO

PROJECT: 10-1118-0020 / 4000

RECORD OF DRILLHOLE: BRH-0017A

SHEET 1 OF 1

LOCATION: N 5425289.5 ;E 619623.7
INCLINATION: -90° AZIMUTH: ---

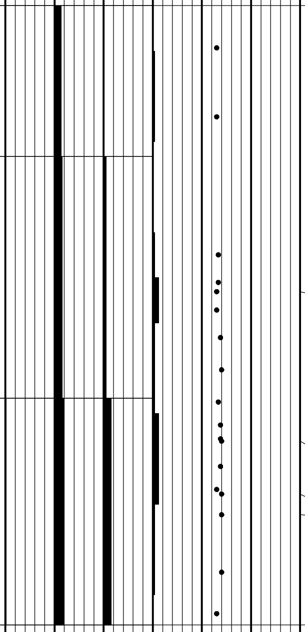
DRILLING DATE: April 7, 2011
DRILL RIG: CME 55 Trackmount
DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DATUM: Geodetic

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
		TOP OF BEDROCK	421.50	
	CME 55 NQ Core	Fresh, bedding, grey, very coarse-grained, crystalline, strong rock (TONALITE).	3.10	1
4				
5				2
6				
				3
7			417.4 7.2	
		END OF DRILLHOLE		
8				
9				
10				
11				
12				
13				

COLOUR % RETURN / FLUSH — RECOVERY: TOTAL CORE %, SOLID CORE % — R.Q.D. % — FRACT. INDEX METRES — DISCONTINUITY DATA: B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn — HYDRAULIC CONDUCTIVITY k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}) — Diametral Point Load Index (MPa) — RMC -Q' AVG.



TYPE AND SURFACE DESCRIPTION:
JPLR
JPLR
JPLSM
JPLSM
JPLSM
JPLR
JIR
JIR
JPLR
JPLR
JPLR
JPLR
JPLR
JPLR
JIR
JIR
JIR
JIR

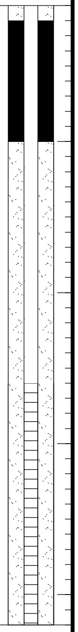
Silica Sand

Bentonite Holeplug

Silica Sand

31.8 mm Diam. PVC #10 Slot Screen

0.84 m Riser Stickup.



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TDM
CHECKED: MO

RECORD OF BOREHOLE: BRH-0017B

PROJECT: 10-1118-0020 / 4000

SHEET 1 OF 1

LOCATION: N 5425289.5 ;E 619623.7

BORING DATE: April 7, 2011

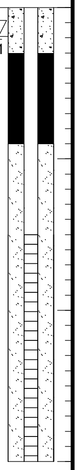
DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (16 32 48 64)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	427.7							
0	CME 55 200 mm Diam. (Hollow Stem Auger)	Refer to Borehole BRH-0017A for stratigraphy details.	0.0							Cement ▽ 29/10/11 Bentonite Holeplug Riser
1			426.2 1.5							
2			425.4 2.3							Silica Sand 31.8 mm Diam. PVC #10 Slot Screen
3	CME 55 NQ Core		424.6 3.1							
4										
5										
6										
7			420.5							
		END OF BOREHOLE Note: 1. Monitoring well installation in same Borehole as BRH-0017A.	7.2							0.81 m Riser Stickup.
8										
9										
10										



DEPTH SCALE
1 : 50

LOGGED: TDM
CHECKED: MO

PROJECT: 10-1118-0020 / 4000

RECORD OF BOREHOLE: BRH-0018

SHEET 1 OF 1

LOCATION: N 5427310.9 ;E 620793.8

BORING DATE: March 28, 2011

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 16 32 48 64	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		430.6							
0	CME 55 200 mm Diam. (Hollow Stem Auger)	Loose, moist, brown, CLAYEY SAND and SILT		0.0	1	50 DO	PH		○	MH	
1					2	50 DO	15				
		Compact, moist, brown to grey, silty SAND, trace to some gravel.		429.2 1.4	3	50 DO	50/ 0.28		○		27/10/11
2	CME 55 NQ Core	Fresh, grey, very coarse-grained, crystalline, strong rock (quartz GRANITE)		428.8 1.8							Bentonite Holeplug
3											Riser
4											
5											
6											31.8 mm Diam. PVC #10 Slot Screen
											Silica Sand
7											
8											
		END OF BOREHOLE Note: 1. For coring details see Record of Drillhole BRH-0018.		421.9 8.7							0.97 m Riser Stickup.
9											
10											

SUD-BOREHOLE 10-1118-0020 (4000).GPJ GLDR_CAN.GDT 21/09/12 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TDM

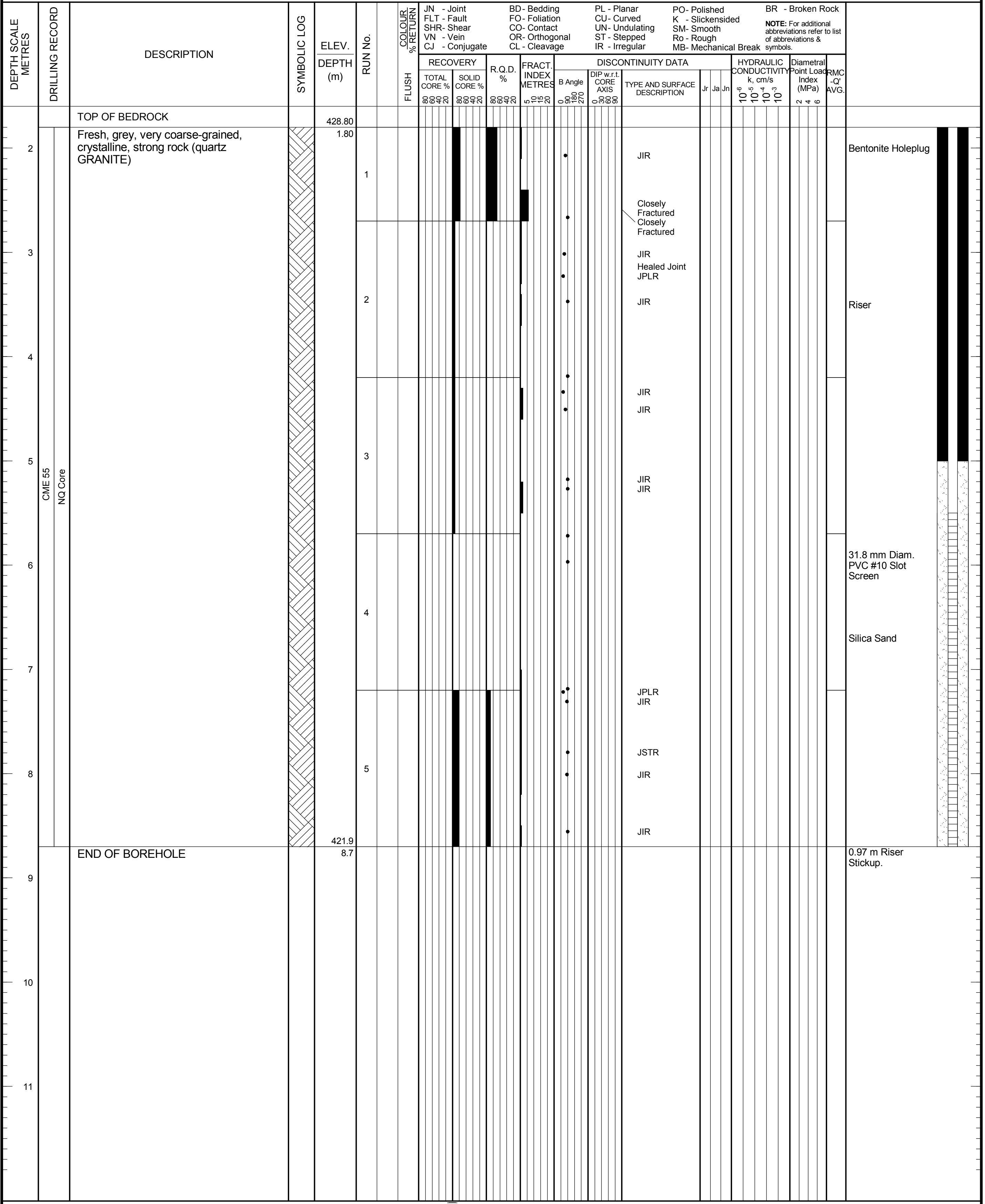
CHECKED: MO

RECORD OF DRILLHOLE: BRH-0018

PROJECT: 10-1118-0020 / 4000
LOCATION: N 5427310.9 ;E 620793.8
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: March 28, 2011
DRILL RIG: CME 55 Trackmount
DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

SHEET 1 OF 1
DATUM: Geodetic



JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
	TOP OF BEDROCK	428.80	
2	Fresh, grey, very coarse-grained, crystalline, strong rock (quartz GRANITE)	1.80	1
3			2
4			
5			3
6			4
7			
8		421.9 8.7	5
	END OF BOREHOLE		
9			
10			
11			

TYPE AND SURFACE DESCRIPTION:

JIR
Closely Fractured
Closely Fractured
JIR
Healed Joint
JPLR
JIR
JIR
JIR
JIR
JIR
JPLR
JIR
JSTR
JIR
JIR

Bentonite Holeplug
Riser
31.8 mm Diam. PVC #10 Slot Screen
Silica Sand
0.97 m Riser Stickup.

DEPTH SCALE
1 : 50

LOGGED: TDM
CHECKED: MO

PROJECT: 10-1118-0020 / 4000

RECORD OF BOREHOLE: BRH-0019

SHEET 1 OF 1

LOCATION: N 5426821.6 ;E 618808.1

BORING DATE: March 19, 2011

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

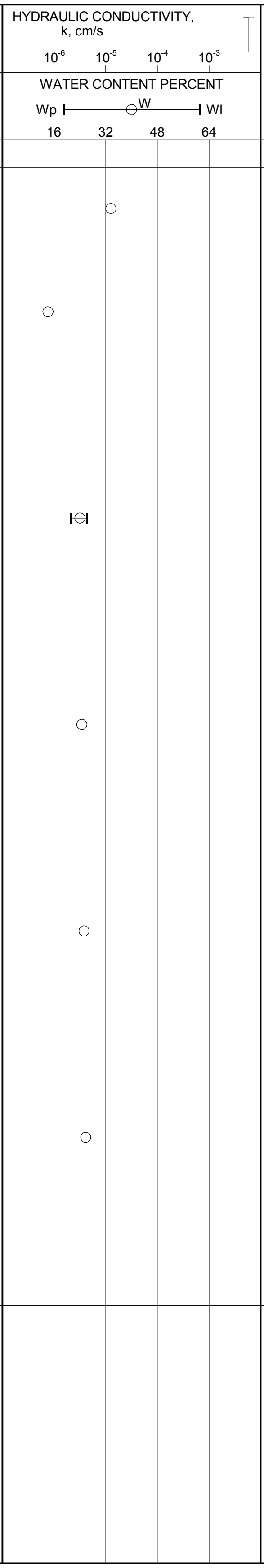
INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

BORING METHOD: CME 55 200 mm Diam. (Hollow Stem Auger)

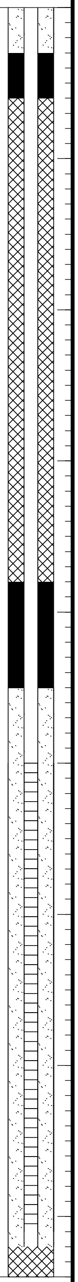
SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	430.6
Wet, dark brown, PEAT (ORGANICS).	0.0
Wet, dark brown, sandy SILT and ORGANICS (TOPSOIL).	430.3 0.3
Grey-brown to brown, layered, SILTY, CLAYEY SAND, oxidized mottling.	430.0 0.6
Wet, brown, layered, clayey SILT, some sand, oxidized mottling.	429.1 1.5
Moist to wet, grey, layered, SILTY CLAY, trace sand to CLAY, some silt, trace sand	427.6 3.0
Wet, brown, medium to coarse, granitic, SAND, trace silt.	423.0 7.6
END OF BOREHOLE PROBABLE BEDROCK REFUSAL	422.2 8.4

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	3	
2	50 DO	5	MH
3	50 DO	25	
4	50 DO	28	MH
5	50 DO	26	
6	50 DO	22	
7	50 DO	27	MH
8	50 DO	15	MH
9	50 DO	15	
10	50 DO	11	
11	50 DO	2	



PIEZOMETER OR STANDPIPE INSTALLATION

26/10/11



Silica Sand
Bentonite Holeplug
Riser
Cuttings
Bentonite Holeplug
Silica Sand
31.8 mm Diam. PVC #10 Slot Screen
Cave
0.83 m Riser Stickup.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MO
CHECKED: MO

PROJECT: 10-1118-0020 / 4000

RECORD OF BOREHOLE: BRH-0023

SHEET 1 OF 1

LOCATION: N 5429127.4 ;E 619973.0

BORING DATE: March 26, 2011

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

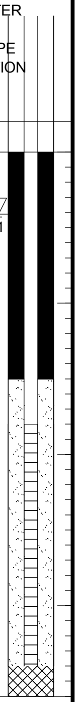
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 16 32 48 64

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
		GROUND SURFACE	434.9				
0	CME 55 200 mm Diam. (Hollow Stem Auger)	Boulders and TOPSOIL.	0.0				
		Moist to wet, greyish-brown, SILT and SAND, trace organics.	434.4 0.5	1	50 DO	11	MH
		Wet, brown, gravelly SILT and SAND.	433.6 1.3				
		Wet, brown, SAND and GRAVEL, some clay, trace silt, trace cobbles and boulders.	433.4 1.5	2	50 DO	21	MH
		SAND and BOULDERS, some gravel, trace silt.	432.6 2.3	3	50 DO	32	
		Gravelly SAND, some silt, trace clay.	432.2 2.7	4	50 DO	8	MH
		END OF BOREHOLE PROBABLE BEDROCK REFUSAL	431.3 3.6				

Depth scale marks: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

PIEZOMETER OR STANDPIPE INSTALLATION



27/10/11

Bentonite Holeplug

Riser

Silica Sand
31.8 mm Diam.
PVC #10 Slot
Screen

Cave In

0.9 m Riser
Stickup.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MO
CHECKED: MO

SUD-BOREHOLE 10-1118-0020 (4000).GPJ GLDR_CAN.GDT 21/09/12 DATA INPUT:

PROJECT: 10-1118-0020 / 4000

RECORD OF BOREHOLE: BRH-0027

SHEET 1 OF 1

LOCATION: N 5425831.2 ;E 619613.6

BORING DATE: April 8, 2011

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

INCLINATION: -90 degrees

PENETRATION TEST HAMMER, 63.5 kg; DROP, 760 mm

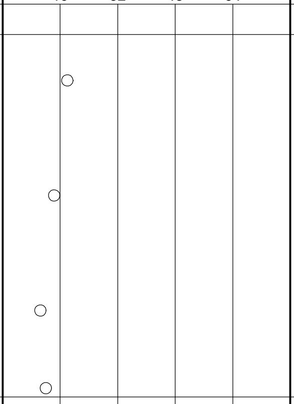
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	434.8					
0	CME 55 200 mm Diam. (Hollow Stem Auger)	Loose, moist, PEAT.	0.0					
		Loose, wet, dark brown, PEAT, some sand, some silt.	434.6 0.2	1	50 DO	PL		
		Loose to compact, wet, grey, SANDY, SILTY CLAY	434.2 0.6					Bentonite Holeplug
1				2	50 DO	8	MH	Riser
								Silica Sand 31.8 mm Diam. PVC #10 Slot Screen
2		Compact, wet, grey, coarse, SILTY SAND, some gravel, some clay.	433.1 1.7	3	50 DO	13		
			432.4	4	50 DO	50/ 0.12	MH	
		END OF BOREHOLE PROBABLE BEDROCK REFUSAL	2.4					0.95 m Riser Stickup.

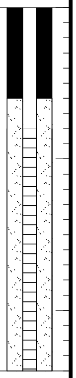
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 16 32 48 64





DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TDM
CHECKED: MO

PROJECT: 11-1118-0074

RECORD OF BOREHOLE: BH 12-4

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: August 8 and 9, 2012

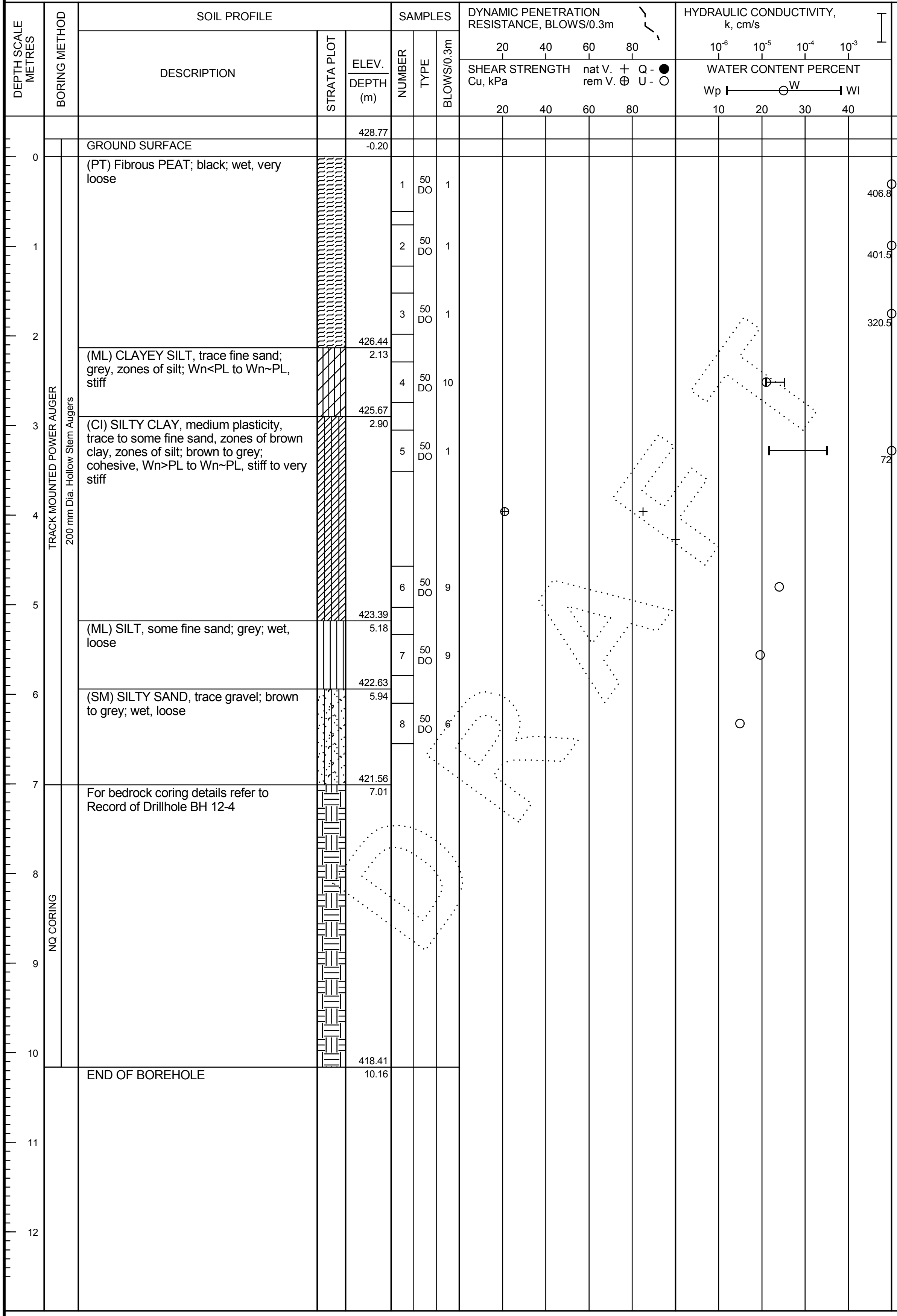
DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	428.77 -0.20
TRACK MOUNTED POWER AUGER 200 mm Dia. Hollow Stem Augers	(PT) Fibrous PEAT; black; wet, very loose	426.44 2.13
	(ML) CLAYEY SILT, trace fine sand; grey, zones of silt; Wn<PL to Wn~PL, stiff	425.67 2.90
	(CI) SILTY CLAY, medium plasticity, trace to some fine sand, zones of brown clay, zones of silt; brown to grey; cohesive, Wn>PL to Wn~PL, stiff to very stiff	423.39 5.18
	(ML) SILT, some fine sand; grey; wet, loose	422.63 5.94
	(SM) SILTY SAND, trace gravel; brown to grey; wet, loose	421.56 7.01
NQ CORING	For bedrock coring details refer to Record of Drillhole BH 12-4	418.41 10.16
	END OF BOREHOLE	

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	1	
2	50 DO	1	
3	50 DO	1	
4	50 DO	10	MH
5	50 DO	1	MH
6	50 DO	9	
7	50 DO	9	
8	50 DO	6	MH



PIEZOMETER OR STANDPIPE INSTALLATION

50 mm Diameter Monitoring Well

Bentonite Seal

Silica Sand Filter

1. Water encountered during drilling at a depth of 0.6 m below ground surface, Aug. 8/12

2. Water level at a depth of 2.7 m below ground surface upon completion of drilling, Aug. 9/12

2. Water level measured in monitoring well at a height of 0.02 m (Elev. 428.59 m) above ground surface, Aug. 28/12

DEPTH SCALE

1 : 63.5

Golder Associates

LOGGED: AM

CHECKED:

PROJECT: 11-1118-0074

RECORD OF BOREHOLE: BH 12-5

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

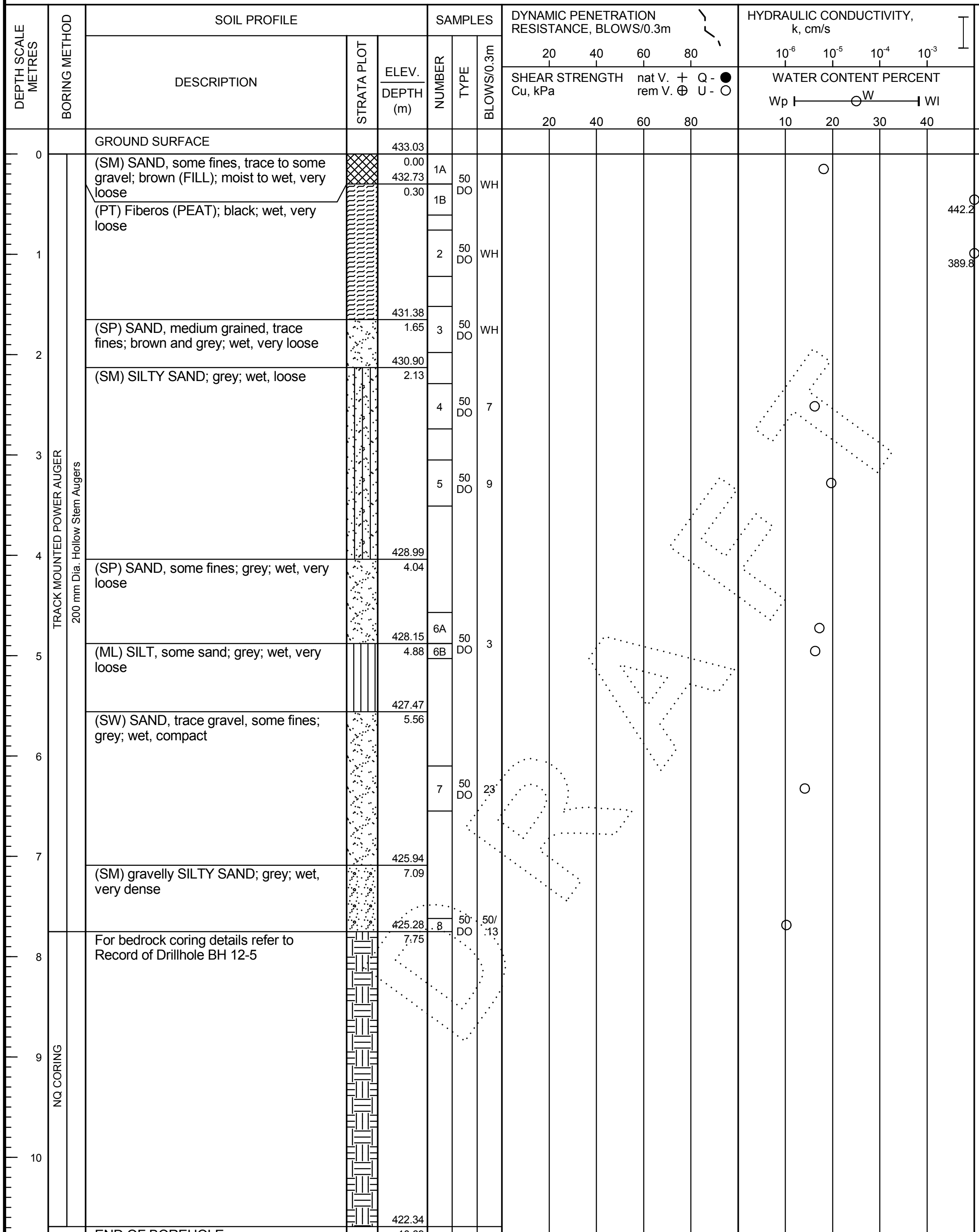
BORING DATE: August 21, 2012

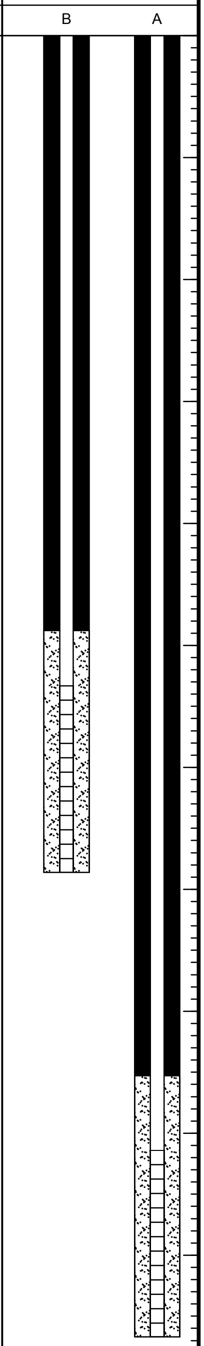
DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
	GROUND SURFACE	433.03				
TRACK MOUNTED POWER AUGER 200 mm Dia. Hollow Stem Augers	(SM) SAND, some fines, trace to some gravel; brown (FILL); moist to wet, very loose	0.00	1A 1B	50 DO	WH	
	(PT) Fiberos (PEAT); black; wet, very loose	432.73 0.30	2	50 DO	WH	
	(SP) SAND, medium grained, trace fines; brown and grey; wet, very loose	431.38 1.65	3	50 DO	WH	
	(SM) SILTY SAND; grey; wet, loose	430.90 2.13	4	50 DO	7	MH
			5	50 DO	9	MH
	(SP) SAND, some fines; grey; wet, very loose	428.99 4.04	6A			
	(ML) SILT, some sand; grey; wet, very loose	428.15 4.88	6B	50 DO	3	
	(SW) SAND, trace gravel, some fines; grey; wet, compact	427.47 5.56	7	50 DO	23	MH
	(SM) gravelly SILTY SAND; grey; wet, very dense	425.94 7.09	8	50 DO	50/ 13	MH
NQ CORING	For bedrock coring details refer to Record of Drillhole BH 12-5	425.28 7.75				
	END OF BOREHOLE	422.34 10.69				





1. Water encountered during drilling at a depth of 0.1 m below ground surface, Aug. 21/12

2. Water level at a depth of 0.3 m below ground surface upon completion of drilling, Aug. 21/12

DEPTH SCALE

1 : 62

Golder Associates

LOGGED: AM

CHECKED: