PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, IGNACE AREA

WP5 Data Report - Geophysical Well Logging for IG_BH01

APM-REP-01332-0234 **January 2019**

Golder Associates Ltd.

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REPORT

Phase 2 Initial Borehole Drilling and Testing, Ignace Area

WP5 Data Report - Geophysical Well Logging for IG_BH01

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NWMO Report: APM-REP-01332-0234

January 2019

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WP5 DATA REPORT
GEOPHYSICAL WELL LOGGING FOR IG_BH01

CLIENT INFORMATION

Project Name:	Phase 2 Initial Borehole Drilling and Testing, Ignace Area	
Project Number:	1671632	
Client PO Number:	01559 A-TGS	
Document Name:	1671632 (1500) ig_bh01_wp05_data_report_10jan2019_r6a	
Client:	Nuclear Waste Management Organization (NWMO)	
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ISSUE/REVISION INDEX

Issue Code	Revision					Revision Details
	No.	By	Revd.	App.	Date	
RR	1	AR	CP	-	May 9, 2018	Initial draft for review and comment
RR	2	AR	CP	-	Sept. 17, 2018	Revised draft for review and comment
RI	3	AR	CP	GWS	Oct. 31, 2018	Revised draft for information
RI	4	AR	CP	GWS	Nov. 28, 2018	Final draft for information
RI	5	AR	CP	GWS	Dec. 14, 2018	Revised final draft for information
RI	6	AR	CP	GWS	Jan. 10, 2019	Revised final draft for information

Issue Codes: RR = Released for Review and Comments, RI = Released for Information

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Table of Contents

TABLES

FIGURES

APPENDICES

APPENDIX A
Calibration and Verification Forms, Data Quality Confirmation Forms, Pre-Use Check Forms

APPENDIX B
Records of Geophysical Logging

APPENDIX C
Geophysical Logs

APPENDIX D
FFEC Modelling Report

APPENDIX E
NRCAN Geomagnetic Field Strength Report

1.0 INTRODUCTION

The Initial Borehole Drilling and Testing project in the Wabigoon and Ignace Area, Ontario is part of Phase 2 Geoscientific Preliminary Field Investigations of the NWMO's Adaptive Phased Management (APM) Site Selection Phase.

This project involves the drilling and testing of the first of three deep boreholes within the northern portion of the Revell batholith. The first drilled borehole, IG_BH01, is located a direct distance of approximately 21 km southeast of the Wabigoon Lake Ojibway Nation and a direct distance of 43 km northwest of the Town of Ignace. Access to the IG_BH01 drill site is via Highway 17 and primary logging roads, as shown on Figure 1.

The project was carried out by a team led by Golder Associates Ltd. (Golder) on behalf of the NWMO. This report describes the methodology, calibration/verification, acquisition and processing for Work Package 5 (WP5) Borehole Geophysical Logging. Information from Borehole Geophysical Logging will ultimately be used to help assess the local thickness of potentially suitable rock units, the geophysical properties of the rock units at depth, and the presence and types of structural features at depth. The geophysical logging provided high-quality, and high-resolution profiles of rock properties including engineering, lithological, hydrogeological, and structural properties.

2.0 BACKGROUND INFORMATION

2.1 Geological Setting

The approximately 2.7 billion year old Revell batholith is located in the western part of the Wabigoon Subprovince of the Archean Superior Province. The batholith is roughly elliptical in shape trending northwest, is approximately 40 km in length, 15 km in width, and covers an area of approximately 455 km^2. It is likely that the batholith is approximately 2 km to 3 km thick through the center of the northern portion (SGL, 2015). The Revell batholith is surrounded by the Raleigh Lake (to the north and east) and Bending Lake (to the southwest) greenstone belts (Figure 2).

Borehole IG_BH01 is within an investigation area of approximately 19 km^2 in size situated in the northern portion of the Revell batholith. Bedrock exposure in this area is very good due to minimal overburden, few water bodies, and relatively recent logging activities. Ground elevations generally range from 400 to 450 m above sea level. The ground surface broadly slopes towards the northwest as indicated by the flow direction of the main rivers in the area (Revell and Mennin rivers). Local water courses within the investigation area tend to flow to the southwest towards Mennin Lake.

The northern portion of the Revell batholith is composed mainly of granodiorite and tonalite, which together form a relatively homogeneous intrusive granitoid complex. The granodiorite and tonalite are massive to weakly foliated. Overall, the tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed. There is also a younger granite intrusion, which is observed southeast of the investigation area and primarily in the central portion of the Revell batholith. The granite, which is massive to weakly foliated, post-dates and intrudes into the granodiorite-tonalite intrusive complex (Golder and PGW, 2017). In the centre of the investigation area, a west-northwest trending mafic dyke is interpreted from aeromagnetic data and observed during detailed mapping to be approximately 15-20 m wide (Figure 2).

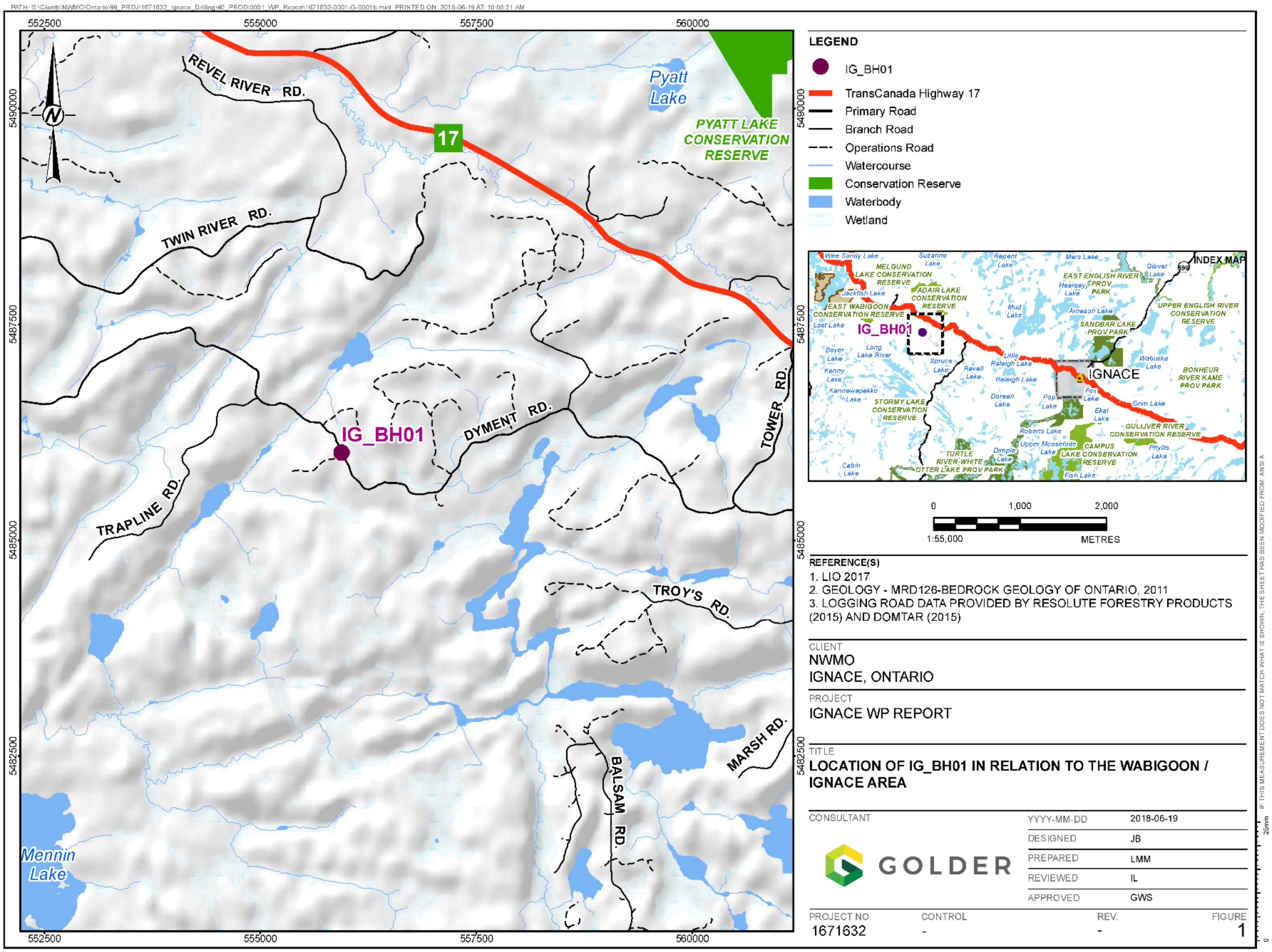

Figure 1: Location of IG_BH01 in relation to the Wabigoon / Ignace Area

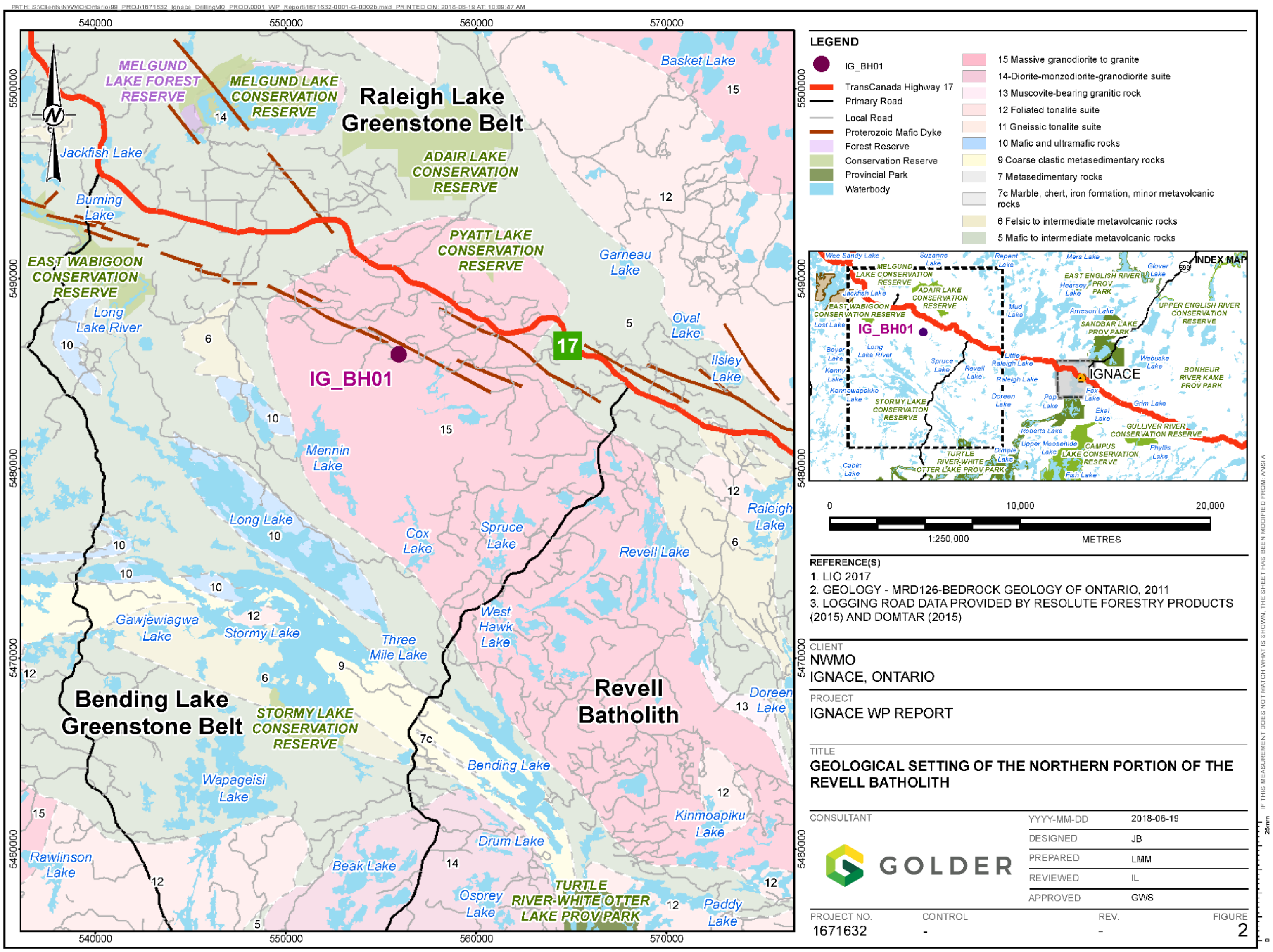

Figure 2: Geological setting of the northern portion of the Revell batholith

This dyke is associated with a similarly-orientated mafic dyke that stretches along the entire northern limit of the investigation area. Both dykes, along with others in the northern portion of the Revell batholith, have a similar character and are interpreted to be part of the Wabigoon dyke swarm. It is assumed based on surface measurements that these mafic dykes are sub-vertical (Golder and PGW, 2017).

Long, narrow valleys are located along the western and southern limits of the investigation area) (Figure 1). These local valleys host creeks and small lakes that drain to the southwest and may represent the surface expression of structural features that extend into the bedrock. A broad valley is located along the eastern limits of the investigation area and hosts a more continuous, un-named water body that flows to the south. The linear and segmented nature of this waterbody's shorelines may also represent the surface expression of structural features that extend into the bedrock.

Details of the lithological units and structures found within the investigation area are provided in (Golder and PGW, 2017).

3.0 DESCRIPTION OF ACTIVITIES

Golder completed the geophysical logging in two stages. The geophysical logging team was mobilized to site in November 2017 to collect acoustic televiewer amplitude and travel-time data from the upper 100 m portion of the borehole on November 16, 2017 prior to the surface casing being set. The main geophysical logging program from the bottom of the finished borehole to the bottom of the steel casing was conducted from January 19 to January 27, 2018 immediately after completion of drilling and flushing the borehole.

The main geophysical logging program was completed by Golder and its subconsultant DGI Geosciences (DGI). Golder personnel carried out the majority of the geophysical logs, and DGI carried out gamma-gamma, neutron and resistivity logs, under Golder supervision. The geophysical logging acquisition took place within the IG_BH01 work site at the drill rig, although some QA/QC procedures and calibrations were undertaken outside of the fenced compound to minimize interference from metal objects and electromagnetic fields.

3.1 Field Equipment

The following list presents the field equipment used to carry out geophysical logging:

- Two (2) Mount Sopris Instruments (MSI) 4MXA-1000 1000m wireline winches (Figure 3);
- Two (2) Advanced Logic Technology (ALT) Matrix logging box (Figure 3);
- Two (2) Laptop computers with LoggerSuite 11.2 (ALT) software (Figure 4);
- One (1) Laptop computer monitoring the RST water level probe;
- Borehole wireline tripod and wheel (Figure 5);
- Borehole logging probes (see Table 1 in Section 3.4);
- Conductivity probe calibration ring;
- Caliper probe calibration jig;
- FTR probe calibration fluid;
- E-Log calibration box;
- MagSus calibration ring;
- Optical televiewer colour strip and housing;
- Televiewer orientation jigs;
- Tape measure (metric);
- Water level tape (metric);

- RST water level probe;
- Grundfos pump and controller;
- Portable shelter with table and chairs;
- Paper towels;
- Cable de-greaser;
- Alconox™ detergent;
- Silicone grease;
- HQ centralizers;
- Extension cord;
- 5 kW generator;
- Rehead kits for the wireline;
- Repacking syringe and accessories; and
- Tool kit consisting of tools necessary for troubleshooting and maintaining equipment.

All equipment was tested and calibrated (when necessary) prior to mobilization to site and was confirmed to be in working order.

3.2 Equipment Checks and Calibration

All geophysical logging equipment was checked prior to shipping to the field, as well as prior to its use. All applicable calibrations or verifications were performed following the procedures outlined in the probe-specific user manuals, which were kept in hard copy on site throughout the geophysical logging program. Specific calibration procedures, documentation, and checks of individual borehole probes are detailed in their logging procedures below. The results of calibration and verification checks are recorded in Appendix A, which includes all Calibration and Verification Forms, Data Quality Confirmation Forms, and Pre-use Check Forms.

Minor damage to probes or testing equipment were noted in field verification checks, and corrective action was taken, such as minor repairs or replacement of a component of the system. Issues with equipment encountered during logging included:

- 2PEA-1000 E-Log Resistivity probe failed its pre-use calibration check and was replaced with an available QL40-ELOG Electrical Resistivity probe run by DGI, prior to the start of the program;
- FWS50 Full Waveform Sonic probe failed a surface test and was replaced with a rental FWS50 in the field;
- Signal drifted out of range of manually set discriminators during initial dynamic FFEC testing, and were subsequently re-set to automatic;
- Power failure due to cold temperatures prematurely terminated initial static FFEC log, a new power source was found, and log was re-run; and
- Telemetry problems with DGI wireline winch were bypassed by use of available Golder winch.

A check of the odometer wheel on the wireline winch was performed prior to use to ensure it was reporting accurate depths, and the results of this check were recorded in the Data Quality Confirmation Form, included in Appendix A.

The logging scientists maintained a Record of Geophysical Logging for each shift, which were provided to NWMO, and which recorded:

- The site conditions;
- The equipment setup arrangement;
- The reference point relative to ground surface;
- The probes used, including their make, model, serial numbers and detector offsets;
- The reported total depth of the borehole;
- The expected depths of investigation or log lengths;
- The static water level in the borehole;
- The reported depth to the bottom of the casing;
- Any reported zones of instability noted during drilling or coring; and
- Any damaged or malfunctioning equipment or components and the steps taken to rectify them.

The above information, where possible, was used to populate the headers of the individual .LAS data files. The Records of Geophysical Logging are included in Appendix B.

3.3 Equipment Setup

Prior to setting up equipment on site, a Field Level Hazard Assessment (FLHA) was conducted to identify and eliminate or mitigate all safety hazards associated with the performance of the work. At each change of shift, the FLHA was updated to reflect any changes in site conditions or logging setup and the incoming cross-shift personnel were briefed of any new developments.

The wireline winch and Matrix were set up approximately 4 m from the borehole collar, next to the workstation, within a temporary heated shelter installed outside the drill rig, which allowed easy access to the borehole. The tripod was installed adjacent to the borehole within the drill rig, with the wheel centred over the casing. The wireline winch and tripod were installed in-line allowing the logging scientist to maintain visual contact with the borehole collar at all times. The floor of the drill shack was established as the reference plane to be used for levelling each probe and was measured at 0.53 m above ground surface. This was done in consultation with WP3 personnel, such that the ground surface reference point was the same for coring as for geophysical logging. Static water levels over the duration of the geophysical logging program were also measured relative to this reference point. The wireline winch (Figure 3) and tripod (Figure 5) were secured to the work surface floor to ensure zero movement during the logging activities.

The wireline winch, Matrix logging box and the laptop were connected to each other and were powered using an external generator through an extension cord and power bar. Real-time telemetry and data monitoring was available through the software application, Matrix Logger (a module of the LoggerSuite Software program version 11.2) running on the dedicated laptop computer (Figure 4). An area within the heated shelter was cleared for assembly, pre-use checks, and calibration of borehole probes. An area designated for the calibration of the conductivity probe was set up outside the fenced perimeter of the drilling zone more than 10 m from any metal object. During the calibration and testing periods, the calibration ring was left at the same location to ensure repeatable calibration values for the post survey calibration.

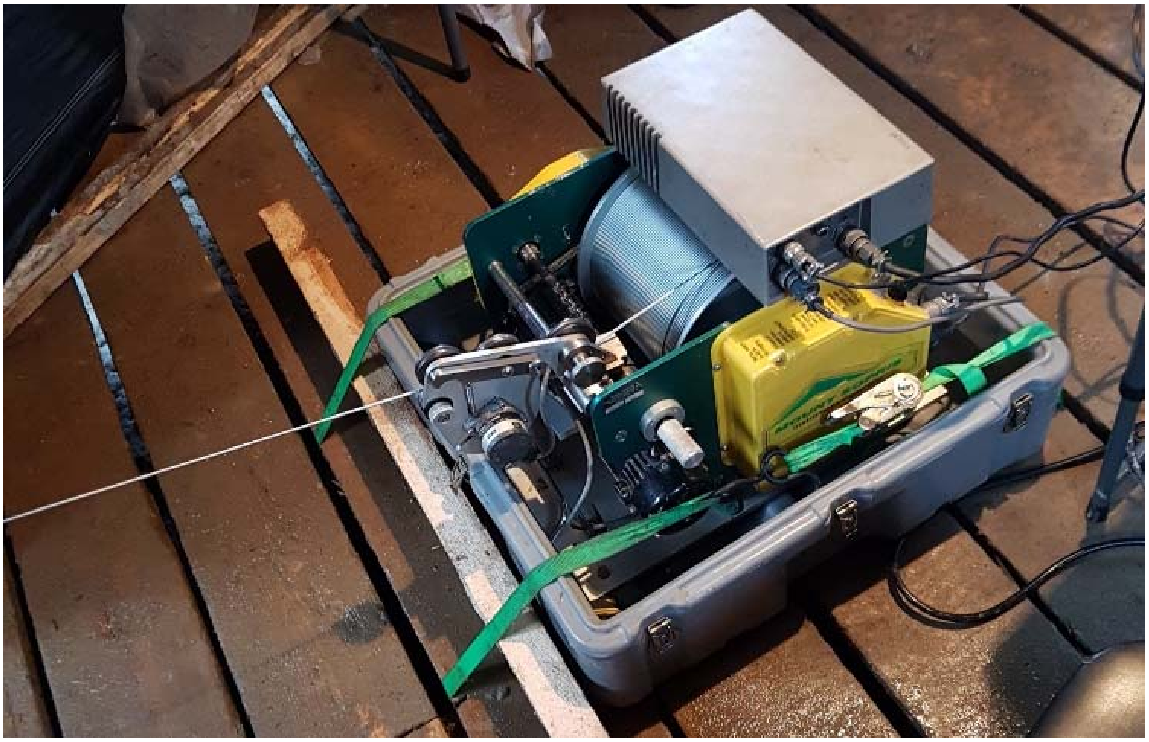

Figure 3: Mount Sopris 2MXA-1000 wireline winch with Matrix logging box

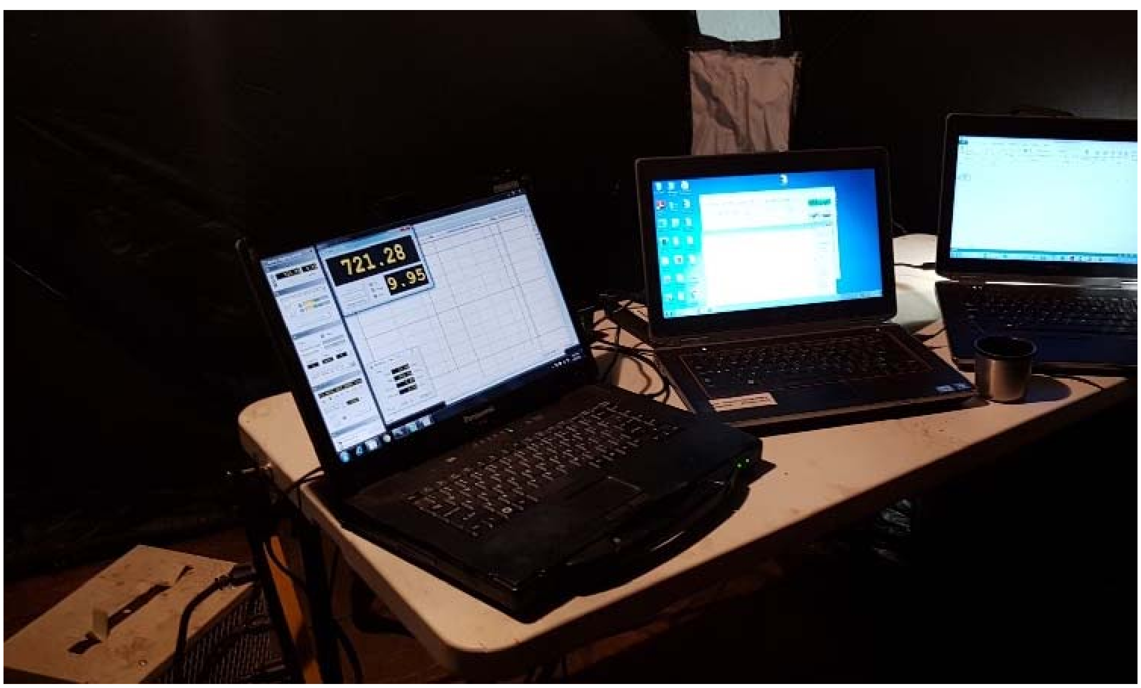

Figure 4: Laptop computer with LoggerSuite 11.2 (ALT) software

Figure 5: Borehole wireline tripod and wheel

3.4 Summary of Borehole Geophysical Logging

Geophysical well logging was conducted in accordance with the requirements of ASTM D5753-18 – Standard Guide for Planning and Conducting Geotechnical Borehole Geophysical Logging (ASTM, 2018). The geophysical well logging program consisted of 15 distinct logging tests using 13 different downhole probes. The logging probes were chosen to help assess the structural, hydrogeological, lithological, and geomechanical properties of the rock, as follows:

- Televiewer, deviation, and caliper logging was carried out to help assess structural properties of the rock, in conjunction with WP3, rock core logging and photography (Golder, 2018b).
- Apparent conductivity, natural gamma, E-log resistivity, spectral gamma, and magnetic susceptibility logging was carried out to help assess lithological properties of the rock, again in conjunction with WP3, rock core logging and photography (Golder, 2018b).
- Full waveform sonic (FWS) and gamma-gamma (density) logging was carried out to help assess the geomechanical properties of the rock, in conjunction with WP4B, geomechanical core testing (Golder, 2018c).
- Flowing fluid electrical conductivity (FFEC), fluid temperature and resistivity (FTR), neutron (porosity), and heat-pulse flowmeter (HPFM) logging was carried out to help assess hydrogeologic properties of the rock, in conjunction with WP6, hydraulic testing (Golder, 2018d) and WP7, opportunistic groundwater sampling (Golder, 2018e).

The geophysical logging probes used in this investigation are listed in Table 1 below, in the order that the logs were acquired in the field. The logging sequence was selected to maximize data quality and minimize the risk of disturbing the borehole walls for subsequent logging probes. The table also provides the main acquisition parameters for each logging probe, including sample interval, logging speed and direction of acquisition (i.e. up or down)

Table 1: Geophysical logging probes and acquisition parameters

Geophysical Test	Probe Model	Sample Interval (m)	Logging Speed (m/min)	Logging Direction
Deviation (upper 100m)	ABI40	0.05	10	Down
Acoustic Televiewer (upper 100m)	ABI40	0.0021	1.5	Up
Flowing Fluid Electrical Conductivity	2CAA-1000	0.05 / 0.10	10 / 20	Down / Up
Apparent Conductivity	2PIA-1000	0.05	4.5	Up
Gamma-Gamma (Density)	2GDA-1000	0.025	2.5	Up
Acoustic Televiewer	ABI40-2G	0.0021	4	Up
Natural Gamma	2PGA-1000	0.025	2.25	Up
Neutron (Porosity)	LLP-2676	0.025	2.5	Up
Full-Waveform Sonic	FWS50	0.05	2	Up
Mechanical Caliper	2PCA-1000	0.01	2.5	Up
E-log Resistivity + SP + SPR	QL40-ELOG	0.05	3	Up
Spectral Gamma	2PCA-1000	0.025	2.25	Up
Fluid Temperature / Resistivity	2CAA-1000	0.0496	4	Down
Magnetic Susceptibility	2BSF-1000	0.05	4.5	Up
Optical Televiewer	OBI40-2G	0.0017	2.5	Up
Heat-Pulse Flowmeter	HFP-2293	20	Stationary	Stationary
Deviation	OBI40-2G	0.10	10	Down and Up

The .TOL files containing the parameters and settings for each probe have been provided to NWMO for their records. The geophysical logging results are provided in Appendix C. Geophysical log acquisition, processing and interpretation are described in the subsections below.

3.4.1 Geophysical Logging Depths

Two main factors affect the accurate reporting of the depth of geophysical log data, particularly in holes as deep as 1,000 m. The steel cable is known to stretch according to the weight of the vertical length of wireline down the hole, as well as the weight of the probe itself. Additionally, the odometer wheel used to track the movement of the cable, and therefore the depth of the probe, has limitations in its precision, which compound over large depths to result in cumulative error at the bottom of a deep hole.

3.4.1.1 Wireline Cable Stretch Correction

To correct for wireline cable-stretch the manufacturer of the wireline cable (Rochester Corporation) provides a stretch factor for the cable of 3.048 m of stretch over 304.8 m of cable for every 453.6 kg of weight supported. Given this information a stretch coefficient of $2.204E^{-5}$ $m{\cdot}kg^{-1}m^{-1}$ can be determined. Given the expected ranges of probe weights the maximum cable stretch expected in the water filled hole is approximately 0.096% at the maximum depth of the borehole, or approximately 96 cm at the bottom of the hole. The depth correction formula that was used to account for cable-stretch is:

$$Corrected\ Depth\ (m) = D + \frac{W * D + 0.03412 * D^2}{45{,}360}$$

where:

$$D = Measured\ Depth\ (m)$$

$$W = Probe\ Weight\ (kg) + 10.4 * \frac{D}{304.8}$$

The cable stretch is influenced by the weight of the probe in water as well as the weight of the wireline itself. Based on the manufacturer the wireline weight is 10.4 kg per 304.8 m of cable. The probe weight used in the calculations above is the probe weight in water.

The cable stretch correction factor was applied to the data for each individual probe based on the probe weight. The cable manufacturer (Rochester Wire & Cable LLC) does not provide specifications for the thermal effects on the stock type 1-H-125A wireline cable, however data available for similar cable from the same manufacturer indicates a change in stretch of no more than 0.005% for 20°C increase in fluid temperature and it is therefore considered negligible.

3.4.1.2 Cumulative Odometer Error Correction

An additional depth correction factor was identified after integrating structural features from televiewer logs and core logs, as part of WP10, single-hole geoscientific data integration (Golder, 2018f). Because of the rigid nature of the drill rods, it was concluded that structure depths recorded during core logging were not subject to cumulative error, and that discrepancies between core and televiewer logged features were caused by the wireline winch odometer.

The difference in recorded depths between corresponding structures in the core and televiewer was plotted against the depth recorded in the televiewer logs. The resulting plot (Figure 6) shows a general linear trend from which a correction factor was derived.

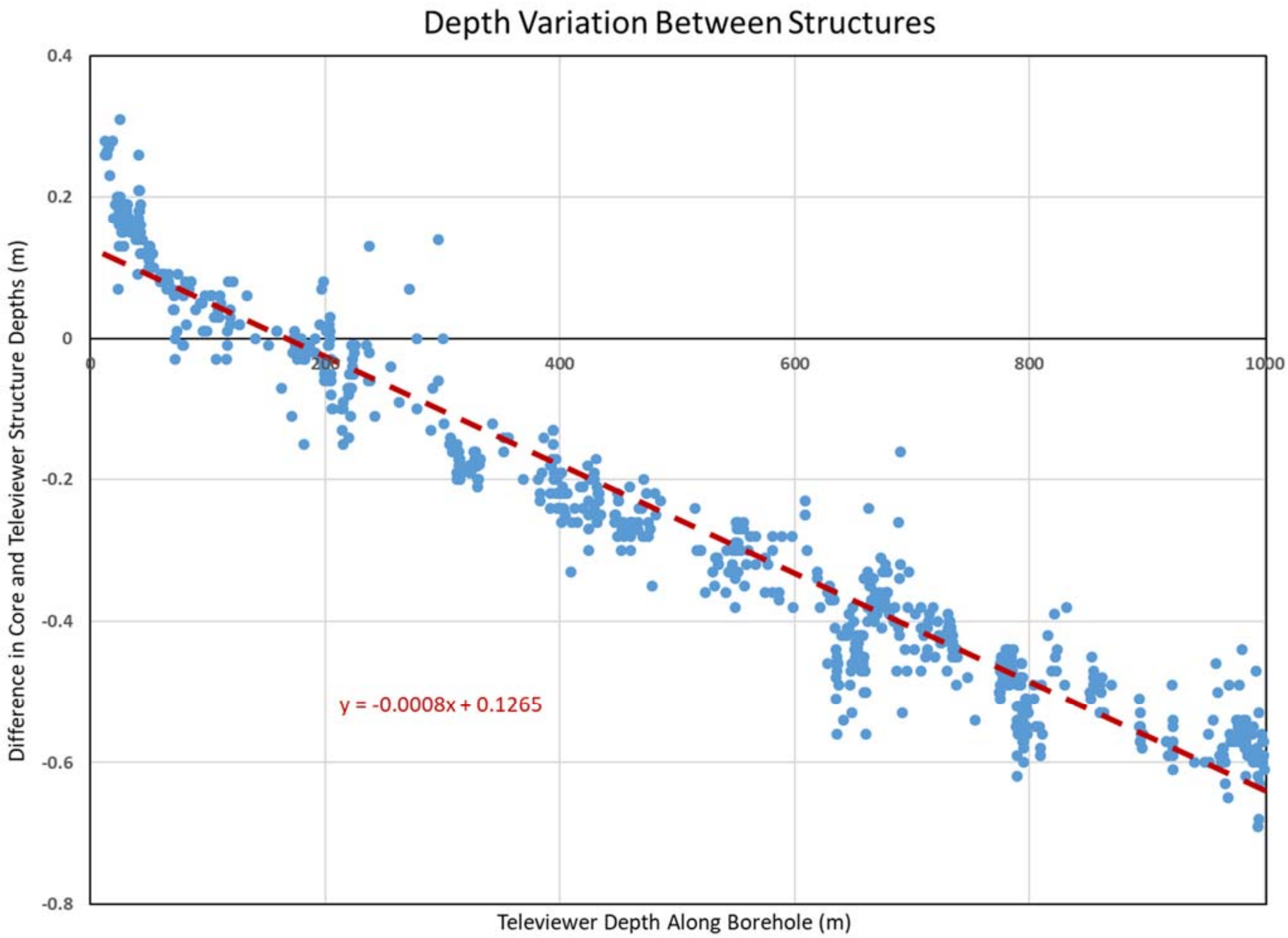

Figure 6: Comparison between depths of structures logged in core and televiewer (acoustic and optical) data

It was decided in consultation with the NWMO to apply this correction factor to the geophysical logs, according to the relationship:

$$Final\ Depth\ (m) = D * 1.0008 - 0.1265$$

where:

$$D = Corrected\ Depth\ (m)$$

This correction factor is interpreted to result from micro-slippage of the wireline winch odometer wheel and/or cable-stretch beyond the original formulae effective measurable range, as indicated by the 0.8 mm per m rate of change between corresponding televiewer structures and core structures. The remaining discrepancies between core and televiewer structure depths ranged from ±0.00 to ±0.88 m, and was on average ±0.05 m. The discrepancies are attributed to imprecision in the depth measurement of structures on the core due to irregular or non-planar structure shapes, or loss of accuracy in zones of poor core integrity.

3.4.1.3 After-Survey Depth Error

The difference between the initial reference depth of the probe relative to ground surface and the final reported depth at the reference point after completion of the logging is called the After-Survey Depth Error (ASDE). For this project, the tolerance for depth error is given as 30 cm plus 0.1% of the total depth of the borehole, meaning for a 1,000 m deep borehole, the maximum allowable ASDE is 1.30 m. This is a stricter tolerance than the allowable ASTM vertical depth error of 0.4%, or 4.0 m for a 1,000 m borehole (ASTM, 2018).

Logs which were collected in multiple sections were shifted to the ASDE of the shallowest section, and depth-matched across the other sections using common features. Table 2 shows the recorded ASDE values. Depth shifts were completed using these ASDE values to adjust the logs either upward (negative ASDE value) or downward (positive ASDE value) during the processing stage.

Table 2: After-survey depth errors reported for each geophysical log acquired

Borehole Log	After-Survey Depth Error (m)
FFEC (0 mins)	0.00
FFEC (50 mins)	0.00
FFEC (180 mins)	0.00
FFEC (330 mins)	0.00
FFEC (460 mins)	0.14
FFEC (545 mins)	0.00
FFEC (642 mins)	-0.08
FFEC (694 mins)	0.00
FFEC (790 mins)	-0.03
FFEC (844 mins)	0.00
FFEC (945 mins)	-0.10
FFEC (1188 mins)	0.00
FFEC (1300 mins)	-0.38
FFEC (1373 mins)	0.00
FFEC (1469 mins)	-0.24
FFEC (1541 mins)	0.00
FFEC (1645 mins)	0.00

Borehole Log	After-Survey Depth Error (m)
FFEC (1788 mins)	0.00
FFEC (1873 mins)	0.00
FFEC (1928 mins)	0.00
FFEC (2001 mins)	-0.51
FFEC (2085 mins)	0.00
FFEC (2188 mins)	-0.17
FFEC (2250 mins)	0.00
FFEC (2348 mins)	0.01
FFEC (2485 mins)	0.00
FFEC (2607 mins)	-0.09
FFEC (2673 mins)	0.00
FFEC (2794 mins)	-0.06
FFEC (2847 mins)	0.00
FFEC (2945 mins)	-0.18
Electromagnetic Induction (Apparent Conductivity)	-0.80
Gamma-Gamma Density	-0.33
Acoustic Televiewer	0.25
Natural Gamma	-0.02
Neutron	-0.02
Full Waveform Sonic	0.21
Resistivity (E-LOG)	-0.99
Mechanical Caliper	-0.19
Spectral Gamma	-0.27

Borehole Log	After-Survey Depth Error (m)
Fluid Temperature / Resistivity	0.00
Magnetic Susceptibility	1.14
Optical Televiewer (Deviation Run)	0.00
Optical Televiewer	-0.31
Heat-Pulse Flowmeter	0.00

In the instance where the ASDE was larger than 1.0 m, for the Magnetic Susceptibility log, a short repeat section was logged over the edge of casing to confirm depth positioning with a known reference point.

3.4.2 Flowing Fluid Electrical Conductivity

In order to help characterize flowing zones within the borehole, flowing fluid electrical conductivity (FFEC) testing was carried out. FFEC testing uses the contrast between the electrical conductivity of the formation fluid and water column within the borehole to identify the location of flow into the borehole and to estimate the flow rate (Paillet et al., 2010). The method requires a measurable contrast in electrical conductivity between the formation and borehole column, and if this does not exist at certain intervals then the FFEC method may not be useful to characterize flow in these intervals. The contrast in electrical conductivity could be easily generated by prior flushing of the hole with fluorescein traced fluid of known electrical conductivity Modelling the changes in fluid column electrical conductivity under static and pumping conditions, allows for calculation of the hydraulic transmissivity, and fluid inflow rate of the flowing fractures within the borehole. Running FFEC tests under static conditions illustrated ambient inflow of fluid, while stressing the borehole by lowering the water level illustrated the dynamic flow potential from the same inflowing fractures.

As part of this geophysical logging program, the Mount Sopris 2CAA-1000 Fluid Temperature / Resistivity probe (FTR) was used to measure the temperature and electrical conductivity of the borehole fluid during both ambient and dynamic (pumping) fluid flowing conditions. This Fluid Temperature / Resistivity probe is part of a combination probe, forming the bottom end of the 3-arm mechanical caliper probe. The probe was checked for functionality prior to shipping to site. Immediately prior to use, the probe was calibrated using two fluids of known conductivity, the first being fluid pumped from the borehole during flushing, and the second being the same fluid diluted with distilled water (6.46 mS/m and 2.54 mS/m, respectively). The calibration values are recorded in the pre-use Calibration and Verification Check form in Appendix A.

Prior to geophysical logging, the borehole was flushed with approximately 37,000 litres of water, representing over 6 borehole volumes. This was done to improve fluid clarity for the optical televiewer, as well as to replace the existing fluid column in the borehole with fluid of a consistent and known electrical conductivity of 4.7 mS/m based on final flushing measurements as reported in WP2 (Golder, 2018a). The flushing process took approximately two days, after which the rods were removed. Details about the flushing process are discussed in WP2, Borehole Drilling and Coring (Golder, 2018a).

Immediately following flushing and removal of the drill rods, the geophysical equipment was set up as described in Section 3.3. The probe was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Logger program was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction is specific to the tool and is calculated based on the stickup of the reference point measured during setup. The offset of the measurement point of each tool is outlined in the Record of Geophysical Logging (Appendix B).

The initial phase of FFEC testing was conducted under static (ambient) flowing conditions, over the course of 1,000 minutes. A total of eleven logs were collected during this phase of testing, including five complete down logs run at 10 m/min sampling every 5 cm, and five complete up logs run at 20 m/min sampling every 10 cm. A partial down log was also collected but was incomplete due to a power outage on site.

After the initial complete down log was collected from the surface to the bottom of the borehole, subsequent complete logs were run from approximately 50 m below ground surface (m bgs) to the bottom. Since the casing was installed to 67 m bgs, no ambient flowing fluid was possible above this depth. The 17 m of data gathered within the casing allowed a background value to be shown which was unaffected by any ambient flow, while still maximizing the number of logs which could be run in the proposed timeframe.

After static testing, the probe was stopped at 69 m bgs and a Grundfos submersible pump was lowered into the borehole to 67 m bgs. FFEC testing was continued from 69 m bgs and below, under pumping conditions to stimulate flow from fractures.

As the probe could not be returned to the surface between tests, due to the presence of the Grundfos submersible pump being located above it, the wireline was marked with tape at a reference point on surface when the probe was at a depth of 69 m bgs to accurately measure the ASCE for each run.

Twenty additional FFEC logs were collected during the dynamic testing phase, over the course of 2000 minutes, between the pump depth (approximately 69 m bgs) and the bottom of the borehole. These included eight complete down logs, run at 10 m/min sampling every 5 cm, and nine complete up logs, run at 20 m/min sampling every 10 cm. Three partial down logs were also run while the tool’s signal discriminator settings were adjusted to compensate for varying wireline resistance and tool signal amplitude. Ultimately, the tool’s signal discriminators were set to automatic and subsequent logs required no adjustment. Dynamic FFEC logs collected prior to the adjustment of the tool’s signal discriminators were found to show invalid data at some depths and were ultimately not included in the analysis. These logs are noted by ”‡ ” in Table 3.

Table 3 presents the Flowing Fluid Electrical Conductivity (FFEC) logs, including the logging time in minutes since start of testing, the logged depth interval, direction, sampling rate, the average pump rate (where applicable), and the recorded After-Survey Depth Error (ASDE). The testing began 60 minutes after the last rods were pulled from the hole, and 710 minutes after the end of flushing. The first 11 logs were acquired during ambient conditions over a 1,000 minute period. The remaining 20 logs were acquired while pumping over a 2,000 minute period.

Table 3: FFEC Logging Details

Log Start Time (mins from start of FFEC)	Interval Top (m)	Interval Bottom (m)	Direction	Speed (m/min)	Sampling Rate (m)	Average Pump Rate (L/min)	After-Survey Depth Error (ASDE) (m)
0	1.36	161.28	Down	10	0.05	-	0.00
50	1.36	1001.08	Down	10	0.05	-	0.00
180	49.79	1000.83	Up	20	0.10	-	0.00
330	50.14	1003.13*	Down	10	0.05	-	0.00
460	49.69	1001.13	Up	20	0.10	-	0.14
545	49.89	1001.13	Down	10	0.05	-	0.00
642	49.89	1001.13	Up	20	0.10	-	-0.08
694	49.94	1001.08	Down	10	0.05	-	0.00
790	49.79	1001.13	Up	20	0.10	-	-0.03
844	49.84	1001.03	Down	10	0.05	-	0.00
945	49.89	1001.03	Up	20	0.10	-	-0.10
1,188‡	69.00	1001.08	Down	10	0.05	1.69	0.00
1,300‡	69.38	1001.08	Up	20	0.10	1.60	-0.38
1,373‡	69.00	1001.10	Down	10	0.05	1.50	0.00
1,469‡	69.24	1001.10	Up	20	0.10	1.39	-0.24
1,541‡	69.00	1001.08	Down	10	0.05	1.31	0.00
1,645‡	69.00	1001.08	Up	20	0.10	1.13	0.00
1,788‡	69.00	238.88	Down	10	0.05	1.17	0.00
1,873‡	69.00	462.42	Down	10	0.05	1.09	0.00
1,928‡	300.03	1001.18	Down	10	0.05	0.86	0.00
2,001	69.70	1001.53	Up	20	0.10	0.76	-0.51
2,085	69.00	1001.18	Down	10	0.05	0.73	0.00
2,188	69.20	1001.03	Up	20	0.10	0.84	-0.17

Log Start Time (mins from start of FFEC)	Interval Top (m)	Interval Bottom (m)	Direction	Speed (m/min)	Sampling Rate (m)	Average Pump Rate (L/min)	After-Survey Depth Error (ASDE) (m)
2,250	69.25	1004.13*	Down	10	0.05	1.21	0.00
2,348	69.30	1004.13*	Up	20	0.10	1.12	0.01
2,485	69.25	1001.13	Down	10	0.05	1.20	0.00
2,607	69.10	1001.13	Up	20	0.10	1.13	-0.09
2,673	69.20	1001.23	Down	10	0.05	1.07	0.00
2,794	69.10	1001.13	Up	20	0.10	1.02	-0.06
2,847	69.20	1001.13	Down	10	0.05	1.10	0.00
2,945	69.10	1001.03	Up	20	0.10	1.12	-0.18

(*indicates overshoot of bottom of BH – no data valid below 1001.18 m bgs, ‡indicates a log found to include invalid data and which was not used in analysis)

During the dynamic (pumping) phase of the FFEC logging, water levels in the borehole and pumping rates were monitored and are shown on Figure 7. Pumping was originally scheduled to occur in three phases with low, medium, and high pumping rates, however the slow initial recovery indicated that the borehole was unable to respond to medium or high pump rates and so a period of ambient testing followed by low-flow pumping was conducted. Alternatively, pump rates were maintained at a stable rate as much as possible. While attempting to maintain a constant draw-down, small fluctuations in water level resulted in changes to pump output. Constant adjustment of pump power was needed to compensate for the change in pump output and water level.

Figure 7 shows the timeline of the FFEC testing, with 0 minutes being the beginning of the first test. The period from -200 minutes to 1150 minutes shows the water level recovery period, following flushing and removal of rods. The static testing phase lasted from 0 minutes to 1,000 minutes, while the water maintained a relatively constant depth of 14 m bgs. During the dynamic testing phase, from 1,150 to 3,000 minutes, the pump was installed at 67 m bgs, inside the casing. The initial drawdown to the target depth of 50 m bgs lasted from 1150 to 1600 minutes. Water was withdrawn at an average rate of between 0.75 and 1.75 litres per minute, in order to maintain a drawdown of between 45 and 50 m bgs. Measured pump rates fluctuated between 0.25 and 2.40 litres per minute, as pump power was adjusted to compensate for change in water level. Average flow values for the pump were calculated using a 33-point moving window approach.

The FFEC log data was imported into WellCAD as .TFD files and an interpolation function was applied to remove data spikes and gaps smaller than 1 metre. The logs were shifted to correct for the After-Survey Depth Error (ASDE), as listed in Table 3. A formula was then applied to correct the recorded depth as described in Section 3.4. The logs, once referenced to the corrected depth, were then exported as .WCA files, one for each logging run.

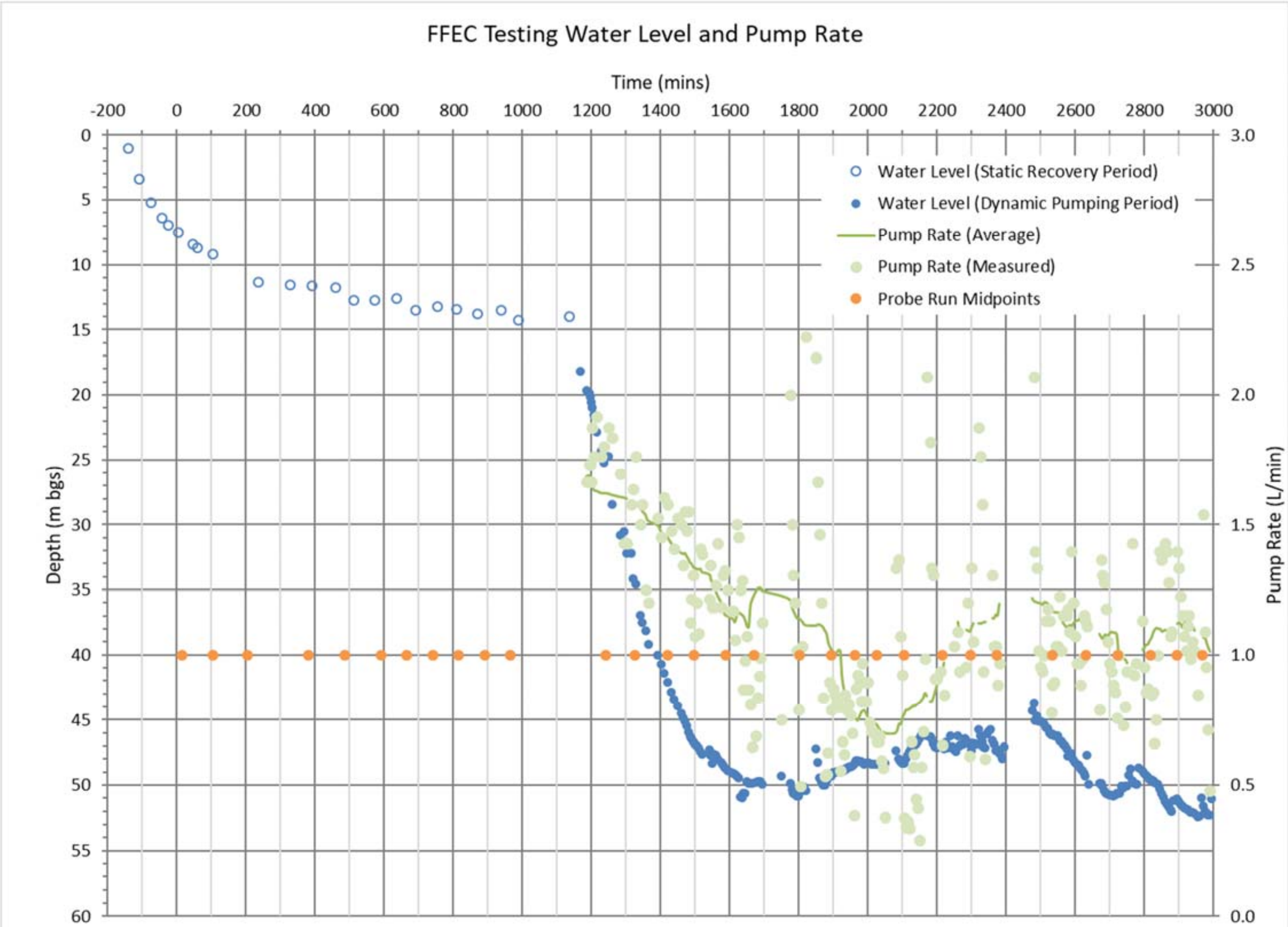

Figure 7: Water level and pumping rate, measured during FFEC testing, from time of start of testing

Each .WCA file was then imported back into one common WellCAD file where they were compared with each other and other geophysical logs, such as the optical televiewer image log. FFEC log depths were matched to common features to further refine their accuracy and one final depth correction was applied according to the results of structural integration between televiewer logs and core logs, using formulae described in Section 3.4.

To interpret the FFEC log results a numerical model was generated using multiple fluid conductivity logs under both ambient (static) and dynamic (pumping) conditions. The logs were first used to identify the discrete inflow points, corresponding to the peaks of the conductivity anomalies seen in the static logs. Six such points were identified, and a numerical model, described by Paillet (2012), was applied to simulate different inflow rates, fluid electrical conductivities, and hydraulic transmissivities. The modelling method assumes one-dimensional mass conservation and a constant longitudinal dispersion coefficient, due to the mixing caused by the repeated passage of the probe through the water column. The inflow rate from each point is also taken to be constant for the measurement period. The mixing volume used to model dispersion was 30 cm of borehole length (approximately 0.4 litres) and the modelled time-step was one minute.

Results from preliminary FFEC modelling (see Appendix D) were imported into the same WellCAD file and compared to the Fluid Conductivity logs and optical televiewer Image log. Model injection points were then refined to reflect associated narrow fractured intervals. Final FFEC model values, as well as flow rates, incoming Fluid Electrical Conductivity, and Transmissivity, were displayed alongside field measured values. Representative logs from both static and dynamic pumping phases of the FFEC testing are presented on the Hydrogeology Log in Appendix C. The individual logs shown are listed in Table 4 below, along with their units, minimum, maximum, and average values. Log times in Appendix D are given in minutes after the start of logging. For clarity, five representative logs were selected from the ambient phase of logging, five from the dynamic phase, and five from the model showing response under modelled dynamic conditions.

Table 4 shows how during the static logging period, in the first 1,000 minutes after the start of logging, the maximum electrical conductivity value drops from 35.40 mS/m to 27.23 mS/m, indicating the dilution of the high conductivity inflow fluid with the lower conductivity flushed fluid due to the mixing caused by the repeated passage of the probe. The symmetrical spreading of the conductivity peaks at the inflow points suggests no preferential direction of static fluid flow in the borehole. Once pumping was initiated and the drawdown stabilized, Table 4 shows that the maximum electrical conductivity response had increased to 43.30 mS/m, and remained relatively constant, while the upward spreading of the high conductivity fluid indicates the expected upward flow induced by the pumping.

Table 4: FFEC Responses

Log Name	Units	Minimum Value	Maximum Value	Average Value	Background Value
Static Fluid Conductivity (T=50 min)	mS/m	2.45	35.40	4.64	2.56
Static Fluid Conductivity (T=180 min)	mS/m	2.52	33.08	4.79	2.80
Static Fluid Conductivity (T=460 min)	mS/m	2.42	30.60	4.79	2.57
Static Fluid Conductivity (T=844 min)	mS/m	2.43	28.27	4.88	2.60
Static Fluid Conductivity (T=945 min)	mS/m	2.42	27.23	4.88	2.60
Dynamic Fluid Conductivity (T=2001 min)	mS/m	2.13	43.30	9.56	2.35
Dynamic Fluid Conductivity (T=2188 min)	mS/m	2.13	43.30	10.63	2.35
Dynamic Fluid Conductivity (T=2348 min)	mS/m	2.13	43.48	11.53	2.18
Dynamic Fluid Conductivity (T=2607 min)	mS/m	2.13	43.85	12.71	2.18
Dynamic Fluid Conductivity (T=2945 min)	mS/m	2.13	44.50	14.69	2.18
Model Fluid Conductivity (T=2026 min)	mS/m	5.00	44.98	8.81	5.00
Model Fluid Conductivity (T=2213 min)	mS/m	5.00	45.32	9.64	5.00
Model Fluid Conductivity (T=2373 min)	mS/m	5.00	45.54	10.34	5.00

Log Name	Units	Minimum Value	Maximum Value	Average Value	Background Value
Model Fluid Conductivity (T=2632 min)	mS/m	5.00	45.81	11.48	5.00
Model Fluid Conductivity (T=2970 min)	mS/m	5.00	46.02	12.71	5.00

The Fluid Conductivity logs are overlaid in the Hydrogeology Log, included in Appendix C, in three groups based on whether they represent static flow (ambient) conditions, dynamic flow (pumping) conditions, or modelled dynamic flow (pumping) conditions. Within these three groups, logs are arranged in descending order of time, from early to late in the testing interval, showing the progression of changes in the conductivity profile with time.

The modelled FFEC logs match well with the observed anomalous pattern of the fluid conductivity logs, where each of the electrical conductivity anomalies can be correlated to a narrow fracture interval observed in the televiewer structural interpretation. There are six injection points considered in the model, though smaller amounts of fluid inflow distributed across multiple minor joints are probable, especially in the zone between 894 m bgs and 923 m bgs. The ambient logs show the conductivity anomalies diminishing in amplitude and spreading out up and down the borehole over time, consistent with dilution and mixing of very low rates of inflowing fluid. The dynamic logs show higher amplitude anomalies with strong upward spreading over time, consistent with upward flow towards the pump.

The FFEC model injection values shown in the Hydrogeology log are described in detail in Appendix D and are summarized in Table 5. The results suggest six inflow points with three being relatively strong and three being relatively weak. The three inflow points are interpreted to be located at 628, 772, and 894 m bgs, and are modelled with flow rates between 0.11 and 0.15 L/min. The modelled hydraulic transmissivity estimates of these points varies from 5.9 x 10^{-8} to 7.9 x 10^{-8} m^2/s. The three weak inflow points are interpreted to be located at 550, 776, and 923 m bgs, and are modelled with flow rates of 0.02 L/min. The modelled hydraulic transmissivity estimates of these points is calculated to be approximately 1.0 x 10^{-8} m^2/s.

Table 5: FFEC Model Injection Values

Depth (m)	Model Flow (L/min)	Conductivity (mS/m)	Modelled Transmissivity (m^2/s)
550	0.02 ± 0.01	86.5 ± 3.0	1.0 x 10^{-8} ± 1.0 x 10^{-8}
628	0.15 ± 0.01	86.5 ± 3.0	7.9 x 10^{-8} ± 1.0 x 10^{-8}
772	0.11 ± 0.01	89.5 ± 3.0	5.9 x 10^{-8} ± 1.0 x 10^{-8}
776	0.02 ± 0.01	89.5 ± 3.0	1.0 x 10^{-8} ± 1.0 x 10^{-8}
894	0.15 ± 0.01	52.5 ± 3.0	7.9 x 10^{-8} ± 1.0 x 10^{-8}
923	0.02 ± 0.01	52.5 ± 3.0	1.0 x 10^{-8} ± 1.0 x 10^{-8}
Total Inflow	0.47 ± 0.01	75.1 ± 3.0	2.5 x 10^{-7} ± 1.0 x 10^{-8}

3.4.3 Electromagnetic Induction (Apparent Conductivity)

Electromagnetic induction data was acquired using a Mount Sopris Instruments (MSI) 2PIA-1000 probe, also known as an Apparent Conductivity probe. This probe was run to investigate the bulk (formation and fluid) electrical conductivity of the bedrock. Changes in electrical conductivity are used to identify changes in mineralization, such as the presence of conductive sulphides, or clay-bearing fracture zones.

The probe contains a transmitter and receiver coil and measures the apparent bulk conductivity of the borehole wall around the probe, in mS/m. The depth at which the measurement is given is the midway point between the two coils. Since the conductivity probe generates a primary magnetic field, which extends through the air or water within the borehole and into the surrounding formations, it is not necessary for the probe to be centralized in the borehole.

This probe is susceptible to drift in changing temperatures, so to ensure optimal data accuracy, it was acclimatized in the borehole fluid prior to calibration and logging, according to ASTM standard D6726-15 (Section 8.2). The probe was turned on and run in Time Mode to display real-time apparent conductivity values. The probe was then lowered to a point below the static water level at the time of survey (46 m bgs) where it was left to acclimatize for 15 minutes until the real-time apparent conductivity readings had stabilized, which indicated that it had equilibrated to the temperature of the borehole fluid at that depth.

The probe was then ascended and removed from the borehole. It was taken away from the drill rig to the conductivity calibration area which was at least 10 m away from the nearest large metal objects. The calibration measurements were completed as soon as possible after the probe was removed from the borehole fluid to minimize temperature changes caused by the cold air outside the logging shelter. The conductivity probe was placed in the calibration ring and probe measurements were carried out using two pre-set conductivity values on the variable dial of the ring (0 mS/m and 102 mS/m). The results were saved into the associated .TOL file and exported as a .TXT file for record keeping. The calibration records were documented in the Record of Geophysical Logging, as well as the Calibration and Verification Check Form, and provided to NWMO.

Following the calibration, the probe was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Logger program was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction was specific to the tool and was calculated based on the stickup of the reference point above ground surface as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

During the descent the probe was run in Time Mode to display real-time values in order to check the expected conductivity range of the bedrock. The sensitivity range setting for the probe was set to the 100 mS/m range for increased probe sensitivity. The probe was descended to a depth of 500 m bgs, turned on and the first log was started. The QA/QC log was recorded for 10% of the borehole depth, from 500 m bgs to 400 m bgs. The probe was run up at 4.5 m per minute and sampled every 5 cm. Once the QA/QC log was complete, the probe was descended to the bottom of the borehole. After reaching the bottom of the borehole, the second file was started, recording up at the same speed and sampling interval.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent and ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe had entered the casing in which the readings were affected by the metallic casing, the second file was terminated. The probe was ascended to the level point, where the final level depth was recorded, and the probe was removed from the borehole. The probe was then run in

Time Mode and placed back in the calibration ring in the same location as the initial calibration. The two pre-set values were checked and recorded in the Record of Geophysical Logging, and the Calibration and Verification Check Form.

The conductivity data required correction for thermal drift, which was initially applied as a bulk correction based on the post-log calibration check. Following examination of the fluid temperature log collected later in the program, a more accurate thermal drift correction was applied, as the temperature of the borehole fluid was found to range significantly (from ~14 °C to ~4 °C) from the bottom to top of the borehole. An empirical relationship was determined between the logged apparent conductivity data and the borehole fluid temperature, which resulted in a thermal correction factor of 1.1 mS/m per 1 °C being applied to the logged apparent conductivity data. The formula used to correct the apparent conductivity log is below, using a temperature difference of -12°C between initial calibration and the start of logging:

$$Apparent\ Conductivity\ \left(\frac{mS}{m}\right) = Raw\ Apparent\ Conductivity\ \left(\frac{mS}{m}\right) + (Fluid\ Temp\ (°C) - -12°C) \times 1.1(\frac{mS}{m})/°C$$

Lastly, an 11-point moving average filter was applied to the data. The .TFD files were imported into WellCAD and the primary log compared favourably to the QA/QC log over the repeated interval from 400 to 500 m bgs. For the primary log, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The log was shifted to correct for the After-Survey Depth Error (ASDE) of 0.80 m that was recorded in the relevant Record of Geophysical Logging field notes. Based on the final calibration check the Apparent Conductivity log was bulk shifted +28 mS/m to correct for the temperature drift, as the probe had warmed up in the borehole fluid from the freezing surface conditions present at time of testing and equilibrated to the borehole fluid temperature prior to the start of logging. Recorded depth was corrected by applying the wireline stretch formula described in Section 3.4. Once drift and wireline stretch were corrected, the log was exported as a .WCA file.

The .WCA file was then imported back into one common WellCAD file where it was compared with other geophysical logs, such as the optical televiewer image log, resistivity logs, magnetic susceptibility log, and natural gamma log. Apparent Conductivity log depths were matched to common features to further refine the accuracy and one final depth correction was applied according to the results of structural integration between televiewer logs and core logs, using Formula 2, formulae described in Section 3.4. The final Apparent Conductivity log is displayed on the Lithology Log, in Appendix C.

Results from the Apparent Conductivity log are measured in millisiemens per metre, ranging from -1.73 mS/m to 16.60 mS/m. The average value is 3.37 mS/m. The general trend of the apparent conductivity curve is flat, with gradual increases corresponding to higher zones of magnetic susceptibility and lower normal resistivity. These zones, specifically from approximately 500 to 630 m bgs, 700 to 800 m bgs, and 850 to 910 m bgs, are interpreted as changes in the borehole fluid conductivity, as shown in the FFEC dynamic fluid conductivity logs in the Hydrogeology Log in Appendix C. The elevated conductivity response between 850 and 910 m bgs also corresponds to an anomalous acoustic caliper response which is interpreted as being due to a slight change in the fluid velocity at this depth.

More localized spikes in apparent conductivity, such as between 793 and 798 m bgs, and at 895 m bgs, correspond with geological features apparent in the optical televiewer log and seen in natural gamma, gamma-gamma density, and neutron logs.

3.4.4 Gamma-Gamma Density

Near- and far-field bulk density data were acquired using the Mount Sopris 2GDA-1000 focused gamma-gamma probe. The gamma-gamma probe measures the electron density of the bedrock by using a radioactive source, Cesium 137, located on the same plane as the detectors, the surrounding bedrock is bombarded with intermediate gamma rays. The probe contains two CsI (Th) detectors spaced 20 and 35 cm from the source to measure “near” and “far” back-scatter of radiation, respectively. The probe is forced against the borehole wall using a single caliper arm ensuring the gamma rays interact with the formation in the correct plane. The phenomenon of Compton scattering takes place in which the back-scattered gamma rays emerge from the borehole wall and are received by the detectors.

Prior to loading the radioactive source into the probe, the instrument was connected to the wireline and tested for operation at surface. The calibration of the density sensors was verified at DGI’s Operation Centre prior to mobilizing the instrument to site. The calibration utilized an aluminium test block with a known density of 2.6 grams per cubic centimetre (g/cm^3) and a test borehole in rock with a known density of 2.942 g/cm^3. The gamma-gamma density probe achieved calibration status with ±0.08 g/cm^3 in near and far density measurements of the aluminium block and ±0.001 g/cm^3 in measurements of the test borehole.

Once the probe was configured, the probe was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Logger program was corrected to report the depth of the measurement point of the tool in relation to ground surface, in this case bedrock surface This depth correction was specific to the tool and was calculated based on the stickup of the reference point above ground surface as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

The probe was lowered down the borehole while data were monitored in time-mode. Once the probe had reached the bottom of the borehole, a single caliper arm was deployed to ensure the probe was forced against the borehole wall. The logging scientists then switched the acquisition system to depth-mode and set the instrument’s acquisition parameters to measure at 0.025 metre intervals up the borehole. The logging scientists started recording data as the instrument was ascended up the borehole at a speed of 2.5 m per minute. Data was recorded only in the up direction, to maintain positive tension in the wireline. The full length of the borehole was surveyed in ten overlapping intervals (including the QA/QC run from 200 m bgs to 100 m bgs) over the course of three shifts.

Multiple logs were collected to ensure high quality repeatable data despite problems with occasional loss of telemetry. A minimum overlap of 12 m across multiple logs was ensured to preserve depth integrity and to allow for merging of data during processing phase.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the multiple ascents to ensure valid telemetry and minimal data errors. Where telemetry became problematic, or error rates became too high, the file was terminated, and a new file was started, overlapping with previous intervals. Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe had reached the reference point at the end of the final primary log, the file was terminated. The probe was descended 20% of the borehole depth and the QA/QC log was started, running up 10% of the borehole depth (from 200 m bgs to 100 m bgs). The file was then terminated, the probe was ascended back to the reference point, and removed from the borehole. The radioactive source was removed from the probe and put back in containment. The calibration of the caliper arm was checked against the same known diameters, then the probe was deactivated.

The .TFD files were imported into WellCAD. For the primary logs, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. Recorded depth was corrected by applying the wireline stretch formula described in Section 3.4. The logs, once referenced to the corrected depth, were then exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they were compared with each other and the QA/QC log, to ensure repeatability. The logs compared favourably over the overlapped sections and the QA/QC run from 100 to 200 m bgs. The logs were depth-shifted as needed to match common features where they overlapped, and the logs were then merged together to form a final Near Density and Far Density log. These logs were then compared to other geophysical logs, such as the optical televiewer Image log, Neutron log, and full waveform sonic velocity logs. Gamma-gamma density log depths were matched to common features to further refine the accuracy and one final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The final Near Density and Far Density curves are displayed on both the Lithology Log and the Engineering Log, in Appendix C. Both Near and Far Density logs are measured in grams per cubic centimetre (g/cc). The Near Density log ranges from 2.57 g/cc to 3.05 g/cc, with an average of 2.74 g/cc. The Far Density log ranges from 2.50 g/cc to 3.18 g/cc, and has an average value of 2.75 g/cc. The background value of the host tonalite ranges from 2.72 to 2.76 g/cc, with zones of apparent mineralogy change distinguishable in the Optical Televiewer log and interpreted as high in biotite, showing slightly higher density, on the order of 0.03 g/cc above background. . Additionally, nine spikes ranging in thickness from 0.41 to 5.56 m are apparent associated with discrete changes in rock type as observed in optical televiewer logs and through geological core logging (WP3: Golder, 2018b), and typically range from 2.89 to 2.94 g/cc, or 0.13 to 0.22 g/cc above background. A detailed interpretation of gamma-gamma density and rock type will be completed as part of the single borehole integration report (WP10: Golder, 2018f).

3.4.5 Televiewer Logging

3.4.5.1 Acoustic Televiewer

The Advanced Logic Technology (ALT) ABI40-2G Acoustic Televiewer probe, also known as the Acoustic Borehole Imager (ABI), was used primarily to image discontinuities (e.g. joints, veins, etc.) intersecting the borehole wall. The ABI40-2G transmits a series of high frequency sonic pulses, reflected off of a rotating mirror, and receives the echo of those pulses from the borehole wall. By analysing the amplitude of the echo relative to the original pulse, as well as the time delay between the original pulse and the return, the ABI40-2G generates a series of thin slices of data which it stacks and translates into a pair of continuous images, the Amplitude and the Travel Time logs. Because of varying hardness, different rocks and minerals absorb or reflect different amounts of the original sonic pulse, thus the ABI40-2G's Amplitude log shows an image of the varying hardness of the borehole wall, plotting these differences using a colour scale. A quartz vein, for example, will reflect more energy than the host shale bed, thus the ABI Amplitude image will show a bright reflection for the quartz and a dimmer reflection for the shale. The ABI40-2G's Travel Time log is an image plotting the differences in echo delay, meaning an open fracture or void into which the sonic pulse had to travel farther before being reflected will appear in contrast to the nearer borehole wall.

Using a depth-dependant fluid velocity log derived from borehole diameter values measured by the mechanical caliper, the average travel time of the pulses at each recorded depth were converted into a distance, producing the Acoustic Caliper log, showing the calculated diameter of the borehole.

In order to translate the travel time of each pulse into distance, and properly analyse the strength of the pulse echoes, the ABI40-2G can only be run in water. Because the ABI40-2G does not use an optical camera, the borehole fluid may be murky without adversely affecting the image quality. Additionally, because of the geometry of the reflections of the pulses, the ABI40-2G must be well centralized in the borehole. Three non-metallic centralizers with a fixed NQ diameter were affixed to the ABI40-2G to maintain centralization of the probe while logging. The use of these centralizers assumes a near-uniform diameter of the borehole.

The ABI40-2G acoustic televiewer contains internal electronics to record tilt, azimuth, and roll of the probe while operating using a 3-axis fluxgate magnetometer and a 3-axis accelerometer. These internal electronics were factory calibrated and the certificate of calibration is included in Appendix A. Prior to shipping and use, the probe was checked for functionality, with the results recorded in the pre-use Calibration and Verification Check form. The magnetometer measurements are susceptible to interference from highly magnetic rock, metallic casing, or geomagnetic interference (e.g. intense auroral activity or solar storms). Under those conditions, the orientation of the probe and its image must be estimated. In IG_BH01, the azimuth log near the bottom of the casing was extrapolated from 1.49 m bgs to 12.28 m bgs using the constant value 250.21 deg, to allow for structures in this interval to be corrected to True Dip and Dip Direction. To ensure no geomagnetic field disturbances, data from NRCAN were obtained prior to logging. Data measured data from the NRCAN magnetic field strength were obtained from the Brandon, Manitoba station for the duration of the field program and are included in Appendix E. No geomagnetic interference was observed during the time of logging.

Once the probe was connected to the wireline, the probe was lowered into the casing until the top of the probe was flush with the reference point. In order to have data measured relative to ground surface (i.e. bedrock surface), corrections were applied to account for the offset distance between the reference point and the probe sensor, and the difference between the reference point and the ground surface. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

Acoustic televiewer logging was completed in two stages, with the upper 100 m being logged prior to the drilling of the rest of the borehole. This was done to allow a section of the upper 100 m to be isolated from the rest of the borehole to prevent groundwater from flowing between near-surface and deeper fractures. Due to the high turbidity of the water column in the upper 100 m, only the acoustic televiewer was run in this interval. Once the first log had been collected, the casing was installed to 69 m bgs and the remainder of the hole was drilled. All additional geophysical logs, including the second stage of acoustic televiewer, were collected below the casing. The procedure for collecting acoustic televiewer in both stages were the same.

The appropriate .TOL file was selected from the tool list, the probe was turned on. The probe was run in Time-Mode, allowing it to transmit real-time images which were monitored by the logging scientist while the ABI40-2G descended down the borehole. This depth was later compared as a QA check to the depth of well casing documented during borehole drilling (WP2: Golder, 2018a) in order to verify the accuracy of the wireline odometer wheel.

The probe was descended the length of the borehole at up to 10 m per minute while the logger monitored the wireline tension and the real-time ABI40-2G images for potential obstructions and image centralization. The probe was descended to 90% of the depth of the borehole, turned on and the first log was begun. The QA/QC log was recorded up 10% of the depth of the borehole, from 900 m bgs to 800 m bgs. Once the log had recorded 10% of the borehole depth, the QA/QC file was terminated, and the probe was returned to surface. An additional log was recorded down the entire length of borehole, sampling at 0.05 m to record deviation. Once the probe reached the bottom of the hole, the deviation file was terminated, and the primary file was started. The ABI40-2G was run up the borehole at 1.4 m per minute, sampling every 2.1 mm with 288 ppt azimuthal resolution. A constant logging speed was used throughout entire length of borehole to ensure consistency.

The log was recorded as a .TFD file and the quality of the data was monitored throughout the ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed ascent. Once the probe had reached the casing, the log was terminated, and the probe deactivated. The probe was then ascended until it was level with the reference point and removed from the borehole. The difference between initial and final depths reported at the reference point, 0.30 m, was recorded as the After-Survey Depth Error (ASDE).

The .TFD files were imported into WellCAD. For the primary log data curves, an interpolation function was applied to remove data spikes and gaps smaller than 1 m, while for the Acoustic Amplitude and Travel Time logs, the Interpolate Bad Traces algorithm was run to remove blank traces. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. Recorded depth was corrected by applying the wireline stretch formula described in Section 3.4 The logs, once referenced to the corrected depth, were then exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they compared favourably with the QA/QC log. A preliminary Acoustic Caliper log was generated from the Travel Time log, assuming an initial constant fluid velocity of 1488 m/s. These logs were then compared and depth-matched to common features of other geophysical logs, such as the optical televiewer Image log, and Mechanical Caliper log. With the Mechanical Caliper log providing known diameters of the borehole, the associated Acoustic Travel Times were used to derive a depth-dependant fluid velocity log according to the following relationship:

$$Estimated\ Fluid\ Velocity\ (m/s) = 0.15 \times D + 1620$$

where:

$$D = Depth\ (m)$$

This Estimated Fluid Velocity log was then used to calculate a revised Acoustic Caliper log which better matched the average borehole diameter values of the Mechanical Caliper. This Estimated Fluid Velocity log compared favourably to automated fluid velocity calculations run using the WellCAD image module.

The magnetic distortion of the casing was corrected by projecting a parallel curve from the non-magnetic ABI Roll log over the affected section of the magnetic ABI MRoll log. The non-oriented acoustic image logs were then rotated using this new corrected MRoll log, plus the 90° Roll-MRoll offset, to orient the images to Magnetic North without the distortion of the metallic casing. The newly oriented image logs were then compared with the original auto-oriented images throughout their non-distorted sections to ensure the rotation resulted in otherwise identical orientation to Magnetic North.

A high-pass normalization function was applied to the acoustic amplitude log, using a window of 5 degrees and 0.01 m, to improve image quality. A centralization function was applied to the acoustic travel time log to correct for minor offsets in image centralization.

The acoustic televiewer logs were then merged with the existing ABI logs from the top 100 m section, to which similar processing steps had been performed prior to the commencement of WP5. As the top 100 m section was logged using a different ABI probe, the image logs could not be merged due to scaling differences in acoustic amplitude, and so were only overlaid. The deviation curves and Acoustic Caliper logs, however, were merged to form single logs that span the entire depth of the borehole. The Azimuth log was then corrected for the magnetic distortion of the metallic casing by extending the last valid azimuth value across the distorted section.

One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, according to formulae described in Section 3.4. The acoustic televiewer images are displayed in the Structural Log, included in Appendix C, while the deviation curves are included in the Deviation Log.

3.4.5.2 Optical Televiewer

The Advanced Logic Technology (ALT) OBI40-2G Optical Televiewer probe, also known as the Optical Borehole Imager (OBI), consists of a camera which records images of the surrounding borehole by focusing downward on a conical mirror and lighting the hole with a ring of LED lights. The thin slices of images are stacked to form a continuous 24 bit RGB true colour image of the unwrapped interior of the borehole. Because the image is a 2-dimensional unwrapped cylinder, planar features (e.g. fractures) intersecting the borehole at an angle appear sinusoidal in the OBI40-2G image log.

The OBI logs are useful for observing layering, banding, foliation, fractures, voids and veins, in addition to obtaining information on visual characteristics such as oxidation staining, mineral infilling, alteration, etc. The probe also contains a 3-axis magnetometer and 3-axis accelerometer which records the tilt and azimuth of the hole, as well as the roll of the probe inside the hole. The magnetometer is susceptible to interference from highly magnetic rock, the metallic casing, or geomagnetic interference (such as intense auroral activity or solar storms). To maximize the accuracy of the deviation package, the NRCAN Space Weather Prediction Centres was consulted prior to logging to ensure no geomagnetic field disturbances. Data from the NRCAN magnetic field strength were obtained from the Brandon, Manitoba station for the duration of the field program and are included in Appendix E.

The OBI40-2G optical televiewer probe's deviation package was factory calibrated and the certificate of calibration was provided to NWMO. The probe was also checked for functionality before shipping and before logging, with the results recorded in the pre-use Calibration and Verification Check form, submitted to NWMO. Prior to use, the fidelity of the optical image was verified using a standardized Kodak strip of colour bars in a specialized canister which was placed over the end of the OBI40-2G, while the probe was still on surface. A file showing the colour bars was recorded for QA/QC purposes. A set of three specialized centralizers for HQ sized borehole were affixed to the OBI40-2G probe to maintain centralization of the probe while logging.

Once the probe was connected to the wireline, the probe was lowered into the casing until the top of the probe was flush with the reference point. In order to have data measured relative to ground surface (i.e. bedrock surface), corrections were applied to account for the offset distance between the reference point and the probe sensor, and the difference between the reference point and the ground surface. This depth correction was specific to the tool and was calculated based on the stickup of the reference point above ground surface as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

The appropriate .TOL file was selected from the tool list in the Logger program and the probe was then turned on. The probe was run at 10 m/min in Depth-Down Mode, recording deviation at 0.10 m intervals, and allowing it to transmit real-time images which were monitored by the logging scientist. During the descent, the logging scientist documented the depth to the bottom of well casing. This depth was later compared as a QA check to the depth of well casing documented during borehole drilling (WP2: Golder, 2018a) in order to verify the accuracy of the wireline odometer wheel. Once the probe reached the bottom of the borehole, the deviation file was terminated, and a new file was started. The probe was run up from the bottom of the borehole to maintain constant tension on the wireline and thus a consistent logging speed (4 m/min). The primary log was sampled at 1.25 mm increments, using 600 ppt azimuthal resolution.

The log was recorded as a .TFD file and the quality of the data was monitored throughout the ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed ascent. Once the probe was level with the reference point the final level depth was recorded to determine the After-Survey Depth Error (ASDE), the log was terminated, and the probe deactivated and removed from the borehole.

Because the OBI40-2G records and optical image through a camera lens it requires a transparent medium to see through. Data from the initial OBI40-G2 logging indicated the presence of turbid water for 8.7 % of the borehole column, from 538.77 m bgs to 625.92 m bgs, therefore a second OBI40-2G log was acquired towards the end of the logging schedule to allow time for the turbid fluid to clear.

For the purpose of demonstrating reproducibility of the image log depth and orientation measurements, a QA/QC log was recorded over 10% of the borehole, from 420 m bgs to 320 m bgs. Comparison between the QA/QC log portion and the primary image logs confirmed the north orientation and depths of the visible features.

The .TFD files were imported into WellCAD. For the primary log data curves, an interpolation function was applied to remove data spikes and gaps smaller than 1 m, while for the Optical Image logs, the Interpolate Bad Traces algorithm was run to remove blank traces. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. The logs, once drift corrected and referenced to the corrected depth, were then exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they compared favourably with the QA/QC log. These logs were then compared and depth-matched to common features of other geophysical logs, such as the acoustic televiewer logs, and Mechanical Caliper log. The two complete Optical Image logs were spliced to create one composite log which maximized the image clarity by removing the section of hole in each log obscured by the increased fluid turbidity.

The magnetic distortion of the casing was corrected over the affected interval from 1.03 m bgs to 70.90 m bgs, by projecting a parallel curve from the non-magnetic OBI Roll log over the affected section of the magnetic OBI MRoll log. The non-oriented optical image log was then rotated using this new corrected MRoll log, plus the 90° Roll-MRoll offset, to orient the image to Magnetic North without the distortion of the metallic casing. The newly oriented image logs were then compared with the original auto-oriented images throughout their non-distorted sections to ensure the rotation resulted in otherwise identical orientation to Magnetic North. This corrected image log was then spliced into the composite image log to achieve a final oriented image log for structure picking. The Azimuth log was then corrected for the magnetic distortion of the metallic casing by extending the last valid azimuth value across the distorted section.

One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, according to formulae described in Section 3.4. The optical televiewer image is displayed for reference in the Structural Log, Lithology Log, Engineering Log, and Hydrogeology Log, included in Appendix C, while the deviation curves are included in the Deviation Log.

The optical image from the televiewer is particularly useful for identifying lithological and alteration zonations based simply on the colour image. Such information is included as a part of the single borehole integration report (WP10: Golder, 2018f), where it is compared to lithology and alterations mapped during core logging. In addition, the optical televiewer image was a key dataset used to interpret structural features throughout the length of the borehole. Description of this interpretation is included in Section 3.4.5.3.

3.4.5.3 Televiewer Structural Interpretation

Once the optical and acoustic televiewer logs were finalized, a structural analysis was completed using the structural interpretation module in WellCAD to obtain the depth, apparent dip, and dip direction (i.e. orientations relative to magnetic north) of each interpreted structure (Figure 8).

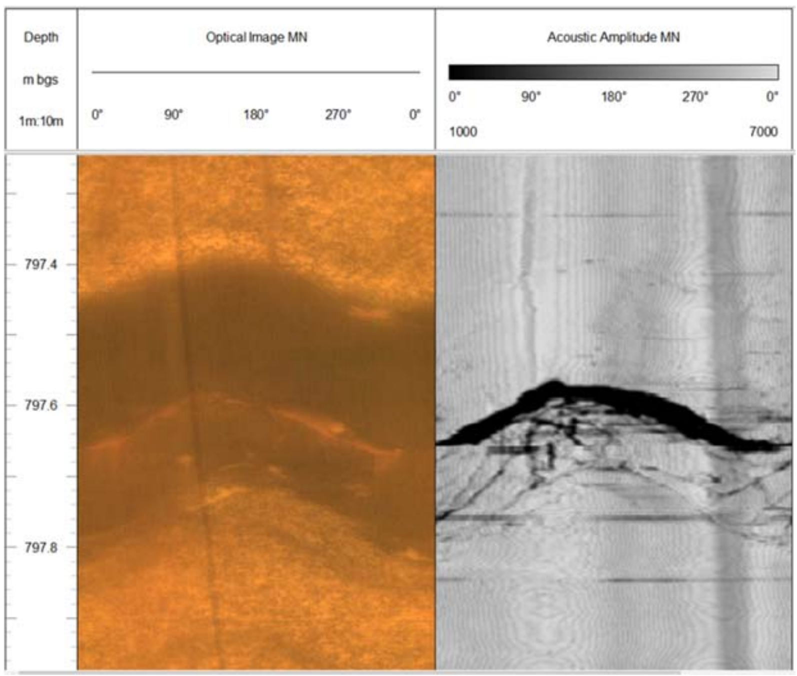

Figure 8: Optical and acoustic televiewer logs showing sinusoidal fracture planes intersecting the borehole wall

To do so a blank structure log was overlain on either televiewer image, switching between data sets as needed, to compare the pick of one feature over multiple images. The Acoustic Caliper log was selected to represent the borehole diameter used to calculate apparent dip, as this log spanned the entire depth of the borehole, including the top 100 m surveyed only with the acoustic televiewer (Figure 9) was consistent with the terminology used during geological and geotechnical core logging outlined in WP3 (Golder, 2018b). However, only a subset of those structures were applicable to picking from the televiewer images. For each type of structure, a certainty value was assigned to address the clarity of the structure traced in the televiewer image (High, Medium and Low). For structures with a measurable thickness (e.g. veins, joints), apparent apertures were also traced as the width of the structure perpendicular to its orientation.

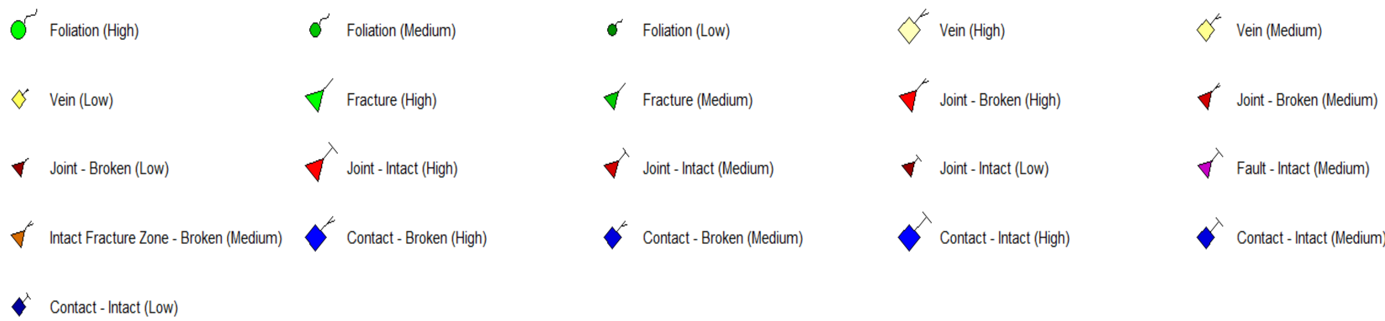

Figure 9: WellCAD Structure Dictionary showing used structures

A Breakout log was also created to allow for the picking of the minimal breakouts observed. Breakouts are defined as open vertical or sub-vertical structures in the borehole wall, aligning with the plane of minimum horizontal stress. Breakouts are formed where stresses around the borehole have exceeded the compressive strength of the rock.

They can be seen in televiewer logs as pairs of vertical or sub-vertical features, and potentially in mechanical caliper logs as increases in borehole dimeter, depending on their size and orientation relative to the caliper arms. Breakouts can be traced on a breakout log by aligning a feature along the breakout axis and assigning it an aperture.

Interpreted structure orientations were corrected from apparent dip and dip direction to true dip and dip direction (i.e. relative to true north), using the final Tilt and Azimuth logs (see Section 3.4.15). Final orientations of structures are presented as tadpoles (Tadpoles TD&DD in Appendix C), showing their dip magnitude along the X-axis and the tail showing their azimuth direction. The corrected structure log was then exported as a .CSV file where the Magnetic North azimuths were corrected with the local magnetic declination (1.361°W), as calculated by the Geological Survey of Canada, to yield True North azimuths. The structure types were converted from numerical labels to descriptive labels and the file was saved.

The Tadpoles TD&DD log was used to generate two frequency logs (Joints / Fractures and Veins), measured in counts per metre. The frequency of Joints/Fractures ranges from 0 counts/m to 11 counts/m, with an average of 0.68 counts/m. The frequency of Veins ranges from 0 counts/m to 7 counts/m, with an average of 0.31 counts/m.

Five equal-angle (Wulff) stereonets, each spanning 200 m of the borehole were plotted to show the change in dip and dip direction of joints / fractures along the borehole. In the near-surface interval, between 0 and 200 m bgs, there are two distinct trends of joints, with the stronger showing a moderate dip towards the South, while the weaker cluster of poles is close to horizontal, with a slight dip to the west. The stronger cluster continues between 200 and 400 m bgs, still dipping to the south, though the weaker cluster diminishes. Between 400 and 600 m bgs, the strong cluster changes to weakly dipping towards the north. This cluster continues in the 600 to 800 m bgs interval, with three new weaker clusters appearing to steeply dip west, south, and southeast. In the bottom interval from 800 to 1001 m bgs, the strong cluster dips more moderately to the northwest, while the weaker trends disappear. Structure orientations and their lithological correlations are discussed in detail in WP10 (Golder, 2018f).

Structures picked from televiewer logs, as well as frequency logs and stereonets, are displayed in the Structural Log, included in Appendix C. Two possible breakout features are observed in the televiewer logs; however their genesis may be related to drill-scour rather than rock stress. The first feature, shown on Figure 10, appears at a depth of 698.5 m and had an azimuth of 165.7 degrees, dipping at -0.7 degrees, with an opening of 81.1 degrees and a maximum caliper of 102 mm. The second feature appears at a depth of 944.31 m bgs, and had an azimuth of 135.1 degrees, dipping at -2.1 degrees, with an opening of 59.8 degrees and a maximum caliper of 101 mm.

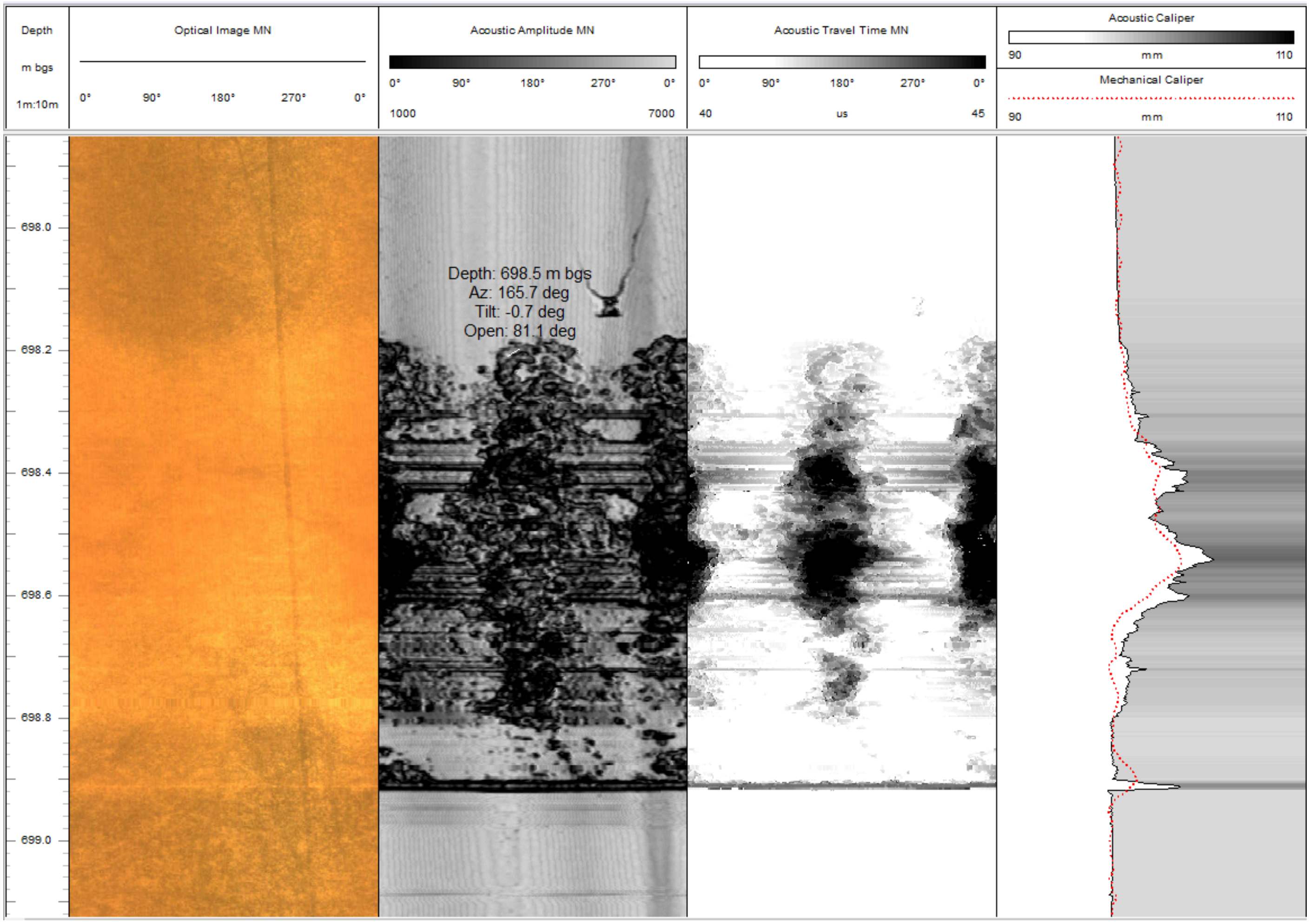

Figure 10: Possible borehole breakout centred at depth of 698.5 m bgs

3.4.6 Natural Gamma

In crystalline rock, the gamma log is used principally for lithologic identification based on presence of minerals with natural radioactivity. The Mount Sopris 2PGA-1000 Natural Gamma probe was used to provide a measurement, recorded in counts per second (cps) that is proportional to the natural radioactivity of the bedrock.

The Mount Sopris 2PGA-1000 natural gamma probe uses a scintillation sodium iodide crystal to measure the incoming natural gamma radiation from the borehole walls. The gamma-emitting radio-isotopes that naturally occur in geologic materials are Potassium 40 and nuclides in the Thorium 232 and Uranium 238 decay series. Potassium 40 occurs with all potassium minerals including potassium feldspars. Thorium 232 is typically associated with biotite, sphene, zircon and other heavy minerals. Uranium 238 is typically associated granitoid rocks with uranium mineralization.

Once the probe was connected to the wireline, it was lowered into the casing until the top of the probe was flush with the reference point. In order to have data measured relative to ground surface (i.e. bedrock surface), corrections were applied to account for the offset distance between the reference point and the probe sensor, and the difference between the reference point and the ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

A QAQC log was recorded for a 100 m interval between 600 m bgs to 500 m bgs. For this log the probe was run at 2.25 m per minute, sampling every 2.5 cm. Once the QA/QC log was complete, the probe was descended to the bottom of the borehole and the continuous borehole log was initiated recording up the borehole at the same speed and sampling interval.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the ascent to ensure valid telemetry and minimal data errors, according to ASTM Standard D6274-10 (Section 9). Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe reached the top of the hole and was level with the reference point, the log was terminated, and the probe was deactivated and removed from the borehole.

The .TFD files were imported into WellCAD where the primary log compared favourably to the QA/QC log. For the primary log, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The log was shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. Recorded depth was corrected by applying the wireline stretch formula described in Section 3.4. Once wireline stretch was corrected, the log was exported as a .WCA file.

The .WCA file was then imported back into one common WellCAD file where it was compared with other geophysical logs, such as the optical televiewer image log, spectral gamma total counts log, and apparent conductivity log. Natural gamma log depths were matched to common features to further refine the accuracy and one final depth correction was applied according to the results of structural integration between televiewer logs and core logs, according to formulae described in Section 3.4.

The final Natural Gamma curve is displayed on the Lithology Log, in Appendix C. The data were measured in counts per second in the borehole, ranging from 0 cps to 256 cps, with an average value is 80.26 cps. The Natural Gamma values are on average 2.7 times higher than the Spectral Gamma total counts values, which is a result of counts falling outside the spectral energy classification window used during spectral gamma acquisition, which filters out counts with energy below 100 keV. Both the Natural Gamma and Spectral Gamma total counts logs match well for their respective ranges, showing the same pattern along the total depth of the borehole. The most apparent anomalies in the data tend to be associated with sharp changes in total counts associated with changes in biotite concentration. The most pronounced change occurs at the depth interval from approximately 180 to 240 m, showing a pronounced decrease of about 40 cps, associated with an increase in biotite within the tonalite bedrock. Elsewhere in the borehole more localized anomalies are also associated with intervals that have undergone alteration. A detailed interpretation of the natural gamma curve and core logging data will be completed as part of the single borehole integration report (WP10: Golder, 2018f).

3.4.7 Neutron

The Mount Sopris LLP-2676 Neutron probe uses an alpha emitting radioactive source, Americium 241 mixed with Beryllium and a single detector, to acquire relative neutron counts principally related to hydrogen ion concentration. Changes in neutron counts can be used to identify changes in rock geology.

Prior to mobilization, the probe was tested for proper calibration at DGI's Operation Centre, using an open air sample and a test block. The calibration test passed with an average count of 87.229 cps in open air, and 1734.483 cps in the test block. Values and verification were recorded in the Calibration and Verification Check Form, included in Appendix A.

Once the probe was configured and calibration was verified, it was lowered into the casing until the top of the probe was flush with the reference point. In order to have data measured relative to ground surface (i.e. bedrock surface), corrections were applied to account for the offset distance between the reference point and the probe sensor, and the difference between the reference point and the ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B. The hole was logged over two shifts, with the primary log being collected in intervals from 300 m bgs to surface and from the bottom of the hole to 275 m bgs. A QA/QC file was also recorded from 315 m bgs to 190 m bgs. The logs were collected in the up direction, with the probe being run at 2.5 m per minute, sampling every 2.5 cm.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent and ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe was level with the reference point, the file was terminated and saved to the laptop and backup drive, and the probe was deactivated and removed from the borehole. The neutron source was removed and returned to its protective case.

The .TFD files were imported into WellCAD where the primary logs compared favourably to the QA/QC log. For the primary logs, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they were compared with other geophysical logs, such as the optical televiewer image log, gamma-gamma density log, and natural gamma log. The two primary logs were merged, and common features were matched, to further refine the accuracy. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs described in Section 3.4.

The final Neutron curve is displayed on the Lithology Log, in Appendix C. The Neutron data is measured in counts per second, ranging from 705 cps to 2825 cps, with an average value of 2254 cps. The neutron curve tends to produce anomalies along the borehole length than inversely correlate with anomalies in the gamma-gamma density curve. A broad anomaly occurs at the depth interval from approximately 180 to 240 m, showing a pronounced decrease in total neutron counts, down to an average of 2160 cps. This depth interval is similarly reflected in the gamma-gamma density and total gamma curves. Based on core logging data (WP3: Golder, 2018b), this interval is associated with an increase in biotite within the tonalite bedrock. Numerous high-frequency anomalies, reflected as sharp 500 to 1200 cps decreases in neutron counts, also occur along the borehole and coincide with peaks in the gamma-gamma density log. The majority of these anomalies occur below a depth of 640 m and coincide with discrete changes in lithology. A detailed interpretation of the neutron log responses associated with changes is lithology will be completed as part of the single borehole integration report (WP10: Golder, 2018f).

3.4.8 Full Waveform Sonic

Full waveform sonic logs provide data on the compression wave and shear wave velocity of the borehole wall. This data can be used in conjunction with density logs from the gamma-gamma density probe to calculate engineering properties like shear modulus, bulk modulus, young's modulus, and Possion's ratio, which are useful for distinguishing rock types.

The Mount Sopris FWS50 Full Waveform Sonic probe (FWS) utilizes a sonic transmitter and three receivers to measure the primary (compression) and secondary (shear) wave velocities of the rock formation. The transmitter and receiver portions of the probe are isolated from each other with a flexible sonic isolator which prevents the transmitted sonic pulses from travelling through the probe. As the calculations for wave velocity require a consistent separation from the transmitter and receivers relative to the borehole wall, centralizers are required for this probe.

Once the probe was assembled, affixed with centralizers, checked for functionality, and connected to the wireline, the probe was lowered into the casing until the top of the probe was flush with the reference point. In order to have data measured relative to ground surface (i.e. bedrock surface), corrections were applied to account for the offset distance between the reference point and the probe sensor, and the difference between the reference point and the ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B. The probe was descended to 50% of the borehole depth, and a QA/QC log was recorded from 500 m bgs to 400 m bgs. The probe was run at 1.5 m per minute, sampling every 0.05 m. Once the QA/QC log was complete, the probe was descended to the bottom of the borehole and, the second file was begun, recording with the same speed and sampling interval. The first primary log was recorded from 1,000 m bgs to 200 m bgs and the probe was returned to surface for shift change.

Deterioration of a pressure seal in the probe resulted in the probe failing a pre-use functionality check on surface before it was to be used after the first FWS logging shift, so a replacement probe of the same make and model was sourced. Prior to using the replacement probe, the initial FWS log data was checked and confirmed to be of good quality. The replacement probe was setup in an identical manner and the second primary log was recorded from 250 m bgs to 55 m bgs (into the casing), overlapping the original log by 50 m.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent and ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe was level with the reference point, the tool was deactivated, and the probe was removed from the borehole.

The .TFD files were imported into WellCAD where the primary logs compared favourably to the QA/QC log. For the primary logs, the Interpolate Bad Traces algorithm was applied to remove any gaps in the data. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they were depth matched and spliced to create one continuous set of FWS logs. They were then compared with other geophysical logs, such as the optical televiewer image log, gamma-gamma density log, and neutron log, and common features were matched to further refine the accuracy.

Compression and shear wave velocities were estimated in WellCAD by computing as semblance plot that evaluates the similarities in the full sonic waveforms across the array of receives in the probe. Graphically, the FWS Semblance Plot is an image log where individual pixels are assigned a colour based on the amplitude of the semblance between the travel times recorded by each of the FWS receivers. The manually picked slowness curves were adjusted using the WellCAD extremum algorithm, and the logs were inverted to generate Compression Wave Velocity and Shear Wave Velocity logs. These logs were then used to calculate the Poisson's Ratio log, according to the formula (ALT 2011):

$$Poisson's\ Ratio = \frac{\frac{1}{2}\left(\frac{dts}{dtc}\right)^2 - 1}{\left(\frac{dts}{dtc}\right)^2 - 1}$$

where:

$$dtc = Compression\ Wave\ Slowness\ \ (\mu s/sm)$$

$$dts = Shear\ Wave\ Slowness\ (\mu s/sm)$$

The calculated Poisson's Ratio was then used in conjunction with the Shear Modulus to generate the Young's Modulus, according to the formula:

$$Young's\ Modulus\ (MPa) = 2 \times \mu \times (1 + \nu)$$

where:

$$\mu = Shear\ Modulus\ (MPa)$$

$$\nu = Poisson's\ Ratio$$

The Bulk Modulus was calculated according to the formula:

$$Bulk\ Modulus\ (MPa) = \rho_b \times \left(\frac{1}{dtc^2} - \frac{4}{3 \times dts^2}\right)$$

where:

$$\rho_b = Bulk\ Density\ (g/cc)$$

Using the Near Density log in conjunction with the Shear Wave slowness log, the Shear Modulus was calculated according to the relationship (ALT 2011):

$$Shear\ Modulus\ (MPa) = \frac{\rho_b}{dts^2}$$

where:

The Near Density log was also used in conjunction with the Compression Wave Velocity log to calculate the Characteristic Acoustic Impedance, according to the following relationship:

$$Characteristic\ Acoustic\ Impedance\ (Rayls_{MKS}) = \rho_n \times v_P$$

where:

$$\rho_n = Near\ Density\ \ (kg/m^3)$$

$$v_P = Compression\ Wave\ Velocity\ (m/s)$$

One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The Full Waveform Sonic (FWS) image log and curves are displayed in the Engineering Log, included in Appendix C. The FWS logs include the Semblance Plot image, the picked Compression Wave and Shear Wave slowness curves, the calculated Compressive Wave Velocity and Shear Wave Velocity curves, the calculated elastic constant curves, and the calculated Characteristic Acoustic Impedance curve. Table 6 lists the FWS logs, along with their units, minimum and maximum values, as well as average values (where applicable).

Table 6: FWS Log Details

Log Name	Units	Min Value	Max Value	Average Value
Compression Wave Slowness	µs/m	153.66	195.19	171.63
Shear Wave Slowness	µs/m	257.39	406.95	297.25
Compression Wave Velocity	m/s	5,243.71	6,268.17	5,832.85
Shear Wave Velocity	m/s	2,664.74	3,885.13	3,370.24
Poisson's Ratio	-	0.04	0.40	0.25
Shear Modulus	MPa	19,382	40,913	31,178
Young's Modulus	MPa	52,486	96,903	77,877
Bulk Modulus	MPa	30,352	69,186	51,803
Characteristic Acoustic Impedance	Rayls (MKS)	1.42×10^7	2.15×10^7	1.60×10^7

The Semblance Plot is overlaid with the picked Compression Wave and Shear Wave slowness curves, which correspond to the two separate peak values shown in the Semblance Plot image. The corresponding Compression Wave Velocity and Shear Wave Velocity curves are overlaid for comparison. The Poisson's Ratio curve is displayed next to the three overlain elastic constants curves, Shear Modulus, Young's Modulus, and Bulk Modulus. Variations in the velocity curves and associated engineering property curves positively correlate to changes in the gamma-gamma density. The interval from 180 to 240 m bgs, which shows a positive density deviation of approximately 0.04 g/cc, corresponds to a compression wave increase of approximately 180 m/s. Higher frequency changes in density at greater depths similarly correlate to changes in velocity and associated engineering properties, which in turn correlate to changes in lithology, notably the increases in biotite content in the tonalite bedrock. A detailed interpretation of the various FWS logs will be completed as part of the single borehole integration report in the context of the geomechanical understanding of the bedrock (WP10: Golder, 2018f).

3.4.9 Mechanical Caliper

Caliper data is used to measure the average diameter of the borehole, showing voids, and open joints and fractures. Caliper data is necessary for accurate calculation of apparent structure dips, and for the determination of the borehole fluid velocity for the calculation of the acoustic caliper log.

The Mount Sopris 2PCA-1000 Mechanical Caliper probe uses three spring-driven arms, held against the borehole wall, to measure the average diameter of the borehole with depth. The caliper probe is run up from the bottom of the borehole such that the arms will expand into voids or fractures. The caliper probe is a combination tool with the fluid temperature / resistivity probe (FTR). The probe was checked for functionality prior to shipping to site and again once on site prior to use. Records of pre-use checks can be found in the pre-use Calibration and Verification Check Form, provided in Appendix A.

Before descending the probe into the borehole, the caliper was calibrated on surface using an associated calibration jig with two known diameters (10.2 cm and 15.2 cm), in accordance with ASTM standard D6167-11 (Section 8.2). The diameters of the calibration jig were recorded with the probe’s response and the results were saved into the associated .TOL file and exported as a .TXT file for record keeping. Calibration values were also recorded in the Calibration and Verification Check Form, provided in Appendix A. Following the calibration, the probe was lowered into the borehole until level with the reference point, and the depth was corrected to report the depth below ground surface of the measurement point of the caliper portion of the combination tool. The probe was then descended the full depth of the borehole. The associated .TOL file was then selected and the probe was activated. The full boot sequence was allowed, requiring 90 seconds as the caliper arms were opened, before the readings were valid. The probe was logged up from 1,000 m bgs to 900 m bgs as a QA/QC file. Once the QA/QC file was complete, the file was terminated, the probe arms were closed, and the probe was descended back to the bottom of the borehole. The primary caliper log was run up from the bottom of the borehole to 65 m bgs (into the casing), at 2 m per minute, sampling every 1 cm.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed ascent.

Once the probe was level with the reference point, it was turned from Depth Up mode to Time Mode and the probe was removed from the borehole with the arms still extended. It was then checked in the calibration jig against the same two known diameter values. Changes in temperature of the probe caused the reported values to drift over the course of the log by -0.35 cm on the low end, and 0.49 cm on the high end. These values were used later in the processing stage to correct the caliper curve, by matching points of stable rock wall and casing to known diameter values.

The .TFD files were imported into WellCAD where the primary log compared favourably to the QA/QC log. For the primary log, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The log was shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the log was exported as a .WCA file.

The .WCA file was then imported back into one common WellCAD file where it was compared with other geophysical logs, such as the optical televiewer image log, and acoustic caliper log. The log was depth matched with common features, to further refine the accuracy. Due to intervals of slightly different average borehole diameter being reported between the larger open joints, the log was split into five pieces which were each drift-corrected separately and merged into one final Mechanical Caliper log. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The final Mechanical Caliper curve is displayed on the Lithology Log, in Appendix C and is overlaid with the Acoustic Caliper curve for comparison purposes. The borehole was drilled using a HQ drill bit with an outer diameter of 96.1 mm. The Mechanical Caliper log measured in mm through the borehole ranges from 96.66 mm to 115.16 mm, with an average value 97.68 mm. The Mechanical Caliper and Acoustic Caliper logs match well for their ranges, showing the same pattern along the length of the borehole. However, the acoustic caliper shows a zone of slightly lower (1.0 mm) values at a depth interval between 845 m bgs and 915 m bgs as a result of a possible change in fluid velocity.

3.4.10 Normal Resistivity, Self-Potential and Single Point Resistance

The Mount Sopris QL40 ELOG (resistivity) probe was used to collect a continuous record of the normal electrical resistivity, electrical resistance, and natural electrical potential of the borehole wall. The probe is comprised of 5 separate electrodes which are used to measure normal resistivity at 4 spacings (8, 16, 32 and 64 inch). The tool also measures self-potential (SP), and single point resistance (SPR) between the uppermost electrode on the probe and a remote reference electrode installed at surface, in a shallow pit filled with bentonite mix located approximately 50 cm from the borehole. The resistivity probe is used with an electrically isolating bridle separating the probe from the wireline cable head.

The SP log provides a measure of the natural voltages within the borehole, which can be related to either electrochemical forces, such as differences in fluid electrical conductivities/salinities between the borehole fluid (flushed fluid) and the formation fluid and movement between the two, or electrokinetic forces, such as fluid flow from a fracture resulting in changes in hydraulic gradients. SP is measured between the 64” electrode and the armour of the probe near the wireline cable head.

The SPR log provides a qualitative indication of electrical resistance of the bedrock adjacent to the current electrode. The resistance measured represents the sum of the resistance between the surface reference electrode and the current electrode. Therefore, it is important to minimize the contact resistance of the surface electrode by seating it in a bentonite/clay mud cake and maintaining a constant temperature throughout the logging. The surface electrode was located within the warmed enclosure surrounding the borehole to maintain the temperature throughout the logging.

The geophysical logging originally planned to use the Mount Sopris 2PEA-1000 PolyElectric Probe for measuring resistivity, however pre-use checks demonstrated that this probe was not functional and a Mount Sopris QL40 ELOG was sourced which operates on the same principles and was designed to replace the 2PEA-1000. The QL40 ELOG was tested prior to use and calibrated using the ELOG calibration box with resistivities of 1, 100, 1,000 and 10,000 Ωm (ohm-metres). The record of calibration is provided in the Calibration and Verification Check Form.

Once the probe and bridle were connected to the wireline, the probe and bridle were lowered into the casing until the top of the bridle was flush with the reference point and the depth was corrected to report the depth of the bottom of the tool referenced to ground surface. Due to the multiple measurement points on the probe, the .TOL file determined the individual offsets of the electrodes automatically, using pre-determined channel shift values. The depth correction is specific to the tool and was calculated based on the stickup of the reference point, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B. The surface electrode was connected to the Matrix logging box. The probe was descended to a depth of 600 m and the tool was turned on, Depth Mode was selected, and the first log was started. The QA/QC log was recorded up from 600 m bgs to 500 m bgs. The probe was run at 3.0 m per minute, sampling every 0.05 m. Once the QA/QC log was complete, the probe was descended to the bottom of the borehole. Once the probe reached the bottom of the borehole, the second file was started, recording with the same speed and sampling interval. The hole was logged over multiple shifts to accommodate shift change and intermittent telemetry errors, resulting in four primary logs and one QA/QC log.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed ascent.

Once the bridle was level with the reference point, it was turned from Depth Up mode to Time Mode and the probe was removed from the borehole. It was then checked in the calibration box against the same known resistivity values. Changes in temperature of the probe caused minimal drift (<0.1%) over the course of the survey. The post-use calibration check values are recorded in the Calibration and Verification Check Form, in Appendix A.

The .TFD files were imported into WellCAD and the primary logs were compared to the QA/QC log to ensure repeatability. For the primary logs, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where they were compared with other geophysical logs, such as the optical televiewer image log, magnetic susceptibility log, and apparent conductivity log. The resistivity logs were depth matched with common features, to further refine the accuracy. The logs were merged into final Self Potential, Single-Point Resistivity, and 8”, 16”, 32” and 64” Resistivity logs. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The final Resistivity, Self-Potential, Single Point Resistance curves are presented in the Lithology Log, included in Appendix C. The Self-Potential and SP Resistance curves are overlaid with the Apparent Conductivity curve for comparison purposes, while the 8”, 16”, 32” and 64” Resistivity curves are displayed in logarithmic scale and overlaid with each other. The logs are shown in Table 7, along with their units, minimum and maximum values, as well as average and estimated background values (where applicable).

In general, the resistivity curve shows a steady decrease with depth, with numerous discrete downward spikes correlating to changes in lithology (e.g. 315 m bgs, 656 m bgs, 895 m bgs, and 979 m bgs) as observed in televiewer logs and core logging. Several of these spikes correlate with low neutron counts and high gamma-gamma density counts throughout the borehole.

The self-potential curve shows variability over much of the borehole, with a general decreasing trend from 300 m bgs to 650 m bgs. Sudden dips in the self-potential often correlate to changes in lithology, with a primary example at 895 m bgs.

Single-point resistance remains high and variable for the upper 400 m of the borehole, then begins to decrease down to 550 m bgs, below which it remains low, with small variations associated with slight increases in resistivity, and reductions in magnetic susceptibility.

Gradual variability in the resistivity, SP, and SPR curves below 530 m bgs is interpreted to be caused by changes in fluid conductivity generated during FFEC testing. Three distinct zones are seen in these curves which correlate to elevated fluid conductivity, specifically 530-640 m bgs, 700-780 m bgs, and 850-930 m bgs.

Where needed, an integrated interpretation of the resistivity, single point resistance and self-potential logs will be completed as part of the single borehole integration report (WP10: Golder, 2018f).

Table 7: ELOG Log Details

Log Name	Units	Min Value	Max Value	Average Value
Self-Potential	mV	178	473	340
Single Point Resistance	Ω	153	13,654	3,878
8” Resistivity	Ωm	357	29,437	8,456
16” Resistivity	Ωm	666	54,828	14,808
32” Resistivity	Ωm	1,209	93,357	23,124
64” Resistivity	Ωm	2,098	138,725	27,530

3.4.11 Spectral Gamma

The Mount Sopris 2SNA-1000 Spectral Gamma probe was used to measure the naturally occurring gamma radiation of distinct energy levels being emitted by the host rock, in order to derive the concentrations of Potassium (K), Uranium (U) and Thorium (Th) as well as their decay products. The logs are used for the identification of lithology, mineralogy and alterations. The probe consists of a scintillation sodium iodide crystal which measures the incoming natural gamma radiation from the borehole walls and is resolved into a spectrum of energy levels associated with the specific radionuclides of Potassium, Uranium and Thorium. The gamma-emitting radio-isotopes that naturally occur in geologic materials are Potassium 40 and nuclides in the Thorium 232 and Uranium 238 decay series. Potassium 40 occurs with all potassium minerals including potassium feldspars. Thorium 232 is typically associated with biotite, sphene, zircon and other heavy minerals. Uranium 238 is typically associated granitoid rocks with uranium mineralization.

The spectral gamma probe was checked for functionality prior to shipping. The results of the functionality test are recorded in the pre-use Calibration and Verification Check Form, included in Appendix A.

Once the tool was connected to the wireline, the probe was powered up and checked for valid data. The probe was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Logger program was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

The probe was descended down to a depth of 500 m and turned on and the first log was started. The QA/QC log was recorded up 10% of the borehole depth, from 500 m bgs to 400 m bgs. The probe was run at 2.25 m per minute, sampling every 2.5 cm. Once the QA/QC log was complete, the first file was terminated, and the probe was descended to the bottom of the hole. The second file was started, logging up into the borehole at the same speed and sampling interval.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent and ascent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the probe was level with the reference point, the second file was terminated, and the probe was deactivated and removed from the borehole.

The .TFD files were imported into WellCAD and the primary logs were compared to the QA/QC log to ensure repeatability. For the primary logs, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as a .WCA file.

The .WCA file was then imported back into one common WellCAD file where the logs were compared with other geophysical logs, such as the optical televiewer image log, and natural gamma log. The logs were depth matched with common features, to further refine the accuracy.

The K, U, and Th curves were generated through the WellCAD procedure for spectrum stacking over a 2 metre window, and a 10 metre window. To generate the individual curves an energy window of 1,360 to 1,560 keV was used for the K band, an energy window of 1,660 to 1,860 keV was used for the U band, and an energy window of 2,520 to 2,720 keV was used for the Th band, which captures energy 100 keV either side of the peak associated with the band. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The Spectral Gamma curves are presented in the Lithology Log, included in Appendix C. The Spectral Gamma total counts curve is overlaid with the Natural Gamma curve for comparison purposes, while the stacked Potassium, Thorium, and Uranium counts logs are overlaid on each other. The Spectral Gamma logs are listed in Table 8, along with their units, minimum and maximum values, as well as average and estimated background values (where applicable).

Table 8: Spectral Gamma Log Details

Log Name	Units	Min Value	Max Value	Average Value
Spectral Gamma	total cps	2.43	121.37	31.94
K – Stacked – 2m	cps	0.10	1.75	0.56
Th – Stacked – 2m	cps	0.00	0.60	0.04
U – Stacked – 2m	cps	0.00	0.56	0.16

Log Name	Units	Min Value	Max Value	Average Value
K – Stacked – 10m	cps	0.27	1.07	0.56
Th – Stacked – 10m	cps	0.00	0.18	0.04
U – Stacked – 10m	cps	0.04	0.34	0.16

The Natural Gamma and Spectral Gamma total counts logs match well for their ranges, showing the same trends, spikes, and plateaus. The Natural Gamma values are on average 2.7 times higher than the Spectral Gamma total counts values, which is a result of counts falling outside the spectral energy classification window used during spectral gamma acquisition, as the Spectral Gamma probe filters out any counts with an energy level less than 100 keV. Trends in both the Natural Gamma and Spectral Gamma total counts logs match well for their respective ranges, showing the same pattern along the total depth of the borehole. In general, the total gamma counts curve is negatively correlated with the presence of biotite in the host tonalite, with interpreted biotite-rich layers appearing as relatively low gamma plateaus. Overall the uranium and thorium curves show very low concentrations, however, the potassium curve appears to represent the bulk of the radioactive response. In particular, where the total gamma counts decrease associated with biotite-rich intervals the potassium curve also shows an apparent decrease. The most prominent correlation is shown at depth intervals of 180 to 240 m bgs and 470 to 480 m bgs. The spectral gamma logs will be integrated as part of the single borehole integration report (WP10: Golder, 2018f).

3.4.12 Fluid Temperature and Resistivity

The Mount Sopris 2CAA-1000 Fluid Temperature / Resistivity probe (FTR) is part of a combination probe, forming the bottom end of the 3-arm mechanical caliper probe. The FTR is run down the borehole within the fluid and records the fluid temperature and electrical resistivity as the fluid passes through the tool.

Immediately prior to use, the probe was calibrated using two fluids of known resistivity (26.17 Ωm and 15.41 Ωm). The calibration values are recorded in the Calibration and Verification Check form, as well as the exported calibration text file, provided to NWMO.

The probe was lowered into the casing until the top of the probe was flush with the reference point and the depth was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point above ground surface, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

Data logging began at the top of casing to obtain a complete profile of the borehole. Starting the log data in the air ensured that it recorded the transition between the air-filled portion and the fluid-filled portion of the borehole; a sharp change in resistivity and temperature indicates the top of static water level in the borehole. Temperature data in the air-filled portion reflects the ambient air temperature, however fluid resistivity values above the static water level are not valid. The primary log was recorded down at a speed of 4 m per minute, sampling every 5 cm. Once the probe reached the bottom of the borehole, the first file was terminated, and the probe was ascended to a depth of 100 m bgs. A new file was started, and the QA/QC log was recorded down for 10% of the borehole depth, from 100 m bgs to 200 m bgs, at the same speed and sampling rate. Once the QA/QC log was complete, the probe was returned to the surface.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent. Once the probe was level with the reference point the recording mode was switched from Depth Down mode to Time Mode and removed from the borehole.

The probe was then checked in the same two fluids of known resistivity and the results recorded in the Calibration and Verification Check form. The probe values drifted by an average of 3.14 Ωm over the course of testing.

The .TFD files were imported into WellCAD where the primary logs compared favourably to the QA/QC log. For the primary logs, an interpolation function was applied to remove data spikes and gaps smaller than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as a .WCA file.

The .WCA file was then imported back into one common WellCAD file where the logs were compared with other geophysical logs, such as the optical televiewer image log, and FFEC logs. The logs were depth matched with common features, to further refine the accuracy. The Fluid Resistivity log was inverted to present Fluid Conductivity for comparison to FFEC logs. Fluid Resistivity Gradient and Temperature Gradient logs were created using the standard WellCAD formula. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, using formulae described in Section 3.4.

The final Fluid Temperature, Fluid Resistivity, and Static Fluid Conductivity curves are displayed on the Hydrogeology Log, in Appendix C. The FTR curves are overlaid with each other and are presented next to the FFEC logs, with log start time in minutes, for comparison purposes. The FTR logs are listed in Table 9, along with their units, minimum and maximum values, as well as average values. In general, the Static Fluid Conductivity curve shows the same three zones of higher electrical conductivity at depth that are observed in the FFEC logs, though much more diluted and spread out considering the time since the FFEC testing was completed. The conductivity peaks reach local maximums of approximately 27 mS/m, compared to the peak values at the end of dynamic FFEC logging, which were in the range of 35 – 44 mS/m. The Fluid Temperature curve shows a steady increase from approximately 6°C at the water table, to 14°C at the bottom of the borehole.

Table 9: FTR Log Details

Log Name	Units	Min Value	Max Value	Average Value
Fluid Temperature (T=11120min)	°C	3.79	14.27	9.20
Fluid Resistivity (T=11120min)	Ωm	6.31	69.82	22.54
Static Fluid Conductivity (T=11120min)	mS/m	10.02	27.54	21.30

3.4.13 Magnetic Susceptibility

Magnetic susceptibility data was collected to measure the magnetic susceptibility of the rock. The Mount Sopris 2BSF-1000 Magnetic Susceptibility probe contains a Bartington BSS-02B-2 sensor and is used to measure the dimensionless magnetic susceptibility constant K of the rock mass, which indicates the degree to which it can be magnetized in the presence of a magnetic field.

The probe was calibrated prior to logging using the manufacturer-supplied calibration block of known magnetic susceptibility of 22.62×10^{-3} SI units (180×10^{-5} CGS) and the 0 (null) magnetic susceptibility value in air. The results of the calibration are recorded in the Calibration and Verification Check form (Appendix A).

Once the probe was calibrated, it was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Logger program was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point above ground surface, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B.

The probe was descended to a depth of 400 m bgs, turned on and the first log was started. The QA/QC log was recorded up the borehole for 10% of the borehole depth, from 400 m bgs to 300 m bgs. The probe was run at 4.5 m per minute, sampling every 5 cm. Once the QA/QC log was complete, the probe was descended to the bottom of the borehole. Once the probe reached the bottom of the borehole, the first file was terminated, and the second file was started, recording up at the same speed and sampling interval. The hole was logged in two files to accommodate a shift change, from 1001 m bgs to 586 m bgs, and from 595 m bgs to surface. An odometer wheel error resulted in a higher than expected After-Survey Depth Error (ASDE) of 1.14 m. This error was less than the allowable ASDE error of 1.30 m, but relatively high in comparison to other logs. Therefore, an additional short log was acquired from 80 m bgs to 60 m bgs to allow for depth confirmation during processing.

The logs were recorded as .TFD files and the quality of the data was monitored throughout the descent to ensure valid telemetry and minimal data errors. Wireline tension was also monitored to ensure continuous, unobstructed descent. Once the probe was level with the reference point, the final log was terminated, and the probe was turned from Depth Up mode to Time Mode and removed from the borehole.

The probe calibration was then checked in the calibration block and in air and the results recorded in the Calibration and Verification Check form. The probe calibration drifted significantly over the course of testing, due to thermal drift, which is caused by changes in measured values due to changing temperature of the probe's internal electronics. Correlation of the raw magnetic susceptibility log response to the fluid temperature log response collected that same day indicated there was a drift in measured magnetic susceptibility 3×10^{-5} CGS per 1 °C increase. This was significant, as the temperature of the borehole fluid ranged from 14.27 °C to 3.79 °C from the bottom to top of the borehole.

The processing steps for the magnetic susceptibility log consisted first of correction for thermal drift. A thermal correction factor of 3×10^{-5} CGS per 1 °C was applied to the magnetic susceptibility data, using a temperature difference of -6.25 °C between the temperature of the probe at the time of initial calibration and the start of logging. The temperature difference was estimated based on change in temperature and adjusted slightly based on correlation of the magnetic susceptibility data in the upper 400 m of the borehole to magnetic susceptibility measurements in the area for tonalite rocks within the Revell batholith (Golder and PGW, 2017). The formula for the correction of the log is presented below:

$$Mag\ Sus\ (CGS \times 10^{-5}) = Raw\ Mag\ Sus\ (SCGS \times 10^{-5}) + (Fluid\ Temp\ (°C) - -6.25°C) \times 3\ \frac{CGS \times 10^{-5}}{°\mathrm{C}}$$

The magnetic susceptibility data was then converted from CGS to SI units, by multiplying the CGS log by a value of 4×π.

As the magnetic susceptibility probe has a relatively small volume of estimation there is a requirement to compensate for the borehole diameter as the probe is designed to read full measurement in a borehole with a diameter of 50 mm. For a borehole diameter of 96 mm the probe manual states the probe will response will be approximately 46% of full response for the uncentralized probe, due to the effects of the open borehole on the response. The magnetic susceptibility data was therefore compensated for borehole diameter by dividing the thermal drift corrected response by 0.46.

Lastly, an 11-point moving average filter was applied to the data. The .TFD files were imported into WellCAD where the primary logs compared favourably to the QA/QC log. For the primary logs, an interpolation function was applied to remove data spikes and gaps larger than 1 m. The logs were shifted to correct for the After-Survey Depth Error (ASDE), recorded in the relevant Record of Geophysical Logging field notes, and the noted depth loss from the odometer wheel error was corrected based on the short repeat log. A formula was then applied to correct the recorded depth as described in Section 3.4. Once referenced to the corrected depth, the logs were exported as .WCA files.

The .WCA files were then imported back into one common WellCAD file where the logs were compared with other geophysical logs, such as the optical televiewer image log, natural gamma log, apparent conductivity log, and resistivity logs. The logs were depth matched with common features, to further refine the accuracy, and merged to produce one final Magnetic Susceptibility log. One final depth correction was applied according to the results of structural integration between televiewer logs and core logs, as described in Section 3.4.

The final Magnetic Susceptibility curve is presented in the Lithology Log, included in Appendix C. Magnetic susceptibility is presented as SI unitless values, and ranges from 0×10^{-3} SI to 8.25×10^{-3} SI, with an average value of 1.476×10^{-3} SI. The average value measured in the upper 400 metre portion of the borehole (0.65×10^{-3} SI) are consistent with the magnetic susceptibility measured at surface (Golder and PGW, 2017) associated with typical tonalite responses (0.48×10^{-3} SI $\pm1.67\times10^{-3}$ SI).

In general, the magnetic susceptibility response mirrors the resistivity response, with higher susceptibility correlating to lower resistivity. There are some sharp positive spikes associated with high biotite tonalites and amphibolite lenses. A broad increase in magnetic susceptibility is observed in the intervals 725-800 m bgs and 850-950 m bgs, but these intervals do not correlate to an obvious or consistent geologic change in the cores (Golder, 2018b).

3.4.14 Heat-Pulse Flowmeter

Vertical fluid flow data in a borehole is useful for inferring where changes in hydraulic head are occurring, where water-bearing fractures are located, and whether systems of joints and fractures are hydraulically connected in proximity to the borehole. The Mount Sopris HFP-2293 Heat-Pulse Flow Meter probe (HPFM) was used to measure the vertical rate of fluid flow in a borehole by collecting data at discrete points along the borehole while the probe is motionless in the water column. The probe uses a rubber skirt to divert all flow at one horizon in the water column through the annulus of the probe, which it marks with a pulse of heat. Two thermistors, one located above and one below the annulus, are used to calculate the velocity and direction of motion of the heated water. This velocity is converted, using a calibration formula, into a flow rate. The probe is factory calibrated and is re-calibrated in the event it is sent for repair. The HPFM is designed to measure low flow conditions, from 0.113 to 3.785 litres per minute. The probe specifications note that the accuracy of the probe is within 5% of the actual flow rate in the mid measuring range, and within 15% at the extremes of the measuring range.

The HPFM was checked for functionality prior to shipping and again prior to use while on site. The pre-use checks are recorded in the pre-use Calibration and Verification Check form. The probe was also tested in the borehole under pumping conditions to simulate flow of known magnitude, and the results of the test are recorded in the Calibration and Verification Check form. All pre-use test results are reported in Appendix A.

An HQ diverter and centralizer were attached to the probe and it was connected to the wireline. The Matrix Heat software was started and the associated .TOL file was selected. The probe was lowered into the casing until the top of the probe was flush with the reference point and the depth in the Matrix Heat program was corrected to report the depth of the measurement point of the tool referenced to ground surface. This depth correction is specific to the tool and was calculated based on the stickup of the reference point above ground surface, as measured during setup. The offset of the measurement point of the tool is outlined in the Record of Geophysical Logging in Appendix B. The probe was then descended below the static water level and powered up. When the static water level was above the bottom of the casing, two measurements were taken within the casing to ensure good response in a zero-flow condition.

A standardized measurement interval of 20 m was used to sample the flow in the borehole. Three separate records of 30 seconds each were gathered from each depth to ensure repeatability. Responses observed outside the first 30 seconds can be attributed to the thermal movement of the heated slug of water and are not considered true flow measurements.

Data was recorded as .MH files (ALT proprietary format). Wireline tension was also monitored to ensure continuous, unobstructed descent and ascent. Once the data had been gathered, the file was saved in Matrix Heat and the probe was powered down and ascended to the next measurement depth.

All the data files (.MH) were reviewed for consistency in pulse time picks, then the depths and flow values were exported as .CSV files. The .CSV file was reviewed manually to remove duplicate entries, which were the result of small (mm) changes in reported probe depth. Flow rates were converted from US gallons per minute to litres per minute. The separate .CSV files were combined to generate one single file.

The .CSV file was then imported into one common WellCAD file where the log was compared with other geophysical logs, such as the optical televiewer image log, FFEC logs, and modelled dynamic flow values. Although flow was observed under dynamic pumping conditions in the FFEC logs, no flow was measurable within the sensitivity range of the HPFM under ambient conditions, meaning if ambient flow existed, it was less than 0.113 litres per minute. The final depth correction was applied according to the results of structural integration between televiewer logs and core logs, according to formulae described in Section 3.4.

The final Heat-Pulse Flow Meter (HPFM) data is presented in the Hydrogeology Log, included in Appendix C. It is presented as the Heat Pulse Static Flow curve, in litres per minute, with indicators at each discrete sample depth. In testing of the open portion of the borehole no static flow was detected with the HPFM run, thus the curve is set to 0 L/min. The Heat Pulse Static Flow curve is overlaid on the FFEC Model Dynamic Flow curve for comparison purposes.

3.4.15 Borehole Deviation

To be able to correct apparent structures to true dip and dip direction, as well as to understand the overall tilt and azimuth of the borehole, multiple deviation logs were collected. These logs were compared to each other to identify and mitigate possible sources of error.

Borehole deviation data were recorded in IG_BH01 using tilt and azimuth information from the optical and acoustic televiewer logs. The tilt and azimuth logs were collected with the same setup procedure as outlined in Section 3.4.5.2, logging the complete borehole down at 10 m per minute, sampling every 5 cm, as well as up at 4 m per minute, sampling every 1.2 mm. An additional probe, the Mount Sopris 2DVA-1000 Deviation probe, containing a three-axis magnetometer and three-axis accelerometer, was also attempted to log tilt and azimuth in the borehole, however data quality suggested it was not repeatable. As a result, two additional optical televiewer runs were completed to measure deviation. In total, seven tilt and azimuth logs were acquired and used to calculate the trajectory of the borehole from ground surface to the bottom of hole (Table 10).

The individual Tilt and Azimuth logs were filtered using a 3-point moving window filter to remove data spikes and interpolated over gaps less than 1 m to remove data blanks. Distortion of the azimuth logs caused by the metallic casing was corrected by extrapolating from the last valid value, 250.21 degrees, over the affected depth interval from 1.49 m bgs to 12.28 m bgs. This correction was performed for the deviation data acquired with the acoustic televiewer log which was run for the top 100 m prior to final casing installation. The subsequent televiewer and associated deviation logs collected between 67 m bgs and 1001 m bgs were trimmed to remove the portion affected by the final casing distortion.

For the interval between 67 m bgs and 1,001 m bgs, tilt and azimuth logs from each of the six completed runs were combined into a single set of logs by calculating an average of the logs on a point-by-point basis. Once the average deviation logs for the interval from 67 m bgs to 1001 m bgs were generated, they were merged with the upper 100 m deviation logs to produce a continuous set of deviation logs. The final Azimuth log was rotated 1.361° to correct for the local magnetic declination, in order to reference it to True North.

The averaged Tilt and Azimuth (True North referenced) logs were used to calculate approximate Easting and Northing displacement of the hole from the collar, as well as the True Vertical Depth below ground surface. These values were used to plot the preliminary trajectory of the borehole shown in a Bull's Eye plot in the header of the Deviation Log included in Appendix C. These deviation results indicate that the end of the borehole is displaced -28.54 m in the Easting direction and -3.50 m in the Northing direction. The individual logs are listed in Table 10, along with their logging direction, sampling rates, units, minimum and maximum values, as well as average values (where applicable).

Table 10: Deviation Log Details

Log Name	Logging Direction	Sampling Rate (m)	Units	Min Value	Max Value	Average Value
ABI Azimuth (Top)	Up	0.003	deg	228.28	294.31	247.60
ABI Azimuth (Down)	Down	0.10	deg	174.40	331.80	267.70
ABI Azimuth (Up)	Up	0.003	deg	233.33	284.56	262.44
OBI Azimuth (Down 1)	Down	0.10	deg	231.60	290.30	266.69
OBI Azimuth (Down 2)	Down	0.10	deg	203.50	329.60	263.57
OBI Azimuth (Up 1)	Up	0.002	deg	234.90	305.20	262.74
OBI Azimuth (Up 2)	Up	0.002	deg	230.30	288.30	260.31
ABI Tilt (Top)	Up	0.003	deg	0.26	1.59	0.88

Log Name	Logging Direction	Sampling Rate (m)	Units	Min Value	Max Value	Average Value
ABI Tilt (Down)	Down	0.10	deg	0.20	4.70	1.64
ABI Tilt (Up)	Up	0.003	deg	0.53	3.00	1.68
OBI Tilt (Down 1)	Down	0.10	deg	0.10	3.20	1.66
OBI Tilt (Down 2)	Down	0.10	deg	0.10	3.60	1.80
OBI Tilt (Up 1)	Up	0.002	deg	0.10	3.10	1.61
OBI Tilt (Up 2)	Up	0.002	deg	0.00	3.40	1.64

The Deviation curves are presented in the Deviation Log, included in Appendix C. The various azimuth and tilt curves are overlaid with each other for comparison. The averaged azimuth log, corrected from Magnetic North to True North (TN), and the averaged tilt log are also presented (Table 11). From the Average Azimuth TN and Tilt Average logs are calculated the Northing, Easting and True Vertical Depth (TVD) logs and are presented in Table 12. The TVD log is used to calculate the Elevation log and the two are presented as depth column logs. The Easting and Northing logs are overlaid and presented beside curves showing the semi-major axis of the error ellipses calculated by WellCAD, based on the tilt and azimuth uncertainty values (±0.5° of tilt, ±1.2° of azimuth). Error ellipses, also known as footprints, are an expression of the uncertainty of the measurement on the calculation of position along the borehole. The WellCAD algorithm is based on a probabilistic approach, meaning that the higher sampling of orientation measurements leads to less overall uncertainty and smaller ellipses, denoted by small semi-major axis values.

A final borehole deviation will be derived as part of the single borehole integration report (WP10: Golder, 2018f) which will include an evaluation of all borehole tilt and azimuth measurements from televiewer probes and from a dedicated gyro system (Reflex EZ gyro) acquired following drilling.

Table 11: Details of the Averaged Deviation Log

Log Name	Units	Min Value	Max Value	Average Value
Azimuth Average TN	deg	226.93	292.81	261.43
Tilt Average	deg	0.34	2.85	1.66

Table 12: Results of Eastings, Northings, and True Vertical Depth (TVD) recorded at bottom of borehole

Log Name	Units	Total Value
Easting	m	-28.54
Northing	m	-3.50

Log Name	Units	Total Value
TVD	m	999.95

4.0 SUMMARY

Borehole Geophysical Logging was carried out at IG_BH01 as part of Work Package 5 (WP5) of the Phase 2 Initial Borehole Drilling and Testing investigation in the Ignace Area. Geophysical logging will ultimately be used to help assess the local thickness of potentially suitable rock units, the geophysical properties of the rock units at depth, and the presence and types of structural features at depth in the Ignace Area. The geophysical logging provided high-quality, and high-resolution profiles of rock properties including engineering, lithological, hydrogeological, and structural properties.

Golder completed the geophysical logging in two stages. The geophysical logging team was mobilized to site in November 2017 to collect acoustic televiewer amplitude and travel-time data from the upper 100 m portion of the borehole on November 16, 2017 prior to the surface casing being set. The main geophysical logging program from the bottom of the open borehole at approximately 1,000 m bgs to the base of the steel casing at approximately 60 m bgs, was conducted from January 19 to January 27, 2018 immediately after completion of drilling and flushing the open borehole. The geophysical logging acquisition took place within the IG_BH01 work site at the drill rig, although some QA/QC procedures and calibrations were undertaken outside of the fenced compound to minimize interference from metal objects and electromagnetic fields.

Geophysical well logging was conducted in accordance with the requirements of ASTM D5753-18 – Standard Guide for Planning and Conducting Geotechnical Borehole Geophysical Logging (ASTM, 2018). The geophysical well logging program consisted of 15 distinct logging tests using 13 different downhole probes. The logging probes were chosen to help assess the structural, hydrogeological, lithological, and geomechanical properties of the rock, as follows:

- Televiewer, deviation, and caliper logging was carried out to help assess structural properties of the rock, in conjunction with WP3, rock core logging and photography (Golder, 2018b).
- Apparent conductivity, natural gamma, E-log resistivity, spectral gamma, and magnetic susceptibility logging was carried out to help assess lithological properties of the rock, again in conjunction with WP3, rock core logging and photography (Golder, 2018b).
- Full waveform sonic (FWS) and gamma-gamma (density) logging was carried out to help assess the geomechanical properties of the rock, in conjunction with WP4B, geomechanical core testing (Golder, 2018c).
- Flowing fluid electrical conductivity (FFEC), fluid temperature and resistivity (FTR), neutron (porosity), and heat-pulse flowmeter (HPFM) logging was carried out to help assess hydrogeologic properties of the rock, in conjunction with WP6, hydraulic testing (Golder, 2018d) and WP7, opportunistic groundwater sampling (Golder, 2018e).

The geophysical logging results are presented in the following suite of log plots provided in Appendix C: Lithological Logs, Structural Logs, Hydrogeological Logs, Engineering Logs and Deviation Logs. The results and discussion presented in this report will ultimately be integrated with other borehole data sets in a Single-hole Geoscientific Data Integration for IG_BH01 report.

5.0 REFERENCES

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Golder (Golder Associates Ltd.), 2018d. Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP6 Data Report - Hydraulic Testing for IG_BH01. NWMO Report Number: APM-REP-01332-0235.

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SGL (Sander Geophysics Limited), 2015. Phase 2 Geoscientific Preliminary Assessment, Acquisition, Processing and Interpretation of High-Resolution Airborne Geophysical Data, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report Number: APM-REP-06145-0002.

c:\users\gschneider\onedrive\1 - active\1671632 ignace bh drilling\08 bh01\06 wp5\12 report\08 10jan2019\1671632 (1500) ig_bh01_wp05_data_report_10jan2019_r6a.docx

APPENDIX A

Calibration and Verification Forms, Data Quality Confirmation Forms, Pre-Use Check Forms

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*18/01/2018*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Pre-use check of borehole geophysical probes:

Probe Name	Date	Checked By	Reference 1	Reference 2	Pre-Use Check File	Pass / Fail
ABI S/N: 154105	11-Jan-18	AR	270 deg	0 deg	ABI-Test_154105	Pass
OBI S/N: 160403	11-Jan-18	AR	270 deg	0 deg	OBI-Test_160403	Pass
2SNA S/N: 4116	12-Jan-18	AR	23 cps	675 cps	2SNA-Test_4116	Pass
2BSF S/N: 3800	12-Jan-18	AR	0 CGS	180 CGS	2BSF-Test_3800	Pass
2PIA S/N: 2680	12-Jan-18	AR	0 mS/m	463 mS/m	2PIA-Test_2680	Pass
2PGA SN: 3991	12-Jan-18	KM	75 cps	2270 cps	2PGA-Test_3991	Pass
2CAA-F SN: 5040	18-Jan-18	AR	2.09 Ohm.m	357.14 Ohm.m	2CAA-F-Test_5040	Pass
2PCA SN: 5032	18-Jan-18	AR	10.2 cm	15.c cm	2PCA-Test_5032	Pass
HFP2293 SN: 4736	18-Jan-18	AR	N/A	N/A	HFP2293-Test_4736	Pass
2PEA SN: 2658	17-Jan-18	AR	100 mS	1000 mS	N/A	Fail

Comments on tool checks:

DGI will provide their pre-use checks before arrival. DGI will be performing resistivity testing using their own probe as our 2PEA-1000 E-Log failed pre-use checks.
Winch odometer check performed: 0.0 cm deviation. Pass.

Logging scientist:

Adam Ramer	Adam Ramer	18-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Adam Ramer	**Verified by:**	Christopher Phillips

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibration Check By	Reference 1	Reference 2	Initial Value 1	Initial Value 2	Final Value 1	Final Value 2	Calibration File
2CAA-F FTR	*19-Jan-18*	*AR*	*154.8 Ohm.m*	393.7 Ohm..	*154.8 Ohm.m*	393.7 Ohm..	N/A	N/A	2CAA-F-_FTR-Calibration_5040

Comments on tool calibration:

Calibration values compared as conductivities with Horiba water quality meter using pure and diluted borehole flush water.

Logging scientist:

Adam Ramer — Print name

Adam Ramer — Signature

19-Jan-18 — Date

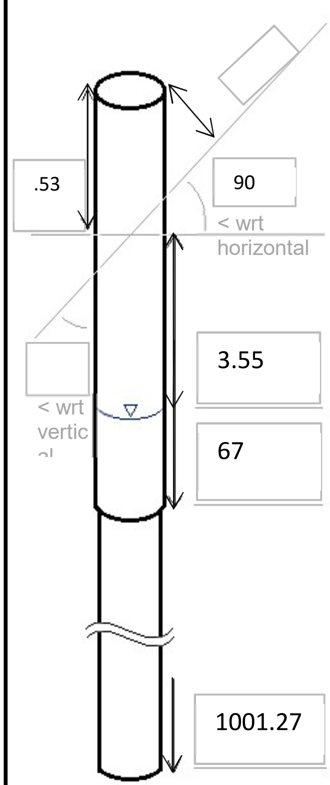
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
1.1	FTR Down	5040	1.89	0.05	10 m/min	0	1001
1.2	FTR Up	5040	1.89	0.10	20 m/min	50	1001
1.3	FTR Down	5040	1.89	0.05	10 m/min	50	1001

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)	3.55 (at start)	BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

191-192, 332-335, 543-546, 563-565, 617-620, 669-680, 762-764, 844-849, 858-864, 882-885

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:00
End Time	15:30
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1.36
END (data)	~ 161.26
Probe Point at Collar (end)	1.36
File Name	IG_BH01_WP5_FFEC_Static_R1_Dn_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Down Run 10 m a minute. Surveyed 1st 40 m with no Rst @ approx. 30m bgl
Power glitch caused probe to free fall brought back to top restart

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:50
End Time	17:40
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1.36
END(data)	1001.05
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG_BH01_WP5_FFEC_Static_R2_Dn_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Restarted the log Ran down to 40 m then installed RST at 30 m

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.3 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	18:00
End Time	18:49
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.05
END (data)	50.00
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG_BH01_WP5_FFEC_Static_R1_Up_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG_BH01_WP5_FFEC_Static_R1_dn_v1a	*19-Jan-18*	*CM*	*0*	160	160	19-Jan-18	CRP	Acceptable
IG_BH01_WP5_FFEC_Static_R2_dn_v1a	*19-Jan-18*	*CM*	*0*	1001.05	1001.05	19-Jan-18	CRP	Acceptable
IG_BH01_WP5_FFEC_Static_R1_up_v1a	*19-Jan-18*	*CM*	*1001.05*	49.96	951.09	19-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Data at top should be referenced to 69.27 at top of reference was 1.49 and should have been 1.36

Logging scientist:

Chris Marchildon	Chris Marchildon	19-Jan-2018
Print name	Signature	Date

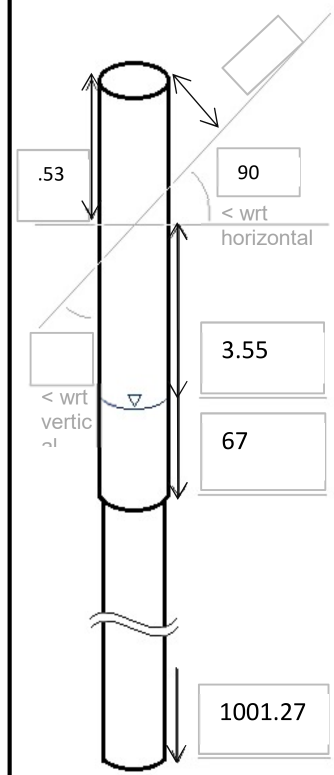
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
2.1	FTR Down	5040	1.89	0.05	10 m/min	0	1001
2.2	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.3	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.4	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.5	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.6	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.7	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.8	FTR Up	5040	1.89	0.10	20 m/min	50	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**11.32 (at start)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	20:30
End Time	22:09
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1002.92
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static2_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.2 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	22:41
End Time	23:31
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.07
END(data)	49.86
Probe Point at Collar (end)	49.86
File Name	IG_BH01_FFEC_Static2-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	00:05
End Time	01:40
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.15
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static3_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.4 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	01:42
End Time	02:29
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.15
END (data)	50.08
Probe Point at Collar (end)	50.08
File Name	IG_BH01_FFEC_Static3-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.5 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	02:34
End Time	04:09
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.07
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static4_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.6 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	04:10
End Time	05:02
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.07
END (data)	50.03
Probe Point at Collar (end)	50.03
File Name	IG_BH01_FFEC_Static4-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.7 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	05:04
End Time	06:39
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.09
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static5_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.8 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	06:41
End Time	07:30
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.09
END (data)	50.10
Probe Point at Collar (end)	50.10
File Name	IG_BH01_FFEC_Static5-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	Log Date	Operator	From (m)	To (m)	Length (m)	Review Date	Reviewed By	Data Quality
IG-BH01_FFEC_Static2_R0a	*19-Jan-18*	*AR*	*50*	1002.92	952.92	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static2-up_R0a	*19-Jan-18*	*AR*	*1001.07*	49.86	951.21	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static3_R0a	*19-Jan-18*	*AR*	*50*	1001.15	951.15	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static3-up_R0a	*19-Jan-18*	*AR*	*1001.15*	50.08	950.35	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static4_R0a	*19-Jan-18*	*AR*	*50*	1001.07	951.07	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static4-up_R0a	*19-Jan-18*	*AR*	*1001.07*	50.03	951.04	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static5_R0a	*19-Jan-18*	*AR*	*50*	1001.09	951.09	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Static5-up_R0a	*19-Jan-18*	*AR*	*1001.09*	50.10	950.99	20-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

[AR] ~1% error rate on in FTR values. Sections of negative resistivity / conductivity – will need to adjust in processing.

[CRP] Calibration range is more narrow than what we are encountering in borehole fluid – will need to set high calibration range using a much more conductive fluid upon completion of FFEC testing to properly compute conductivity values.

Logging scientist:

Adan Ramer		20-Jan-2018
Print name	Signature	Date

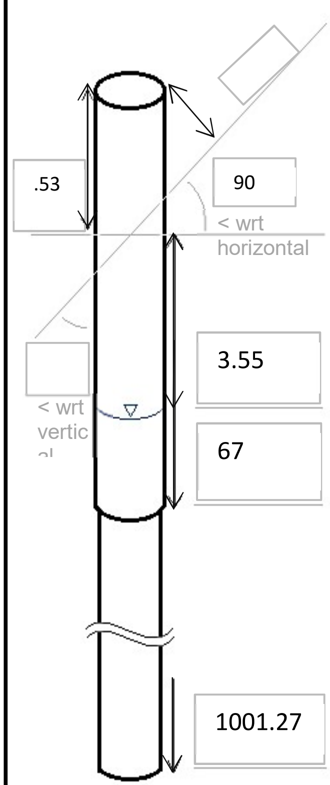
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
3.1	FTR Down	5040	1.89	0.05	10 m/min	69	1001.08
3.2	FTR UP	5040	1.89	0.10	20 m/min	69	1001.08
3.3	FTR Down	5040	1.89	0.05	10 m/min	69	1001.08
3.4	FTR UP	5040	1.89	.10	20 m/min	69	1001.08
3.5	FTR Down	5040	1.89	.05	10m/min	69	1001.08
3.6	FTR UP	5040	1.89	.10	20m/min	69	1001.08

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	10:48
End Time	12:34
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	1.36
File Name	IG-BH01_FFEC_Dynamic1 _1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity Jan/19/2017
Final Calibration	

Comments:

Start pump approximately 10:30am
Down Run 10 m a minute. Pump at approx. 66 m tried to maintain 1.5 m per min also collected water levels and manual confirmation of pump rate over time. 19.217 W.L 30.47 m W.L

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	12:40
End Time	13:32
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1001.08
END(data)	69.38
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG-BH01_FFEC_Dynamic1_1_5_up_R0a_.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
End at 69.00 at 69.38

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	13:53
End Time	15:29
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.10
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic2_1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.4 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:29
End Time	16:25
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.10
END (data)	69.24
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic2_1_5_up_R0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.5 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	16:41
End Time	18:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic3_1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments: Water Level at 16:50 approx. 48 m bgl

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.6 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	18:25
End Time	19:14
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic3_1_5_up_R0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
WL @ 19:15 50.442

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FFEC_Dynamic1 _1_5_dn_R0.tfd	*20-Jan-18*	*CM*	*69*	1001.08	932.08	21-Jan-18	CRP	Acceptable to 600m
IG-BH01_FFEC_Dynamic1_1_5_up_R0a_.tfd	*20-Jan-18*	*CM*	*1001.08*	69.38	931.70	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic2_1_5_dn_R0.tfd	*20-Jan-18*	*CM*	*69.00*	1001.10	932.10	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic2_1_5_up_R0a.tfd	*20-Jan-18*	*CM*	*1001.10*	69.24	931.86	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic3_1_5_dn_R0.tfd	*20-Jan-18*	*CM*	*69.00*	1001.08	931.70	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic3_1_5_up_R0a.tfd	*20-Jan-18*	*CM*	*1001.08*	69.54	931.54	21-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

[CRP] Resistivities logged are in many cases much higher than spec of probe (> 100 Ohm-m)
[CRP] The high fluid resistivities encountered is causing 'wrapping' of data on the probe side. Higher resistivities reading as lower resistivities – only seems to happen when resistivities much larger than probe specs but causes issues in log interpretation of what is correct low resistivity and what is high. Selected ranges in data quality column where I can see data is correct and not strongly affected by data wrapping issue. This issue also is affecting the temperature logs in certain cases – when resistivities are high the temperature values appear erroneous (getting up to 200 degrees celcius in some cases).

Logging scientist:

Chris Marchildon — Print name

Chris Marchildon — Signature

20-Jan-2018 — Date

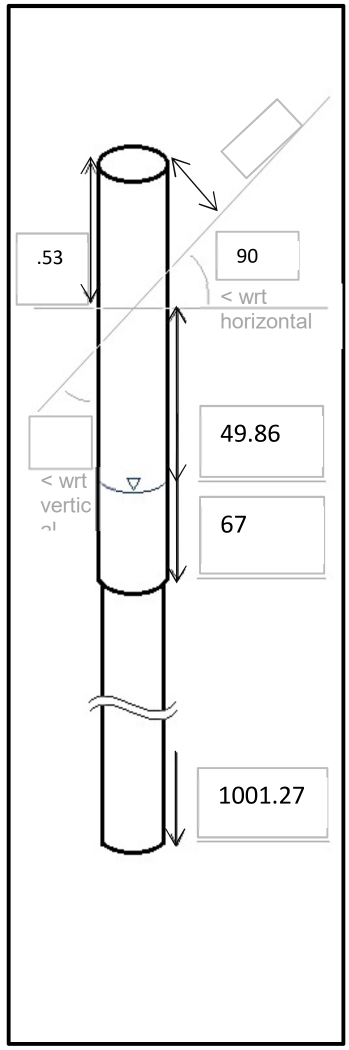
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
4.1	FTR Down	5040	1.89	0.05	10 m/min	69	239
4.2	FTR Down	5040	1.89	0.05	10 m/min	69	462
4.3	FTR Down	5040	1.89	0.05	10 m/min	300	1001
4.4	FTR Up	5040	1.89	0.10	20 m/min	69	1001
4.5	FTR Down	5040	1.89	0.05	10 m/min	69	1001
4.6	FTR Up	5040	1.89	0.10	20 m/min	69	1001
4.7	FTR Down	5040	1.89	0.05	10 m/min	69	1001
4.8	FTR Up	5040	1.89	0.10	20 m/min	69	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**49.86 (at start)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

191-192, 332-335, 543-546, 563-565, 617-620, 669-680, 762-764, 844-849, 858-864, 882-885

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	20:48
End Time	21:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	69.00
START (data)	69.00
END (data)	238.88
Probe Point at Collar (end)	
File Name	IG-BH01_FFEC_Dynamic4-1_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Probe initially unresponsive – restart Logger, adjust discriminators. Down Run 10 m a minute. Pause at 201.98 for 10 min (pump died). Reset pump, run at 301Hz. Pause at 238.88m (pump died again) @21:15. Resume at 21:18. Pump died again at 21:20. Find different power source – no good. Allow W.L. to recover to ease load on pump. Abandon log, re-start (next page).

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	22:13
End Time	22:55
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	69.00
START (data)	69.00
END(data)	462.42
Probe Point at Reference (end)	
File Name	IG-BH01_FFEC_Dynamic4-2_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Values maxed out at 440.55 Ohm.m. Re-set discriminators, start new file at 300 m

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.3 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	23:08
End Time	00:19
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69
START (data)	300.01
END (data)	1001.15
Probe Point at Ref (end)	
File Name	IG-BH01_FFEC_Dynamic4-3_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Reset discriminators to automatic. Start at 300m to catch first anomaly. Adjust discriminators ~475 – 480m, then return to auto. Below ~485, res begins to drop + signal changes shape and discriminators automatically re-adjusted. Suspect res maxing out between cond peaks.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.4 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	00:21
End Time	01:11
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	1001.15
END (data)	69.58
Probe Point at Ref (end)	69.51
File Name	IG-BH01_FFEC_Dynamic4-4_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.5 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	01:45
End Time	03:27
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	69.00
END (data)	1001.11
Probe Point at Ref (end)	
File Name	IG-BH01_FFEC_Dynamic4-5_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Adjusted RST and Level Troll positions prior to logging. 3m above pump. Fluid sampled from pump: 95 mS/m. Time-mode FTR value ~3m under pump: 32.5 mS/m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.6 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	3:28
End Time	4:25
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	1001.11
END (data)	69.45
Probe Point at Collar (end)	69.17
File Name	IG-BH01_FFEC_Dynamic4-6_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Wireline twisting around hose prevents probe from reaching 69m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.7 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	4:30
End Time	6:03
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.28
START (data)	69.28
END (data)	1004.14
Probe Point at Collar (end)	
File Name	IG-BH01_FFEC_Dynamic4-7_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Wireline twisting around hose prevents probe from reaching 69m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.8 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	6:08
End Time	6:57
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.28
START (data)	1004.14
END (data)	69.40
Probe Point at Ref (end)	69.27
File Name	IG-BH01_FFEC_Dynamic4-8_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Wireline twisting around hose prevents probe from reaching 69m.

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FFEC_Dynamic4-1_R0a	20-Jan-18	AR	69	239	170	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-2_R0a	20-Jan-18	AR	69	462	393	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-3_R0a	20-Jan-18	AR	300	1001	701	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-4_R0a	21-Jan-18	AR	69	1001	932	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-5_R0a	21-Jan-18	AR	69	1001	932	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-6_R0a	21-Jan-18	AR	69	1001	932	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-7_R0a	21-Jan-18	*AR*	*69*	1004	935	21-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic4-8_R0a	21-Jan-18	*AR*	*69*	1001	932	21-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Logging scientist:

Adam Ramer	Adam Ramer	21-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

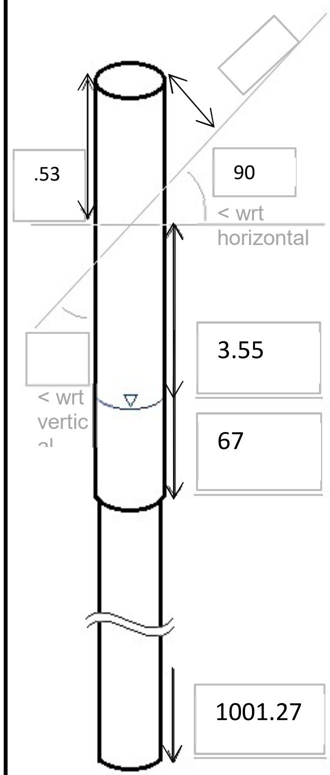
Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
5.1	FTR Down	5040	1.89	0.05	10 m/min	69.27	1001.08
5.2	FTR UP	5040	1.89	0.10	20 m/min	69.27	1001.08
5.3	FTR Down	5040	1.89	0.05	10 m/min	69.27	1001.12
5.4	FTR UP	5040	1.89	0.10	20 m/min	69.27	1001.12
5.5	FTR Down	5040	1.89	0.05	10m/min	69.27	1001.12
5.6	FTR UP	5040	1.89	0.10	20m/min	69.27	1001.11

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	8:25
End Time	10:02
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	69.27
END (data)	1001.12
Probe Point at Collar (end)	1.36
File Name	IG-BH01_FFEC_Dynamic5-1__DN_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity Jan/19/2017
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.2 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	10:27
End Time	11:17
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1001.12
END(data)	69.36 should be 69.27
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG-BH01_FFEC_Dynamic5-2__UP_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Pump stopped at 10:52 started again at 11:05

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	11:33
End Time	13:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.27
END (data)	1001.12
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-3__DN_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments: **had issues with water level but hopefully fixed it. WL approx. 50 mbgl.**
Pumped kicked off at 12:31 12:53

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.4 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	13:34
End Time	14:24
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.12
END (data)	69.33
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-4__up_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.5 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	14:27
End Time	16:02
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.27
END (data)	1001.11
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-5__Dn_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Pump out at 15:05 back on at 15:15

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.6 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	16:05
End Time	16:50
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.11
END (data)	69.45
Probe Point at Collar (end)	1.49
File Name	IG-BH01_FFEC_Dynamic5-6__up_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Pump off 16:19 pump off at 16:53 close to top of log

Back up to reference 1.49

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

orehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FFEC_Dynamic5-1__DN_r0a.tfd	*21-Jan-18*	*CM*	*69.27*	1001.12	931.85	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic5-2__UP_r0a.tfd	*21-Jan-18*	*CM*	*1001.12*	69.36	931.76	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic5-3__DN_r0a.tfd	*21-Jan-18*	*CM*	*69.27*	1001.12	931.85	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic5-4__UP_r0a.tfd	*21-Jan-18*	*CM*	*1001.12*	69.33	931.79	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic5-5__DN_r0a.tfd	*21Jan-18*	*CM*	*69.27*	1001.11	931.84	20-Jan-18	CRP	Acceptable
IG-BH01_FFEC_Dynamic5-6__up_r0a.tfd	*21-Jan-18*	*CM*	*1001.11*	69.45	931.66	20-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Data at top should be referenced to 69.27 at top of reference was 1.49 and should have been 1.36

Logging scientist:

Chris Marchildon — Chris Marchildon — 20-Jan-2018

Print name — Signature — Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

Golder Associates

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibration Check By	Reference 1	Reference 2	Initial Value 1	Initial Value 2	Final Value 1	Final Value 2	Calibration File
2PIA-1000	*21-Jan-18*	*AR*	*0 mS*	102 mS	0 mS	102 mS	-20.10 mS	79.10 mS	2PIA_Cond-Calibration_2680

Comments on tool calibration:

Logging scientist:

Adam Ramer	Adam Ramer	21-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

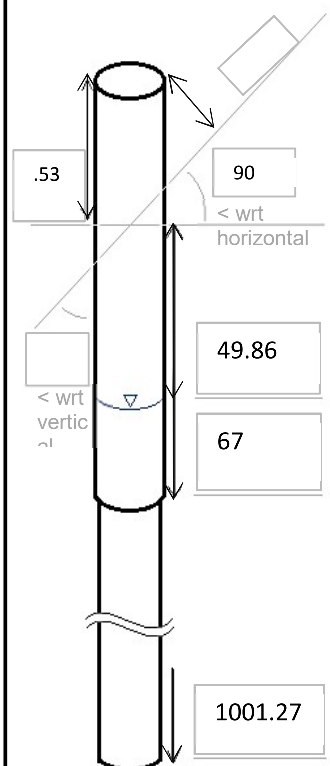
TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
6.1	2PIA QA/QC	2680	1.01	0.05	4.5 m/min	400	500
6.2	2PIA	2680	1.01	0.05	4.5 m/min	64	1001
6.3	ABI QA/QC	154105	1.58	0.0021	1.5 m/min	800	900
6.4	ABI	154105	1.58	.0021	1.5m/min	0	1001
6.5	ABI	154105	1.58	.0021	1.5 m/min	998.11	890

Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)	40.45 mbgs (20:20h)	BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.1 Field Notes	
Probe	2PIA-1000 Electromagnetic Induction (Apparent Conductivity)
Start Time	21:10
End Time	21:31
Run Direction	Up
Offset	1.01
Stick Up	0.53
Probe Point at Reference (start)	0.48
START (data)	500
END (data)	400
Probe Point at Reference (end)	1.28
File Name	IG-BH01_2PIA_QAQC_6-1_r0a
Initial Calibration	0 mS, 102 mS
Final Calibration	-20.10 mS, 79.10 mS

Comments:

Acclimatize probe in water @46.38 mbgs for 15 minutes prior to disc calibration.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.2 Field Notes

Probe	2PIA-1000 Electromagnetic Induction (Apparent Conductivity)
Start Time	21:58
End Time	01:24
Run Direction	Up
Offset	1.01
Stick Up	0.53
Probe Point at Reference (start)	0.48
START (data)	1001.22
END (data)	63.96
Probe Point at Reference (end)	1.28
File Name	IG-BH01_2PIA_6-2_r0a
Initial Calibration	0 mS, 102 mS
Final Calibration	-20.10 mS, 79.10 mS

Comments:

Drift of approx. -30 mS/m by the bottom.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.3 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	3:57
End Time	5:10
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	900.02
END (data)	799.99
Probe Point at Reference (end)	
File Name	IG-BH01_ABI_QAQC_6-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.
Used 3 HQ centralizers. Centralizers bolstered to improve in 100mm diameter hole. Excellent centralization overall.
@2:17 Generator quit – lost power and probe free fell 78m. Generator required oil change. Running again at 2:30. Retrieve probe, unresponsive. Re-start system. Still unresponsive. Switch Matrix. Re-start system. Working.
Could not get ABI running in depth mode faster than 1.5m/min. ABI logging will take twice as long as proposed.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.4 Field Notes	
Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	5:29
End Time	6:25
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.10 (top of mud)
END (data)	861.66
Probe Point at Ref (end)	
File Name	IG-BH01_ABI_6-4_r0a
Initial Calibration	
Final Calibration	

Comments:
Run at azimuthal resolution of 144 pt/turn.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.5 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	6:37
End Time	7:59
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.11 (top of mud)
END (data)	890
Probe Point at Ref (end)	.93
File Name	IG-BH01_ABI_6-5_r0a
Initial Calibration	
Final Calibration	

Comments:
Run at azimuthal resolution of 288 pt/turn.
For repeating and overlap approx. 291 - 292 and also 893 good features
Pull out of Hole so DGI can access the hole
Approx. 227 errors

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_2PIA_QAQC_6-1_R0a	21-Jan-18	AR	400	500	100	22-Jan-18	CRP	Acceptable
IG-BH01_2PIA_6-2_R0a	21-Jan-18	AR	64	1001	937	22-Jan-18	CRP	Acceptable
IG-BH01_ABI_QAQC_6-3_R0a	21-Jan-18	AR	800	900	100	22-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

ABI 2G probe cannot run faster than 1.2-1.4 m/min at 288 pt/turn, 2.1mm resolution.

Logging scientist:

Adam Ramer	Adam Ramer	22-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

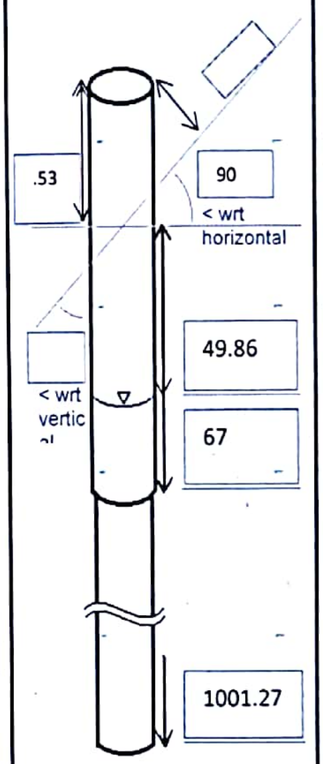
Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	JAN 22 - DAY DGI
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
7.1	GDA	5172		0.025	1.7	982.90	995.00
7.2	GDA	5172		0.025	1.7	884.22	970.01
7.3	GDA	5172		0.025	1.7	830.97	896.04
7.4	GDA	5172		0.025	1.7	840.94	860.02
7.5	GDA	5172		0.025	1.7	660.25	860.01

TOL FILE

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	[signature]
Page:	1 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN 22, 2018 SHIFT #7
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 7.1	**Field Notes**
Probe	GDA - Focus Density - Gamma Gamma
Start Time	~~10:15 AM~~ 12:35 CM
End Time	
Run Direction	Up. runs
Offset	See .Tol File for probe offsets.
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	995.00
END (data)	952.90
Probe Point at Reference (end)	N/A
File Name	IG-BH01_GDA_7.1u_rDa
Initial Calibration	Test In Barrie
Final Calibration	Certificate Sent By DGI

Comments:

- Winch encoder wheel was loose and had to be fixed. Runs were unaffected.
- Mx winch motor was hot due to the force required to pull up the density probe. Motor required cooling with water and periodic stops.
- Lower logging speed was required to best mitigate telemetry issues with the probe.
-

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Machildon	**Verified by:**	
Page:	2 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN/22/2018 – DAY DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Run 7.2 Field Notes	
Probe	GDA – Gamma Gamma
Start Time	
End Time	2:01 PM
Run Direction	UP
Offset	See .tol File
Stick Up	0.63 m
Probe Point at Ref (start)	2.99
START (data)	970.01
END (data)	884.72
Probe Point at Ref (end)	N/A
File Name	IG-BH01_GDA_7.2u_rDa
Initial Calibration	Test In BARRIE
Final Calibration	Certificate Sent By DGI

Comments:

- MX winch motor was hot, had to manually cool it.
- Logging Speed of roughly 2.1 m/min to 2.3 m/min

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris MARCHILDON	**Verified by:**	
Page:	3 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	JAN/22/2018 DAY DGI
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 7.3 Field Notes	
Probe	GDA – Gamma Gamma
Start Time	
End Time	2:48 PM
Run Direction	UP
Offset	
Stick Up	0.53
Probe Point at Ref (start)	2.99
START (data)	896.04
END (data)	830.97
Probe Point at Ref (end)	N/A
File Name	IG-BH01_GDA_7.3U_r0a
Initial Calibration	Sent in Bowie
Final Calibration	Certificate Sent by DGI

Comments:

- Mx winch motor was hot and needed manual cooling.
- GDA Probe telemetry failed at 834m. Probe was restarted and resolved issue.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	4 of 6		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	JAN 22 DAY DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	Distributed By:	Email

Run 7.4 Field Notes	
Probe	GDA – Gamma Gamma
Start Time	
End Time	3:22
Run Direction	up
Offset	see tol File
Stick Up	0.53m
Probe Point at Reference (start)	2.99m
START (data)	860.02
END (data)	840.94
Probe Point at Reference (end)	N/A
File Name	IG-BH01_GDA_7-4u_r0a
Initial Calibration	Test in shop in BARRIE
Final Calibration	Certificate Sent by DGI

Comments:

- Motor still hot
- GDA probe telemetry failed, restart resolved issue.
- Run only over laps 7.3 and 7.5

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Martin	Verified by:	
Page:	5 of 6.		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN/22/2018- Day DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Run 7.5 Field Notes	
Probe	GDA - Gamma Gamma
Start Time	
End Time	5:31
Run Direction	up
Offset	See .tol file
Stick Up	0.53 m
Probe Point at Ref (start)	2.99
START (data)	860.01
END (data)	660.25
Probe Point at Ref (end)	22.06
File Name	IG-BH01_GDA_7-5u_r0a
Initial Calibration	
Final Calibration	

Comments:

- Motor was hot
- Probe was run at 1.5m/min to 1.9m/min and seemed to help prevent telemetry failures.
- On the way out of hole, the Mx winch encoder wheel came loose and depth was lost. About 19m off our zero depth.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris M.	**Verified by:**	
Page:	6 of 6.		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_GDA_7-1u_r0a.tfd	*22/01/18*	*JS*	*995.00*	952.90	42.1	22-Jan-18	CRP	Acceptable
IG-BH01_GDA_7-2u_r0a.tfd	*22/01/18*	*JS*	*970*	884.72	85.28	22-Jan-18	CRP	Acceptable
IG-BH01_GDA_7-3u_r0a.tfd	*22/01/18*	*JS*	896.06	830.97	65.09	22-Jan-18	CRP	Acceptable
IG-BH01_GDA_7-4u_r0a.tfd	*22/01/18*	*JS*	*840.94*	860.02	19.08	22-Jan-18	CRP	Acceptable
IG-BH01_GDA_7-5u_r0a.tfd	*22/01/18*	*JS*	*860.01*	660.25	199.76	22-Jan-18	CRP	Acceptable (note below)

Comments on log quality and tool performance:

[CM] Encoder wheel slid off on way up the hole, Apparently probe commonly has many errors, Probe offsets are in .tol file as there are many sensors on this probe
[CRP] Attached is DGI QA/QC report. Encoder wheel slipped off matrix on up run after completion of logging. Overlap in earlier file allows for anchoring of bottom elevation and overlap of next run completed by DGI will anchor top portion of log to ensure proper depth control maintained

Logging scientist:

Chris Marchildon	Chris Marchildon	22-Jan-2018
Print name	Signature	Date

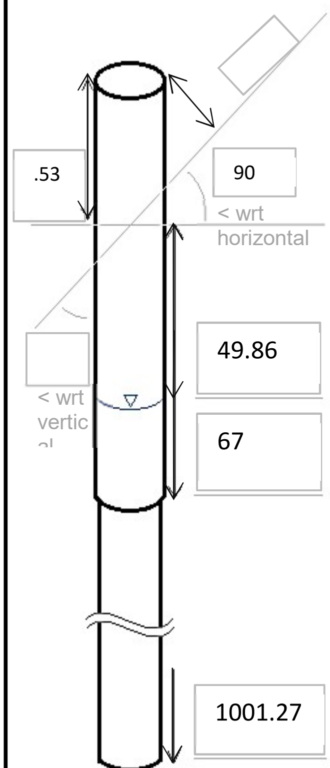
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
8.1	ABI Down	154105	1.58	0.05	10 m/min	1	1001
2.2	ABI	154105	1.58	0.0021	1.4 m/min	232	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**~26 (low res ABI check)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 8.1 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	20:05
End Time	21:44
Run Direction	Down
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	1.05
END (data)	998.71 (into mud)
Probe Point at Reference (end)	
File Name	IG-BH01_ABI_Down_8-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 8.2 Field Notes	
Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	21:50
End Time	06:50
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.72 (into mud)
END (data)	232.00
Probe Point at Ref (end)	0.80
File Name	IG-BH01_ABI_8-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Run at azimuthal resolution of 288 pt/turn.

Much less “bounce” in the data.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_ABI_Down_8-1_R0a	22-Jan-18	AR	1	998	997	23-Jan-18	CRP	Acceptable
IG-BH01_ABI_8-2_R0a	22-Jan-18	AR	998	232	766	23-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

[AR] ABI 2G probe cannot run faster than 1.2-1.4 m/min at 288 pt/turn, 2.1mm resolution.

Logging scientist:

Adam Ramer	Adam Ramer	23-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

Golder Associates RECORD OF GEOPHYSICAL LOGGING

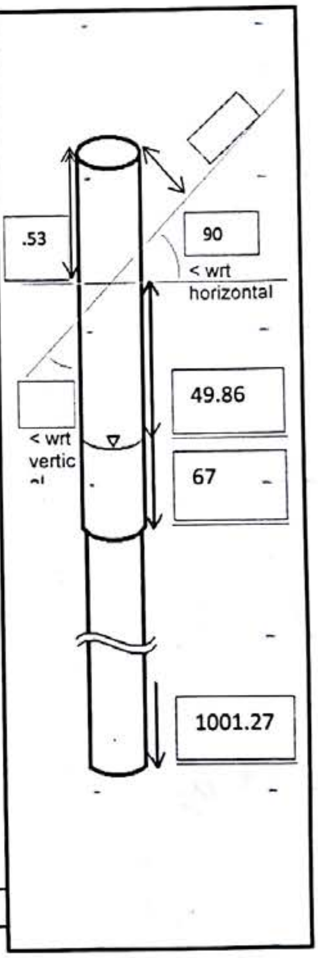
TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 23, 2018 Shift #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
U1	GDA Density	5172		0.025	1.6-1.8	555.73	735.01
U2	GDA Density	5172.		0.025	1.6-1.8	450.04	580.00

Borehole Data

Depth Reference	Ground Surface	**Casing Diameter (mm)**	100
Stickup (m)	0.53	**Inclination**	Vertical
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Mardhildon	**Verified by:**	
Page:	1 of 3		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN 23/2018/ShiFT #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 9-1 Field Notes	
Probe	2GDA - DENSITY 5172
Start Time	2:10 pm
End Time	3:55 pm.
Run Direction	up Run #1
Offset	See tol file.
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	735.01
END (data)	553.73
Probe Point at Reference (end)	Did not come to surface. cm See tol file
File Name	~~[illegible]~~ IG–BH01–GDA–9–1u.rDa
Initial Calibration	REFER TO CERTIFICATES SENT FROM DGI
Final Calibration	" " " "

Comments:

* Run repeated with Last Run From From yesterday. (up #5)
* Had to stop File due to bandwith spike.
* Sent tool back downhole 25m to ensure repeatability.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	2 of 3		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	JAN 23/2018 Shift #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	Distributed By:	Email

Run 9-2 Field Notes	
Probe	2GDA-Density 5172
Start Time	4:05 pm.
End Time	5:45 pm
Run Direction	up Run #7
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	580.00
END (data)	450.04
Probe Point at Reference (end)	4.79
File Name	IG_BH01_GDA_9-2u.rDa
Initial Calibration	REFER TO CERTIFICATES SENT by EMAIL FROM DGI
Final Calibration	

Comments:
* STARTED up run #7 but as I reached 563m, we encountered another bandwidth spike with the tool.
* we simply override the U7 run previously recorded with a new up 7 run since we did not collect any new data
* STARTED new up 7 file @ 4:26 pm.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris MARCHILDON	Verified by:	
Page:	3 of 3		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / AM DGI*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_GDA_9-1u_r0a.tfd	*23/01/18*	*JS/KS*	*735.01*	553.73	181.28	24-Jan-18	CRP	Acceptable (note below)
IG-BH01_GDA_9-2u_r0a.tfd	*23/01/18*	*JS/KS*	*580.00*	450.04	129,96	24-Jan-18	CRP	Acceptable (note below)

Comments on log quality and tool performance:

[CM] Tool failed on the run down the hole on the DGI winch. Brought to surface tested with Golder 1000 m winch and worked fine. Decided to use the tool on the 1000 m winch. Likely issue on DGI winch is the cablehead on the big winch. Off by almost 2 m at top reference.
[CRP] DGI noted a 1.8m offset from start to end of logging which is out of spec for depth verification. From their QA/QC logs: *Depth shift is greater then the 1.3m error tolerance. We typically use the runs closer to surface to "anchor" the deeper runs – runs closer to surface are less subject to cable stretch and can be used as an accurate benchmark to shift deeper runs.*

Logging scientist:

Chris Marchildon — [signature: Chris Marchildon] — 23-Jan-2018

Print name — Signature — Date

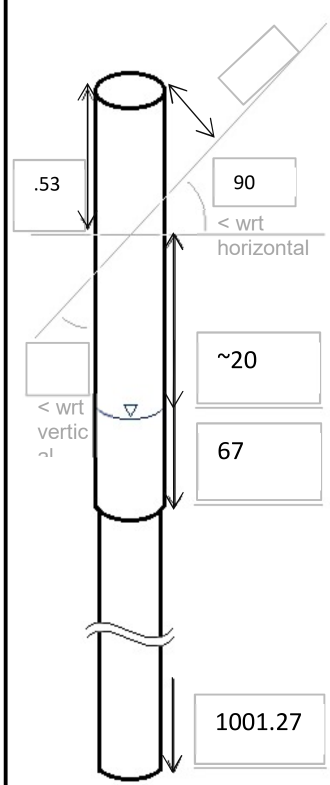
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
10.1	ABI	154105	1.58	0.0021	1.4 m/min	67	245
10.2	2PGA Gam	3991	0.65	0.025	2.25 m/min	500	600
10.3	2PGA Gam	3991	0.65	0.025	2.25 m/min	1.49	1001

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)	~20 (low res ABI check)	BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.1 Field Notes	
Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	20:11
End Time	22:01
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	245.00
END (data)	67.00
Probe Point at Reference (end)	1.35
File Name	IG-BH01_ABI_10-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.2 Field Notes

Probe	2PGA Natural Gamma SN: 3991
Start Time	23:17
End Time	00:01
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	600.00
END (data)	499.83
Probe Point at Ref (end)	Did not return to surface
File Name	IG-BH01_2PGA_QAQC_10-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.3 Field Notes

Probe	2PGA Natural Gamma SN: 3991
Start Time	00:30
End Time	7:51
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	1001.14
END (data)	1.49
Probe Point at Ref (end)	1.49
File Name	IG-BH01_2PGA_10-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_ABI_10-1_R0a	23-Jan-18	AR	245	67	178	24-Jan-18	CRP	Acceptable
IG-BH01_2PGA_QAQC_10-2_R0a	23-Jan-18	AR	600	500	100	24-Jan-18	CRP	Acceptable (note below)
IG-BH01_2PGA_10-3_R0a	23-Jan-18	AR / CM	1001	1.49	999.51	24-Jan-18	CRP	Acceptable (note below)

Comments on log quality and tool performance:

[CM] Top of Gamma run should be 0.12
[CRP] Depth check was slightly above allowable spec (1.37m vs. allowable 1.3m). Reviewing the data we believe that the majority of the depth error occurred between the QA/QC run (10.2) and the main run (10.3). Shifting the data ~0.9m and they match quite well. We will collect an additional Gamma run from 100 to 60 metres which should be within depth threshold to anchor the actual depth of the main gamma log.

Logging scientist:

Adam Ramer	Adam Ramer	24-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

Golder Associates

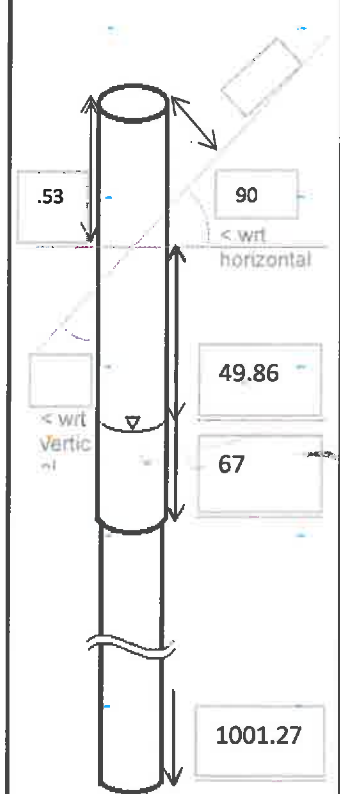
RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 24, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
11.1	6DA	5172	Seetol	0.025	1.7m/min	475.11	97.17
11.2	6DA	5172	Seetol	0.025	1.7m/min	122.03	3.32
11.3	6DA	5172	Seetol	0.025	1.7m/min	200.05	99.95
11.~~3~~4	Neutron	3312	.33	0.025	2.5m/min	300.00	1.00

cm



Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	1 of ~~4~~ 5		

cm

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 24, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Run 11 Field Notes	
Probe	GDA Density
Start Time	9:05 AM
End Time	12:35 PM
Run Direction	up
Offset	See .tol file
Stick Up	0.53
Probe Point at Ref (start)	2.44 CM Not top of Hole
START (data)	475.11
END (data)	97.17
Probe Point at Ref (end)	N/A
File Name	IG-BH01_GDA_11-~~1~~ r0a CM
Initial Calibration	DONE OFFSITE
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Rainer
Page:	~~1 of~~ 2 of 5 CM		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 24, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 1,2 Field Notes	
Probe	GDA Density
Start Time	12:45 PM
End Time	1:45 PM
Run Direction	up
Offset	See tol file
Stick Up	0.63
Probe Point at Reference (start)	2.99
START (data)	122.03
END (data)	3.32
Probe Point at Reference (end)	3.32
File Name	IG-BH01_GDA_11:20 cm_r0a
Initial Calibration	Done offsite
Final Calibration	

Comments: .33 @ Ref Point

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	3 of 5		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 24, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 11.3 Field Notes	
Probe	GDA Density
Start Time	2:00PM
End Time	2:50PM
Run Direction	UP
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	2.99
START (data)	200.05
END (data)	CM ~~3.10~~ 99.95
Probe Point at Ref (end)	3.10
File Name	I6-BH01-GDA-11.3QAQC-r0a
Initial Calibration	Done offsite CM
Final Calibration	

Comments: .11 @ Ref Point

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	~~2 of~~ 4 of 5 CM		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	Jan 24, 2018 / AM
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 11.4 Field Notes	
Probe	Neutron
Start Time	3:35PM
End Time	5:50
Run Direction	Up
Offset	See tol File :33
Stick Up	0.53m
Probe Point at Reference (start)	0.98
START (data)	300.00
END (data)	1.00
Probe Point at Reference (end)	1.00
File Name	IG-BH01_Neutron-11-4u-r0a
Initial Calibration	Done of site
Final Calibration	

Comments:

Probe ran great, no errors

.02 at Ref Point.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	A. Ramer
Page:	5 of 5		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / AM DGI*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_GDA_11-1u_r0a.tfd	*24/01/18*	*JS/KS*	*475.11*	97.17	377.94	24-Jan-18	CRP	Acceptable
IG-BH01_GDA_11-2u_r0a.tfd	*24/01/18*	*JS/KS*	*122.03*	3.32	118.71	24-Jan-18	CRP	Acceptable
IG-BH01_GDA_QAQCu_11-3u_r0a.tfd	*24/01/18*	*JS/KS*	*200.05*	99.95	100.10	24-Jan-18	CRP	Acceptable
IG-BH01_Neutron_11-4u_r0a.tfd	*24/01/18*	*JS/KS*	*300.00*	1.00	299.00	24-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

GDA Top of Run (1&2) .33 [CM]
GDA Top of QA/QC Run .11 [CM]

Logging scientist:

Chris Marchildon

Chris Marchildon — Print name

Signature

24-Jan-2018 — Date

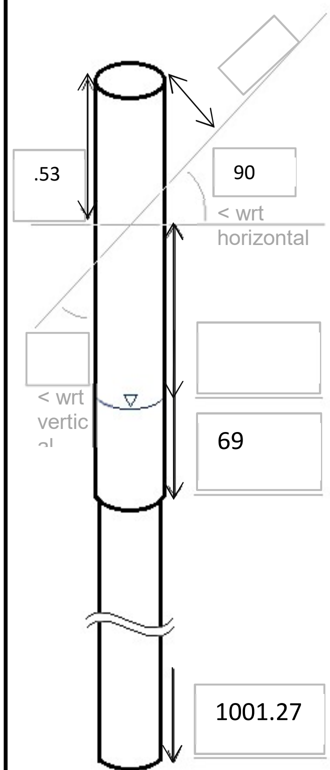
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
12.1	FWS50	074301	1.84	0.05	1.5 m/min	400	500
12.2	FWS50	074301	1.84	0.05	1.5 m/min	199	1000

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 12.1 Field Notes	
Probe	FWS50 Full Waveform Sonic SN: 074301
Start Time	20:47
End Time	21:51
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	500.00
END (data)	400.00
Probe Point at Reference (end)	
File Name	IG-BH01_FWS50_QAQC_12-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Pre-use check conducted below water, in rock. Response good.
Needed to adjust discriminators mid-run. Turned off automatic, manually set positive, negative and gain.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 12.2 Field Notes

Probe	FWS50 Full Waveform Sonic SN: 074301
Start Time	22:28
End Time	06:58
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	999.80
END (data)	198.80
Probe Point at Reference (end)	2.63
File Name	IG-BH01_FWS50_12-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FWS50_QAQC_12-1_R0a	24-Jan-18	AR	500	400	100	24-Jan-18	CRP	Acceptable
IG-BH01_FWS50_12-2_R0a	24-Jan-18	AR	1000	199	801	24-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

[CRP] Depth check on 12-2 slightly above tolerance limits (1.32m vs. 1.30m allowable). Will overlap approximately 30 m on surface run and anchor to this run, casing feature, and bottom of hole.

Logging scientist:

Adam Ramer	Adam Ramer	24-Jan-2018
Print name	Signature	Date

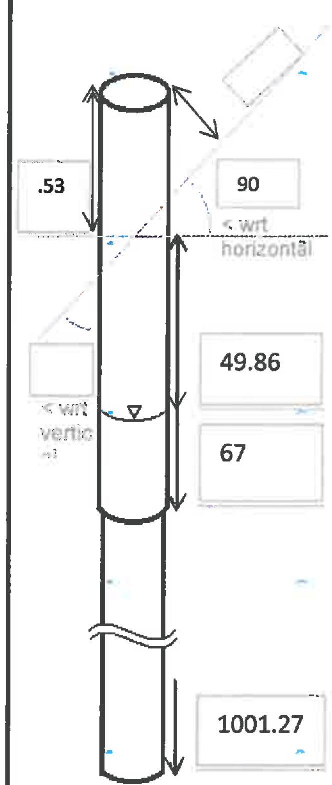
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 25, 2018 / Shift #13 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run Top	Expected Run Bottom
13.1	Neutron	3312		0.025	2.5	274.85	995.02
13.2	Neutron	3312		0.025	2.5	190.00	315.00
13.3	Resistivity.	6360		0.05	3 CM	~~[illegible]~~	~~[illegible]~~
						68.84	305.31

CM



Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	1 of 4		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	Jan 25, 2018 Shift #13/AM
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 13.1 Field Notes	
Probe	Neutron
Start Time	9:00 AM
End Time	1:55 pm
Run Direction	up 1
Offset	see tol file
Stick Up	0.53 m
Probe Point at Reference (start)	0.98 m
START (data)	995.02 m
END (data)	274.85 m
Probe Point at Reference (end)	1.50 m
File Name	IG-BH01_Neutron_13-1u_r0a
Initial Calibration	Refer to DGI certificates sent through email
Final Calibration	" " " "

Comments:

* made it downhole with no issues.
* up run went well!
* Brought tool all the way up to surface to re-zero before sending back down for QA QC runs.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	2 of 4		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	Jan 25, 2018 Shift #3/AM
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 13.2 Field Notes	
Probe	Neutron
Start Time	2:40 pm
End Time	3:31 pm
Run Direction	UP.2
Offset	see tol file
Stick Up	0.53 m
Probe Point at Reference (start)	0.98 m
START (data)	315.00 m
END (data)	190.00 m
Probe Point at Reference (end)	1.01 m CM
File Name	IG-BH01-Neutron-13-~~2u~~QAQC-Da
Initial Calibration	REFER TO DGI CERTIFICATES SENT THROUGH EMAIL
Final Calibration	

Comments:

* QA QC RUN

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	A. Ramer
Page:	3 of 4		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 25, 2018 / Shift #13 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 13.3 Field Notes	
Probe	Resistivity
Start Time	5:00 pm
End Time	6:25 pm.
Run Direction	up
Offset	See tol File
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	~~300~~ 305.31m
END (data)	68.84m
Probe Point at Reference (end)	10.04
File Name	~~IG-BH01~~ Resistivity – 13-3u – r0a
Initial Calibration	
Final Calibration	

Comments:

* pre + post run calibration checks were completed.
under file name IG-BH01_Resistivity_13-preruncheck.r1a
IG-BH0_Resistivity-13-post runcheck.r1a

* 1ohm setting in post check was ~~different~~ giving errors 100%.
when calibrator removed from cm transmitter, the tool worked 100% well/functional.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	9 of 9		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / AM DGI*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_Neutron_13-1u_r0a.tfd	*25/01/18*	*JS/KS*	*995.02*	274.85	720.17	26 Jan 18	CRP	Acceptable
IG-BH01_Neutron_13-2QAQCu_r0a.tfd	*25/01/18*	*JS/KS*	*315.00*	190.00	125.00	26 Jan 18	CRP	Acceptable
IG-BH01_Resistivity_13-3u_r0a.tfd	*25/01/18*	*JS/KS*	*305.31*	68.84	236.16	26 Jan 18	CRP	Acceptable

Comments on log quality and tool performance:

Did peruse check with Resistivity calibration box. [CM]
Did post use check with Resistivity calibration box [CM]
IG-BH01_Neutron_13-1u_r0a.tfd top reference .52 IG-BH01_Neutron_13-2QAQCu_r0a.tfd top reference .03 [CM]
IG-BH01_Resistivity_13-3u_r0a.tfd .19 [CM]

Logging scientist:

Chris Marchildon	Chris Marchildon	25-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibration Check By	Reference 1	Reference 2	Initial Value 1	Initial Value 2	Final Value 1	Final Value 2	Calibration File
2PCA-1000	*25-Jan-18*	*AR*	*10.2 cm*	15.2 cm	10.20 cm	15.20 cm	9.85 cm	14.69 cm	2PCA_Cal-Calibration_5032

Comments on tool calibration:

Logging scientist:

Adam Ramer — *Adam Ramer* — 25-Jan-2018

Print name — Signature — Date

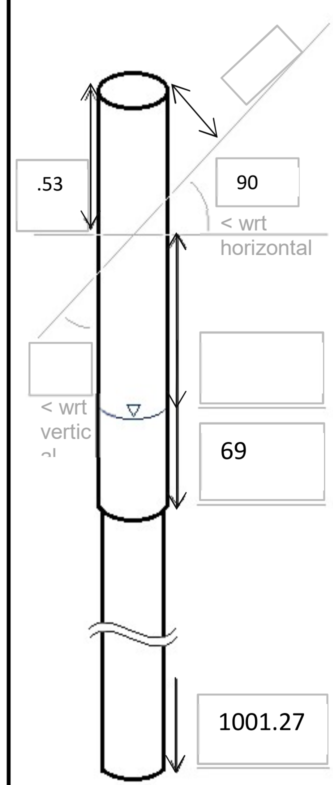
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**		
						Top	**Bottom**	
14.1	2PCA	5032	1.41	0.01	2 m/min	900	1001	
14.2	2PCA	5032	1.41	0.01	2 m/min	65	1001	

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 14.1 Field Notes

Probe	2PCA-1000 Mechanical Caliper SN: 5032
Start Time	23:23
End Time	00:04
Run Direction	Up
Offset	1.41
Stick Up	0.53
Probe Point at Reference (start)	0.88
START (data)	1001.13
END (data)	900.00
Probe Point at Reference (end)	1.07
File Name	IG-BH01_2PCA_QAQC_14-1_r0a
Initial Calibration	10.2 cm, 15.2 cm
Final Calibration	9.85 cm, 14.69 cm

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 14.2 Field Notes

Probe	2PCA-1000 Mechanical Caliper SN: 5032
Start Time	00:15
End Time	06:22
Run Direction	Up
Offset	1.41
Stick Up	0.53
Probe Point at Reference (start)	0.88
START (data)	1001.12
END (data)	64.58 (into casing)
Probe Point at Reference (end)	1.07
File Name	IG-BH01_2PCA_14-2_r0a
Initial Calibration	10.2 cm, 14.2 cm
Final Calibration	9.85 cm, 14.69 cm

Comments:

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_2PCA_QAQC_14-1_R0a	25-Jan-18	AR	1001	900	101	26-Jan-18	CRP	Acceptable
IG-BH01_2PCA_14-2_R0a	25-Jan-18	AR	1001	65	936	26-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

[AR] Got several “fetching parameters of tool failed” errors when starting the FWS. Could not get valid telemetry from FWS – suspect bad solder in transmitter.

Logging scientist:

Adam Ramer	Adam Ramer	26-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibrated By	Reference 1	Reference 2	Initial Value 1	Initial Value 2	Final Value 1	Final Value 2	Calibration File
QL40-IP	*26-Jan-18*	*JS/KS*	*1000 Ohm.m*	1.0 Ohm,m	1000.05 Ohm.m	0.83 Ohm.m	1000.73 Ohm.m	0.83 Ohm.m	IG-BH01_Resistivity_15-PreRunCheck_r2a

Comments on tool calibration:

Pre and post-run calibration files recorded using test box, at 10,000 Ωm, 1000 Ωm, 100 Ωm, and 1 Ωm. 1000 Ωm and 1 Ωm shown for N8 electrode for scale.

Logging scientist:

Chris Marchildon	Chris Marchildon	26-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

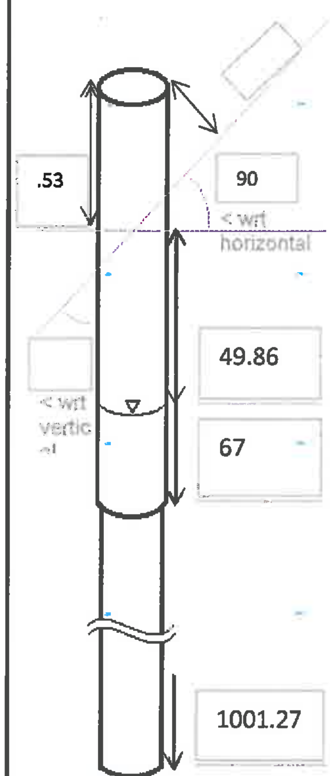
TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 26, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run Top	Expected Run Bottom
15.1u	Resistivity	6360		0.05	3	500	600
15.2u	Resistivity	6360		0.05	3	823	999
15.3u	Resistivity	6360		0.10	10	623	967
15.4u	Resistivity	6360		0.05	3	271	967
15.5u	Resistivity	6360		0.05	3	841	932

Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Ramer
Page:	1 of 6		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	Jan 26, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	Distributed By:	Email

Run 15.1 Field Notes	
Probe	Resistivity
Start Time	8:15
End Time	9:15
Run Direction	Up
Offset	See tol file
Stick Up	0.53m
Probe Point at Ref (start)	9.85
START (data)	600.09
END (data)	500.00
Probe Point at Ref (end)	N/A
File Name	IG-BH01_Resistivity_15.1vQAQC-rDa
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- QAQC run went well.
- Pre Calibration Checks were done on 10,000/1,000/100/1 ohms.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	A. Ramer
Page:	2 of 6		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 26, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Run 52 Field Notes	
Probe	Resistivity
Start Time	9:55
End Time	11:00
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	9.85
START (data)	999.41
END (data)	823.74
Probe Point at Ref (end)	N/A
File Name	IG-BH01_Resistivity_15-20_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- Probe experienced low resistivity values from ~904m to ~860 m, which caused telemetry issues. Little to no data collected in this section.

- File was stopped shortly after so we could attemp to re-survey this section of hole to see if errors continued.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	A. Rauner
Page:	3 ~~6~~ of 6 CM		

RECORD OF GEOPHYSICAL LOGGING

Golder Associates

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	Jan 26, 2018 / AM
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 15.3 Field Notes	
Probe	Resistivity
Start Time	11:05
End Time	11:20
Run Direction	Down
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	9.85
START (data)	823.74
END (data)	967.13
Probe Point at Ref (end)	N/A
File Name	IG-BH01_Resistivity_15-3d_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- Down run with 10cm increments at 10m/min.
- File was recorded to help confirm low resistivity and telemetry issue at 870m to 904m.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	A. Ramer
Page:	4 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	26 Jan, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 15.4 Field Notes	
Probe	Resistivity
Start Time	11:20
End Time	3:45
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	967.13
END (data)	271.34
Probe Point at Reference (end)	9.87
File Name	IG-BH01_Resistivity_15-4u_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- Run repeats low resistivity and error section with the two previous runs.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Mardhilkon	**Verified by:**	A. Renner
Page:	5 ~~6~~ of 6 cm		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	Jan 26, 2018 / AM
		Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 5.5 Field Notes	
Probe	Resistivity
Start Time	5:10
End Time	5:40
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	932.40
END (data)	841.48
Probe Point at Reference (end)	10.31
File Name	IG-BH01_Resistivity_15-5u_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

Tuned telemetry and was able to get valid data for almost all of this section.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Maschiedan	Verified by:	A. Rainer
Page:	6 of 6		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / AM DGI*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_Resistivity_15-1uQAQC_r0a.tfd	26/01/18	JS/KS	600	500.09	100.09	26-Jan-18	CRP	Acceptable
IG-BH01_Resistivity_15-2u_r0a.tfd	26/01/18	JS/KS	999.41	823.74	175.67	26-Jan-18	CRP	Acceptable
IG-BH01_Resistivity_15-3u_r0a.tfd	26/01/18	JS/KS	823.74	967.13	143.39	26-Jan-18	CRP	Acceptable
IG-BH01_Resistivity_15-4u_r0a.tfd	26/01/18	JS/KS	967.13	271.34	695.79	26-Jan-18	CRP	Acceptable
IG-BH01_Resistivity_15-5u_r0a.tfd	26/01/18	JS/KS	840.79	931.64	90.85	26-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Did preuse check with Resistivity calibration box. [CM]
Did post use check with Resistivity calibration box [CM]
IG-BH01_Neutron_13-1u_r0a.tfd top reference 0.52m IG-BH01_Neutron_13-2QAQCu_r0a.tfd top reference .03 [CM]
IG-BH01_Resistivity_13-3u_r0a.tfd .19 [CM]
[CRP] Significant Errors between 870 and 900 on Log 15.2 and 15.3 (area of anomalous low resistivity. DGI contacted Mount Sopris and adjusted discriminators and reran this log in 15.5 which solved the issue.

Logging scientist:

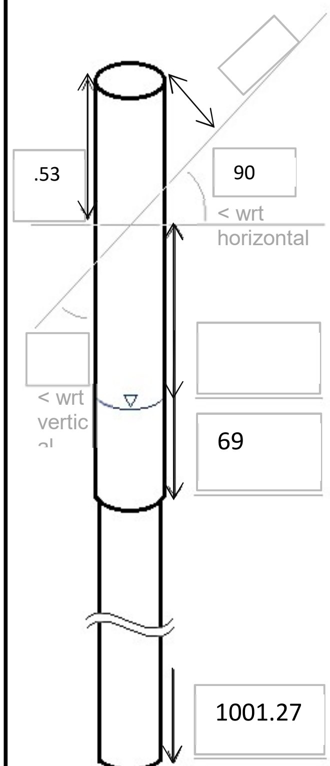
Chris Marchildon	Chris Marchildon	26-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
16.1	2SNA	4116	1.22	0.025	2.25 m/min	400	500
16.2	2SNA	4116	1.22	0.025	2.25 m/min	1	1001



Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		

Zones of instability / Zones noted during Survey (m bgs):

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 16.1 Field Notes	
Probe	2SNA-1000 Spectral Gamma SN: 4116
Start Time	20:33
End Time	21:18
Run Direction	Up
Offset	1.22
Stick Up	0.53
Probe Point at Reference (start)	0.69
START (data)	500.00
END (data)	399.89
Probe Point at Reference (end)	0.96
File Name	IG-BH01_2SNA_QAQC_16-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 16.2 Field Notes	
Probe	2SNA-1000 Spectral Gamma SN: 4116
Start Time	22:32
End Time	05:54
Run Direction	Up
Offset	1.22
Stick Up	0.53
Probe Point at Reference (start)	0.69
START (data)	1000.02
END (data)	0.96
Probe Point at Reference (end)	0.96
File Name	IG-BH01_2SNA_16-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Got "fetching parameters from tool failed" error after getting poor response on first attempt. Re-start system, no change. Switch Matrix. Re-set some settings to default. Ascend probe 10m, re-boot. Good response. Start at 1000m bgs.

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_2SNA_QAQC_16-1_R0a	26-Jan-18	AR	500	400	100	27-Jan-18	CRP	Acceptable
IG-BH01_2SNA_16-2_R0a	26-Jan-18	AR	1001	1	1000	27-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Logging scientist:

Adam Ramer	Adam Ramer	27-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibration Check By	Reference 1	Reference 2	Initial Value 1	Initial Value 2	Final Value 1	Final Value 2	Calibration File
2BSF-1000	*27-Jan-18*	*AR*	*0 $x10^{-5}$ CGS*	*180 $x10^{-5}$ CGS*	*0 $x10^{-5}$ CGS*	*180 $x10^{-5}$ CGS*	*-22.7 $x10^{-5}$ CGS*	*181.57 $x10^{-5}$ CGS*	Checked, not calibrated.

Comments on tool calibration:

Calibration checked with reference values, no calibrations performed in the field, as per user manual.

Logging scientist:

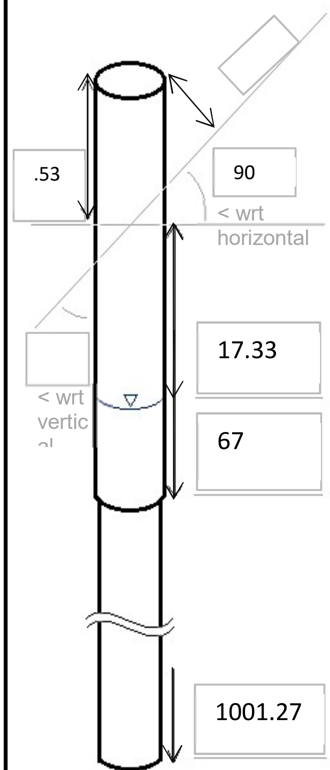
Adam Ramer	Adam Ramer	27-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
17.1	2CAA-F	5040	1.89	0.05	4.0	1	1001
17.2	2CAA-F	5040	1.89	0.05	4.0	100	200
17.3	2BSF-1000	3800	1.42	0.05	4.5	299	402
17.4	2BSF-1000	3800	1.42	0.05	4.5	958	1001
17.5	2BSF-1000	3800	1.42	0.05	4.5	586	1001
17.6	2BSF-1000	3800	1.42	0.05	4.5	0	595
17.7	2BSF-1000	3800	1.42	0.05	4.5	60	80



Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**17.33 (9:08)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		

Zones of instability / Zones noted during Survey (m bgs):

533 BGL increase it conductivity

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.1 Field Notes

Probe	2CAA-F-1000 Fluid Temperature Resitivity SN: 5040
Start Time	8:19
End Time	12:26
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	1.36
START (data)	1.36
END (data)	1001
Probe Point at Reference (end)	1.90
File Name	IG-BH01_FTR_5040_17-1d_r0a.tfd
Initial Calibration	26.4 Ohm.m, 15.7 Ohm.m
Final Calibration	22.84 Ohm.m, 12.46 Ohm.m

Comments:
Saved preuse and post use file using 2 solutions that we used to calibrate.   Also recalibrated the FTR prior to use. Let probe acclimatize for 90 seconds.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.2 Field Notes

Probe	Fluid Temperature Resistivity 2CAA-1000
Start Time	13:32
End Time	13:58
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	1.36
START (data)	100.00
END (data)	200.05
Probe Point at Reference (end)	1.90
File Name	IG-BH01_FTR_5040_17-1d_QAQC_r0a.tfd
Initial Calibration	26.4 Ohm.m, 15.7 Ohm.m
Final Calibration	22.84 Ohm.m, 12.46 Ohm.m

Comments: **Asked to do a QAQC log from 100 down to 200 m. More than average errors. Likely due to running fast up the hole to top.**

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.3 Field Notes	
Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	15:44
End Time	16:04
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Reference (start)	0.89
START (data)	402.04
END (data)	299.89
Probe Point at Reference (end)	0.97
File Name	IG-BH01_2BSF_QAQC_17-3_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments: Recalibrated in the hole with lowest negative still gave negative numbers will pull out of hole and walk out side yard with probe. And recalibrate
.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.4 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	17:50
End Time	18:05
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	1001.01
END (data)	958.04
Probe Point at Ref (end)	n/a
File Name	IG-BH01_2BSF_17-4_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Done with calibration outside of fence held in the Air
Point in the hole 566.61 = -42.27 average
Probe 100% bandwidth usage rebooted matrix working now depth not working.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.5 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	18:23
End Time	19:55
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	1001.02
END (data)	586.68
Probe Point at Ref (end)	-0.25
File Name	IG-BH01_2BSF_17-5_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Dropped probe down 40 from previous run. Stopped (maxed bandwidth) at 586.68m. Re-start./

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.6 Field Notes	
Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	20:00
End Time	22:12
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	595.00
END (data)	-0.26
Probe Point at Ref (end)	-0.25
File Name	IG-BH01_2BSF_17-6_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Overlap by ~10m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.7 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	22:19
End Time	22:27
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	80.00
END (data)	60.00
Probe Point at Ref (end)	0.86
File Name	IG-BH01_2BSF_17-7_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments: Level depth at casing re-set to 0.89 before running. This log will be used to tie-in previous logs.

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FTR_17-1_r0a.tfd	27/01/18	CM	1.36	1001	999.64	28-Jan-18	CRP	Acceptable
IG-BH01_FTR_QAQC_17-2_r0a.tfd	27/01/18	CM	100	200.05	100.05	28-Jan-18	CRP	Acceptable
IG-BH01_2BSF_QAQC_17-3_r0a.tfd	27/01/18	CM	402.04	299.89	102.15	28-Jan-18	CRP	Acceptable
IG-BH01_2BSF_17-4_r0a.tfd	27/01/18	CM	1001.01	958.04?	42.97	28-Jan-18	CRP	Acceptable
IG-BH01_2BSF_17-5_r0a.tfd	27/01/18	CM/AR	1001.02	586.68	414.34	28-Jan-18	CRP	Acceptable
IG-BH01_2BSF_17-6_r0a.tfd	27/01/18	AR	595.00	0	595	28-Jan-18	CRP	Acceptable
IG-BH01_2BSF_17-7_r0a.tfd	27/01/18	AR	80.00	60.00	20	28-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Did calibration of the FTR and pre-use and post-use checks [CM]
Good Quality on the initial run of FTR [CM]. More errors than usual on 17-2 log (likely cause of moisture from running up hole fast)
Mag Sus QAQC done with calibration in the hole. actual 17-4 done with probe out of yard and held in air [CM]
Lost communication and depth counting on 17-4 went down to bottom of hole and started over with 17-5 [CM]

Logging scientist:

Chris Marchildon — Print name

Chris Marchildon — Signature

27-Jan-2018 — Date

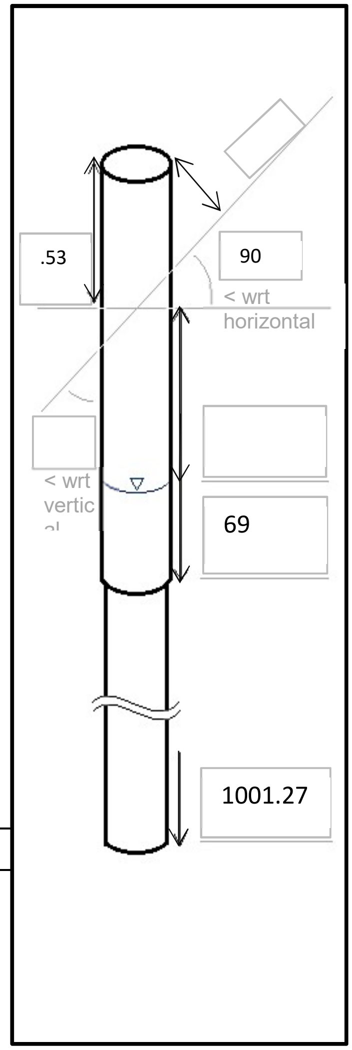
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
18.1	OBI40 – 2G	160403	1.62	0.0017	1.8 m/min	10.99	18.27
18.2	OBI40 – 2G	160403	1.62	0.0017	1.3 m/min	68.44	75.00

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 18.1 Field Notes	
Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	23:48
End Time	23:59
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	10.99
END (data)	18.27 (under water)
Probe Point at Reference (end)	1.09
File Name	IG-BH01_OBI_18-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Tested with Kodak colour can before use. Run down to show transition from dry to wet.
Got “fetching parameters from tool failed” error when booting, though probe still gave data. Note: there are no settings I have found that will allow running at more than 1.5-1.7 m/min while sampling 1.7mm & 360 pt/turn. Image window shows lots of blanks even when error rate / bandwidth usage is low. “Workload” and “Frame Rate” bars are very high when running above 1m/min.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 18.2 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	00:10
End Time	00:15
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	75.00
END (data)	68.43 (into casing)
Probe Point at Reference (end)	1.09
File Name	IG-BH01_OBI_18-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Tried running at 180 pt/turn – too coarse to see detail. Ran at 360 pt/turn, 1.7mm. Lots of errors / blanks in image at 1.4 m/min. Image no better than first gen televiewer. Water appears clear.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_OBI_18-1_r0a	27-Jan-18	AR	10.99	18.27	7.28	29-Jan-18	CRP	Re-run
IG-BH01_OBI_18-2_r0a	27-Jan-18	AR	75.00	68.44	6.56	29-Jan-18	CRP	Re-run

Comments on log quality and tool performance:

Could not get OBI to run faster than 1.2 m/min at 360 pt/turn, 1.7mm resolution. Still had many errors. Troubleshoot with TP / MSI tomorrow to get it working faster.
Water appears clear at 75m bgs.

Logging scientist:

Adam Ramer	Adam Ramer	28-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

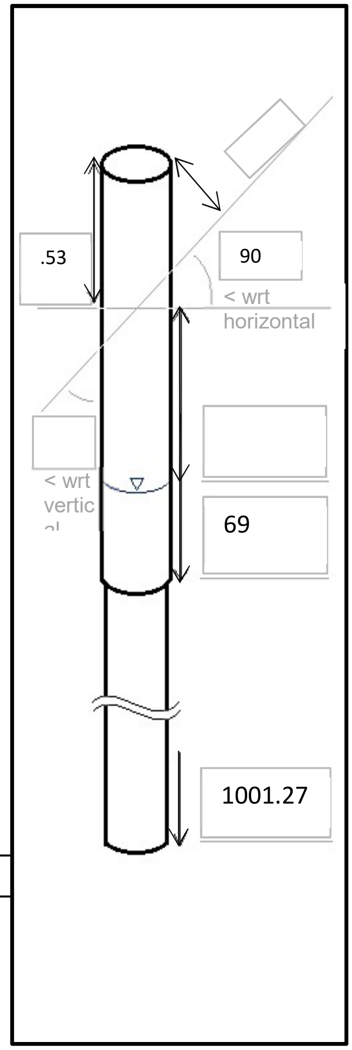
Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
19.1	OBI40 – 2G Deviation Run	160403	1.62 (1.51)	.1	10	.98	998.65
19.2	OBI40 – 2G	160403	1.62 (1.51)	0.00125	4	.98	998.65

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 19.1 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	12:25
End Time	14:10
Run Direction	Down
Offset	1.62 (1.51)
Stick Up	0.53
Probe Point at Reference (start)	.98
START (data)	.98
END (data)	998.65
Probe Point at Reference (end)	1.62
File Name	IG-BH01_OBI_Deviation_19-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 19.2 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	14:12
End Time	18:21
Run Direction	Up
Offset	1.62 (1.51)
Stick Up	0.53
Probe Point at Reference (start)	.98
START (data)	998.65
END (data)	1.62
Probe Point at Reference (end)	1.62
File Name	IG-BH01_OBI_Deviation_19-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Running at .00125 sampling with 600 pts per turn

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_OBI_Deviation_19-1_r0a	*28/01/18*	*CM*	*.98*	998.65	997.67	29-Jan-18	CRP	Acceptable
IG-BH01_OBI_19-2_r0a	*28/01/18*	*CM*	*998.65*	1.62	997.03	29-Jan-18	CRP	Acceptable (note)

Comments on log quality and tool performance:

[CRP] more errors than usual above 315 m – recommended to repeat collect OBI-2G log from 420m up.

Logging scientist:

Chris Marchildon — Print name

Chris Marchildon — Signature

28-Jan-2018 — Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

CALIBRATION AND VERIFICATION CHECK FORM

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Calibration of borehole geophysical probes:

Probe Name	Date	Calibration Check By	Pump Rate 1	Pump Rate 2	Probe Value 1	Probe Value 2	WL Drop 1	WL Drop 2	Calibration File
HFP2296	*28-Jan-18*	*AR*	*3.33 Lpm*	0.53 Lpm	0.30 Lpm	0.12 Lpm	2.07m	0.07	IG-BH01_HPFM-Test_4736

Comments on tool calibration:

HPFM not stabilizing when turned on.

Logging scientist:

Adam Ramer	Adam Ramer	28-Jan-2018
Print name	Signature	Date

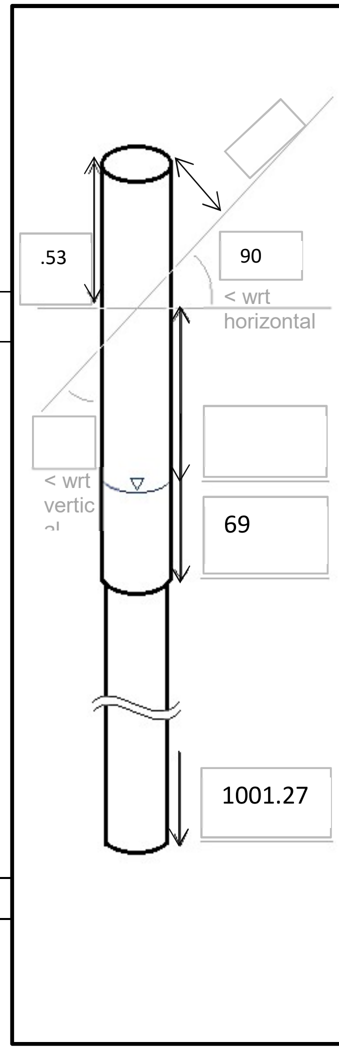
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
20.1	OBI40 – 2G	160403	1.62	0.00125	4 m/min	320	420
20.2	OBI40 – 2G	160403	1.62	0.00125	4 m/min	65	320
20.3	HFP2293	4736	0.85	20	N/A	40	620

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.1 Field Notes	
Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	20:29
End Time	20:55
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	420.00
END (data)	320.00
Probe Point at Reference (end)	1.15
File Name	IG-BH01_OBI_QAQC_20-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.2 Field Notes	
Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	20:56
End Time	22:23
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	320.00
END (data)	67.5
Probe Point at Reference (end)	1.15
File Name	IG-BH01_OBI_20-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

Run at 2.5 -2.7 m/min to minimize errors.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.3 Field Notes

Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	01:35
End Time	06:24
Run Direction	Down
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	40.00
END (data)	620.00
Probe Point at Reference (end)	1.07
File Name	IG-BH01_HPFM_20-3_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Difficulty getting HPFM to stabilize on start-up. Bring to surface – troubleshoot in bucket. Calibration values tested under known pumping conditions in casing prior to use. Had to allow WL to recover after pumping to avoid detecting upward flow in casing.

Brought back to surface to re-pack cable head after 620m – signal would no longer stabilize.

Golder Associates

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_OBI_QAQC_20-1_r0a	28-Jan-18	AR	420	320	100	28-Jan-18	CRP	Acceptable
IG-BH01_OBI_20-2_r0a	28-Jan-18	AR	320	67.5	252.5	28-Jan-18	CRP	Acceptable
IG-BH01_HPFM_20-3_r0a	28-Jan-18	AR	40	620	580	28-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Tested HPFM in casing with pump.

Logging scientist:

Adam Ramer		29-Jan-2018
Print name	Signature	Date

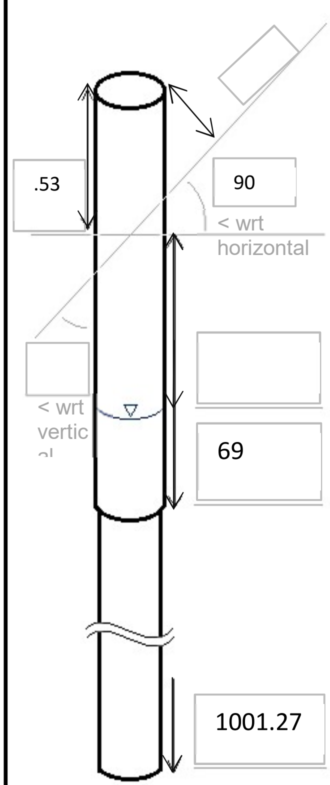
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
21.1	HFP2293	4736	0.85	20	N/A	620	980
21.2	HFP2293	4736	0.85	10	N/A	920	880

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 21.1 Field Notes	
Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	8:56
End Time	14:25
Run Direction	Down
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	620
END (data)	980
Probe Point at Reference (end)	1.45
File Name	IG-BH01_HPFM_21-1_r0a.mh
Initial Calibration	
Final Calibration	Factory Calibrated

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 21.2 Field Notes	
Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	15:31
End Time	16:30
Run Direction	Up
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	920
END (data)	880
Probe Point at Reference (end)	1.45
File Name	IG-BH01_HPFM_21-2_r0a.mh
Initial Calibration	
Final Calibration	Factory Calibrated

Comments: tried to do next file could not it was never stabilizing had to pull up and repack and check probe at 17:00 hrs pulled up from 720

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	***Log Date***	***Operator***	***From (m)***	***To (m)***	***Length (m)***	***Review Date***	***Reviewed By***	***Data Quality***
IG-BH01_HPFM_21-1_r0a.mh	29/01/18	CM	620	980	360	30-Jan-18	CRP	Acceptable
IG-BH01_HPFM_21-2_r0a.mh	29/01/18	CM	920	880	40	30-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Initially 20 m coarse. Infilling around [CM]

Logging scientist:

Chris Marchildon	Chris Marchildon	29-Jan-2018
Print name	Signature	Date

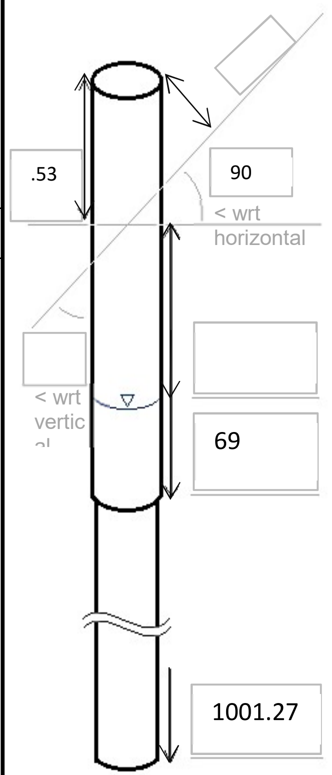
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
22.1	FWS40	060102	1.84	0.05	1.5 m/min	55	250
22.2	2PGA	3991	0.65	0.025	2.25 m/min	0	100
22.3	2DVA	3957	0.64	0.01	2.5 m/min	0	

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.1 Field Notes

Probe	FWS40 Full Waveform Sonic SN: 060102
Start Time	22:56
End Time	00:59
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	250.01
END (data)	55.00
Probe Point at Reference (end)	1.10
File Name	IG-BH01_FWS40_22-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Pre-use test in casing. Probe in working order. Overlap previous FWS log by 50m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.2 Field Notes	
Probe	2PGA Natural Gamma SN: 3991
Start Time	01:43
End Time	02:28
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	100.01
END (data)	0.14
Probe Point at Ref (end)	0.16
File Name	IG-BH01_2PGA_22-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.3 Field Notes	
Probe	2DVA-1000 Deviation SN: 3957
Start Time	03:20
End Time	07:25
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Ref (start)	0.11
START (data)	0.11
END (data)	644.93
Probe Point at Ref (end)	
File Name	IG-BH01_2DVA_Down_22-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Tool offset taken to be midway between centralizers.

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_FWS40_22-1_r0a	29-Jan-18	AR	250	55	195	30-Jan-18	CRP	Acceptable
IG-BH01_2PGA_22-2	29-Jan-18	AR	100	0	100	30-Jan-18	CRP	Acceptable
IG-BH01_2DVA_Down_22-3	29-Jan-18	AR	0	645	645	30-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Tested HPFM in casing with pump. [AR]

Logging scientist:

Adam Ramer	Adam Ramer	30-Jan-2018
Print name	Signature	Date

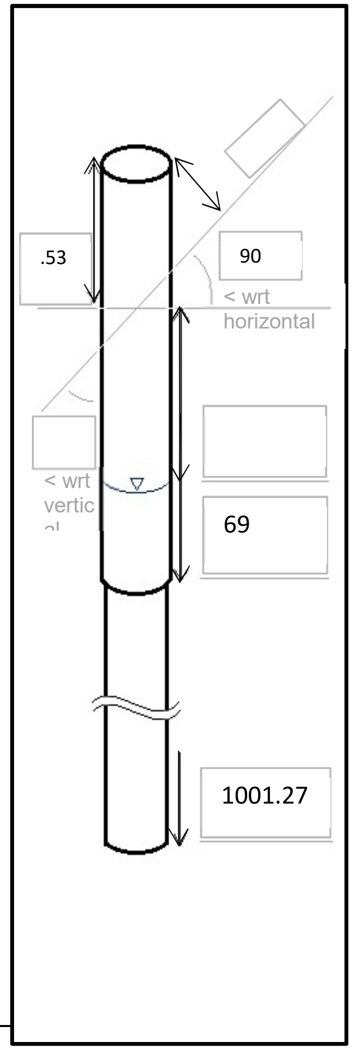
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
23.1	2DVA	3957	.64	.01	2.5	630.00	665.00
23.2	2DVA	3957	.64	.01	2.5	660.01	1001.03
23.3	2DVA	3957	.64	.01	2.5	1001.02	820.02
23.4	2DVA	3957	.64	.01	2.5	860.03	635.04
23.5	2DVA	3957	.64	.01	2.5	650	617.67
23.6	2DVA	3957	.64	.01	2.5	630.02	-.31

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.1 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	9:00
End Time	9:15
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	630.00
END (data)	665.00
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Backed up and started at 630. We did lose power for a moment at shift change. Had some issues with matrix when starting up again. Bandwidth usage was 100 %. Did reboots etc.. was unresponsive on the field laptop

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.2 Field Notes

Probe	2DVA-1000 Deviation SN: 39572
Start Time	9:20
End Time	11:40
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	660.01
END (data)	1001.01
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: had some issues with matrix and communicating. The depth counter all of a sudden showed 0. Restarted everything and backed up to 660 m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.3 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	11:41
End Time	12:55
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	1001.02
END (data)	820.02
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Stopped log dropped down to 860

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.4 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	13:01
End Time	14:33
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	860.03
END (data)	635.04
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-4_r0a
Initial Calibration	Calibrated in factory
Final Calibration	
Comments:	

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.5 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	14:36
End Time	14:55
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	650
END (data)	617.67
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-5_r0a
Initial Calibration	Calibrated in factory
Final Calibration	
Comments:	

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.6 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	14:55
End Time	18:33
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	630.02
END (data)	55.99
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-6_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

Golder Associates

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / AM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_2DVA_Down_23-1_r0a.tfd	*30/01/18*	*CM*	*630.00*	665.00	35.00	31-Jan-18	CRP	Acceptable (note)
IG-BH01_2DVA_Down_23-2_r0a.tfd	*30/01/18*	*CM*	*660.01*	1001.03	340.04	31-Jan-18	CRP	Acceptable (note)
IG-BH01_2DVA_Up_23-3_r0a.tfd	*30/01/18*	*CM*	*1001.02*	820.02	200.00	31-Jan-18	CRP	Acceptable (note)
IG-BH01_2DVA_Up_23-4_r0a.tfd	*30/01/18*	*CM*	*860.03*	635.04	224.99	31-Jan-18	CRP	Acceptable (note)
IG-BH01_2DVA_Up_23-5_r0a.tfd	*30/01/18*	*CM*	*650.00*	617.67	32.33	31-Jan-18	CRP	Acceptable (note)
IG-BH01_2DVA_Up_23-6_r0a.tfd	*30/01/18*	*CM*	*630.02*	630.02	-.31	31-Jan-18	CRP	Acceptable (note)

Comments on log quality and tool performance:

Throughout all data sets there is the odd bump of data which is all on both the Azimuth and Tilt. [CM]
[CRP] Anomalies appear to be possibly spin in the probe but it doesn't make sense as the spin seems to be filtered at deeper depths. Calculated northing and eastings generally agree with Gyro and OTV/ATV data but are much noisier with these anomaly locations causing these bumps. Waiting for troubleshooting from MSI. Discussed with Aaron and will repeat OTV log for deviation instead of the 2DVA.

Logging scientist:

Chris Marchildon	Chris Marchildon	30-Jan-2018
Print name	Signature	Date

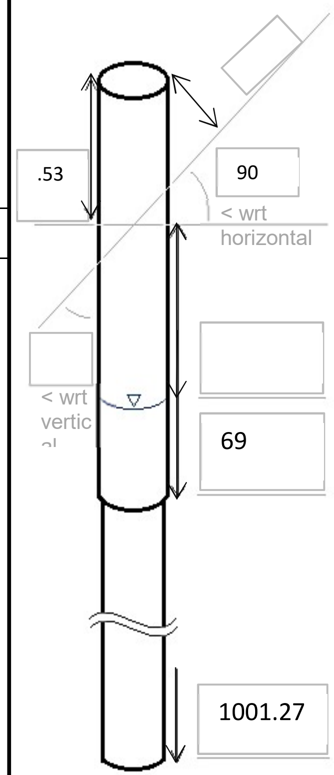
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:	Chris Marchildon	**Verified by:**	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
24.1	OBI40-2G	160403	1.62	0.05	10 m/min	1	1001
24.2	OBI40-2G	160403	1.62	0.0012	3.5 m/min	1	1001
24.3	BHFS	6359	0.63	545	N/A	545	545

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**17.8**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.1 Field Notes

Probe	OBI40-2G Optical Televiewer SN: 160403
Start Time	20:12
End Time	21:53
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	1.09
END (data)	997.84
Probe Point at Reference (end)	1.40
File Name	IG-BH01_OBI_24-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.2 Field Notes

Probe	OBI40-2G Optical Televiewer SN: 160403
Start Time	21:56
End Time	02:32
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	999.47
END (data)	1.40
Probe Point at Reference (end)	1.40
File Name	IG-BH01_OBI_24-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.3 Field Notes	
Probe	BHFS Fluid Sampler SN: 6359
Start Time	04:00 (5 min pressure test)
End Time	05:32 (Sample)
Run Direction	N/A
Offset	0.63
Stick Up	0.53
Probe Point at Reference (start)	0.10
START (data)	545 (5 min pressure test)
END (data)	545 (sample)
Probe Point at Reference (end)	0.22
File Name	N/A
Initial Calibration	Electronic valve tested on surface, seals tested at depth.
Final Calibration	

Comments: Probe left closed at 545m bgs for 5 min. Return to surface – no seal leakage.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

QUALITY CONFIRMATION REPORT

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / PM*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Borehole Geophysical Logs:

Log Name	*Log Date*	*Operator*	*From (m)*	*To (m)*	*Length (m)*	*Review Date*	*Reviewed By*	*Data Quality*
IG-BH01_OBI_24-1_r0a	*30-Jan-18*	*AR*	*1*	998	997	31-Jan-18	CRP	Acceptable
IG-BH01_OBI_24-2_r0a	*30-Jan-18*	*AR*	*1000*	1	999	31-Jan-18	CRP	Acceptable

Comments on log quality and tool performance:

Also sampled water from 545 m bgs.

Logging scientist:

Adam Ramer	*[signature]*	31-Jan-2018
Print name	Signature	Date

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	Phase 2 Initial Borehole Drilling
Prepared by:		**Verified by:**	

APPENDIX B

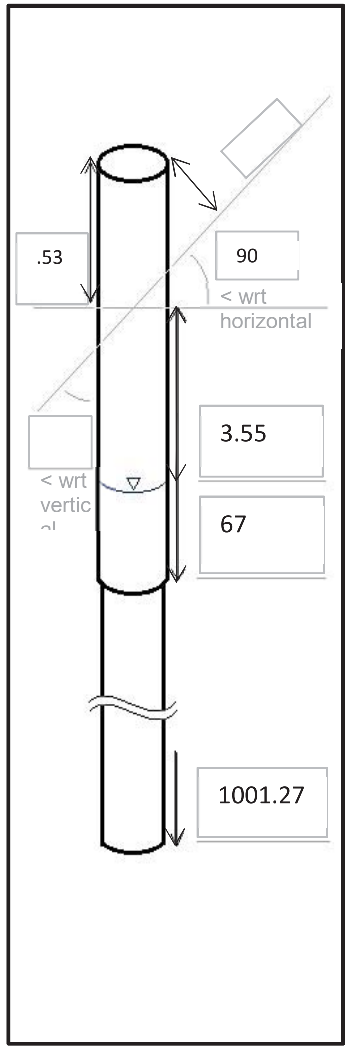
Records of Geophysical Logging

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
1.1	FTR Down	5040	1.89	0.05	10 m/min	0	1001
1.2	FTR Up	5040	1.89	0.10	20 m/min	50	1001
1.3	FTR Down	5040	1.89	0.05	10 m/min	50	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**3.55 (at start)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

191-192, 332-335, 543-546, 563-565, 617-620, 669-680, 762-764, 844-849, 858-864, 882-885

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.1 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:00
End Time	15:30
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1.36
END (data)	~ 161.26
Probe Point at Collar (end)	1.36
File Name	IG_BH01_WP5_FFEC_Static_R1_Dn_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Down Run 10 m a minute. Surveyed 1st 40 m with no Rst @ approx. 30m bgl
Power glitch caused probe to free fall brought back to top restart

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.2 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:50
End Time	17:40
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1.36
END(data)	1001.05
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG_BH01_WP5_FFEC_Static_R2_Dn_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Restarted the log Ran down to 40 m then installed RST at 30 m

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 1.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	18:00
End Time	18:49
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.05
END (data)	50.00
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG_BH01_WP5_FFEC_Static_R1_Up_v1a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

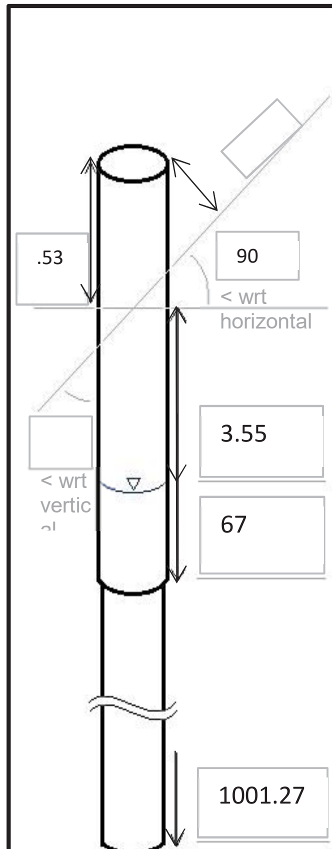
Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
2.1	FTR Down	5040	1.89	0.05	10 m/min	0	1001
2.2	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.3	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.4	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.5	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.6	FTR Up	5040	1.89	0.10	20 m/min	50	1001
2.7	FTR Down	5040	1.89	0.05	10 m/min	50	1001
2.8	FTR Up	5040	1.89	0.10	20 m/min	50	1001



Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**11.32 (at start)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	20:30
End Time	22:09
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1002.92
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static2_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	22:41
End Time	23:31
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.07
END(data)	49.86
Probe Point at Collar (end)	49.86
File Name	IG_BH01_FFEC_Static2-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	00:05
End Time	01:40
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.15
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static3_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.4 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	01:42
End Time	02:29
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.15
END (data)	50.08
Probe Point at Collar (end)	50.08
File Name	IG_BH01_FFEC_Static3-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.5 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	02:34
End Time	04:09
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.07
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static4_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.6 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	04:10
End Time	05:02
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.07
END (data)	50.03
Probe Point at Collar (end)	50.03
File Name	IG_BH01_FFEC_Static4-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.7 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	05:04
End Time	06:39
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	50.00
START (data)	50.00
END (data)	1001.09
Probe Point at Collar (end)	
File Name	IG_BH01_FFEC_Static5_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*19/Jan/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 2.8 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	06:41
End Time	07:30
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	
START (data)	1001.09
END (data)	50.10
Probe Point at Collar (end)	50.10
File Name	IG_BH01_FFEC_Static5-up_R0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

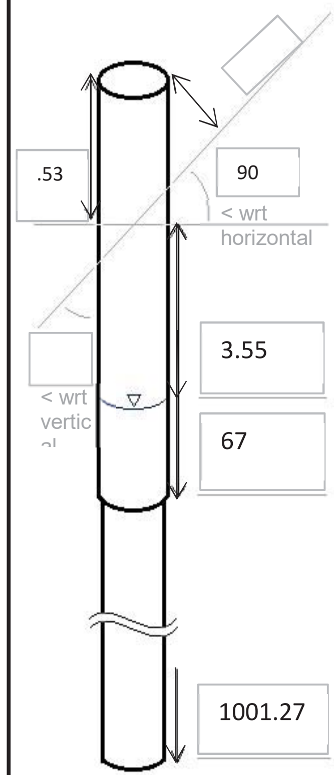
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	*20/Jan/2018 / Day*
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
3.1	FTR Down	5040	1.89	0.05	10 m/min	69	1001.08
3.2	FTR UP	5040	1.89	0.10	20 m/min	69	1001.08
3.3	FTR Down	5040	1.89	0.05	10 m/min	69	1001.08
3.4	FTR UP	5040	1.89	.10	20 m/min	69	1001.08
3.5	FTR Down	5040	1.89	.05	10m/min	69	1001.08
3.6	FTR UP	5040	1.89	.10	20m/min	69	1001.08



Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.1 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	10:48
End Time	12:34
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	1.36
File Name	IG-BH01_FFEC_Dynamic1 _1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity Jan/19/2017
Final Calibration	

Comments:

Start pump approximately 10:30am
Down Run 10 m a minute. Pump at approx. 66 m tried to maintain 1.5 m per min also collected water levels and manual confirmation of pump rate over time. 19.217 W.L 30.47 m W.L

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	12:40
End Time	13:32
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1001.08
END(data)	69.38
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG-BH01_FFEC_Dynamic1_1_5_up_R0a_.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
End at 69.00 at 69.38

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	13:53
End Time	15:29
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.10
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic2_1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.4 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	15:29
End Time	16:25
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.10
END (data)	69.24
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic2_1_5_up_R0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.5 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	16:41
End Time	18:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic3_1_5_dn_R0.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments: Water Level at 16:50 approx. 48 m bgl

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 3.6 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	18:25
End Time	19:14
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.00
END (data)	1001.08
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic3_1_5_up_R0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
WL @ 19:15 50.442

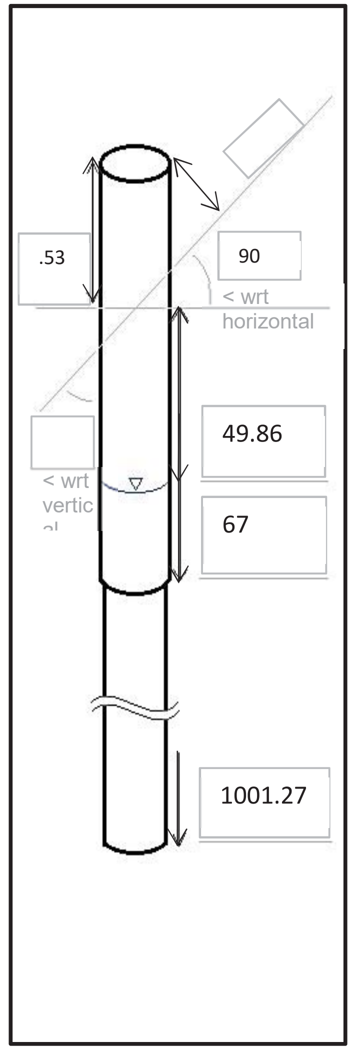
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
4.1	FTR Down	5040	1.89	0.05	10 m/min	69	239
4.2	FTR Down	5040	1.89	0.05	10 m/min	69	462
4.3	FTR Down	5040	1.89	0.05	10 m/min	300	1001
4.4	FTR Up	5040	1.89	0.10	20 m/min	69	1001
4.5	FTR Down	5040	1.89	0.05	10 m/min	69	1001
4.6	FTR Up	5040	1.89	0.10	20 m/min	69	1001
4.7	FTR Down	5040	1.89	0.05	10 m/min	69	1001
4.8	FTR Up	5040	1.89	0.10	20 m/min	69	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**49.86 (at start)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

191-192, 332-335, 543-546, 563-565, 617-620, 669-680, 762-764, 844-849, 858-864, 882-885

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.1 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	20:48
End Time	21:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	69.00
START (data)	69.00
END (data)	238.88
Probe Point at Collar (end)	
File Name	IG-BH01_FFEC_Dynamic4-1_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Probe initially unresponsive – restart Logger, adjust discriminators. Down Run 10 m a minute. Pause at 201.98 for 10 min (pump died). Reset pump, run at 301Hz. Pause at 238.88m (pump died again) @21:15. Resume at 21:18. Pump died again at 21:20. Find different power source – no good. Allow W.L. to recover to ease load on pump. Abandon log, re-start (next page).

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.2 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	22:13
End Time	22:55
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	69.00
START (data)	69.00
END(data)	462.42
Probe Point at Reference (end)	
File Name	IG-BH01_FFEC_Dynamic4-2_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Values maxed out at 440.55 Ohm.m. Re-set discriminators, start new file at 300 m

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	23:08
End Time	00:19
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69
START (data)	300.01
END (data)	1001.15
Probe Point at Ref (end)	
File Name	IG-BH01_FFEC_Dynamic4-3_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Reset discriminators to automatic. Start at 300m to catch first anomaly. Adjust discriminators ~475 – 480m, then return to auto. Below ~485, res begins to drop + signal changes shape and discriminators automatically re-adjusted. Suspect res maxing out between cond peaks.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.4 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	00:21
End Time	01:11
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	1001.15
END (data)	69.58
Probe Point at Ref (end)	69.51
File Name	IG-BH01_FFEC_Dynamic4-4_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.5 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	01:45
End Time	03:27
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	69.00
END (data)	1001.11
Probe Point at Ref (end)	
File Name	IG-BH01_FFEC_Dynamic4-5_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Adjusted RST and Level Troll positions prior to logging. 3m above pump. Fluid sampled from pump: 95 mS/m. Time-mode FTR value ~3m under pump: 32.5 mS/m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.6 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	3:28
End Time	4:25
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.00
START (data)	1001.11
END (data)	69.45
Probe Point at Collar (end)	69.17
File Name	IG-BH01_FFEC_Dynamic4-6_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Wireline twisting around hose prevents probe from reaching 69m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.7 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	4:30
End Time	6:03
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.28
START (data)	69.28
END (data)	1004.14
Probe Point at Collar (end)	
File Name	IG-BH01_FFEC_Dynamic4-7_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Wireline twisting around hose prevents probe from reaching 69m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	Adam Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*20/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 4.8 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	6:08
End Time	6:57
Run Direction	Up
Offset	1.89
Stick Up	0.53
Probe Point at Ref (start)	69.28
START (data)	1004.14
END (data)	69.40
Probe Point at Ref (end)	69.27
File Name	IG-BH01_FFEC_Dynamic4-8_r0a
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

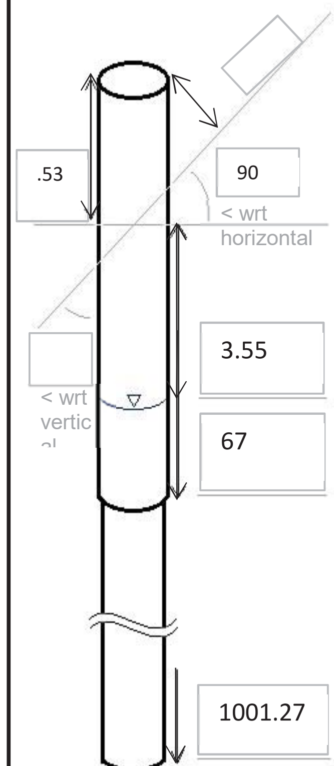
Comments:
Wireline twisting around hose prevents probe from reaching 69m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
5.1	FTR Down	5040	1.89	0.05	10 m/min	69.27	1001.08
5.2	FTR UP	5040	1.89	0.10	20 m/min	69.27	1001.08
5.3	FTR Down	5040	1.89	0.05	10 m/min	69.27	1001.12
5.4	FTR UP	5040	1.89	0.10	20 m/min	69.27	1001.12
5.5	FTR Down	5040	1.89	0.05	10m/min	69.27	1001.12
5.6	FTR UP	5040	1.89	0.10	20m/min	69.27	1001.11

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.1 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	8:25
End Time	10:02
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	69.27
END (data)	1001.12
Probe Point at Collar (end)	1.36
File Name	IG-BH01_FFEC_Dynamic5-1__DN_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity Jan/19/2017
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.2 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	10:27
End Time	11:17
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	1.36
START (data)	1001.12
END(data)	69.36 should be 69.27
Probe Point at Collar (end)	n/a – did not return to surface for next run
File Name	IG-BH01_FFEC_Dynamic5-2__UP_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Pump stopped at 10:52 started again at 11:05

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.3 Field Notes	
Probe	FTR Serial # 5040 – FFEC Testing
Start Time	11:33
End Time	13:15
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.27
END (data)	1001.12
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-3__DN_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments: **had issues with water level but hopefully fixed it. WL approx. 50 mbgl.**
Pumped kicked off at 12:31 12:53

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.4 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	13:34
End Time	14:24
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.12
END (data)	69.33
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-4__up_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.5 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	14:27
End Time	16:02
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	69.27
END (data)	1001.11
Probe Point at Collar (end)	n/a – did not return to surface at end of run
File Name	IG-BH01_FFEC_Dynamic5-5__Dn_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:
Pump out at 15:05 back on at 15:15

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/Jan/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 5.6 Field Notes

Probe	FTR Serial # 5040 – FFEC Testing
Start Time	16:05
End Time	16:50
Run Direction	UP
Offset	1.89
Stick Up	0.53
Probe Point at Collar (start)	n/a – did not start at collar
START (data)	1001.11
END (data)	69.45
Probe Point at Collar (end)	1.49
File Name	IG-BH01_FFEC_Dynamic5-6__up_r0a.tfd
Initial Calibration	Tested in field it passed to known resistivity
Final Calibration	

Comments:

Pump off 16:19 pump off at 16:53 close to top of log

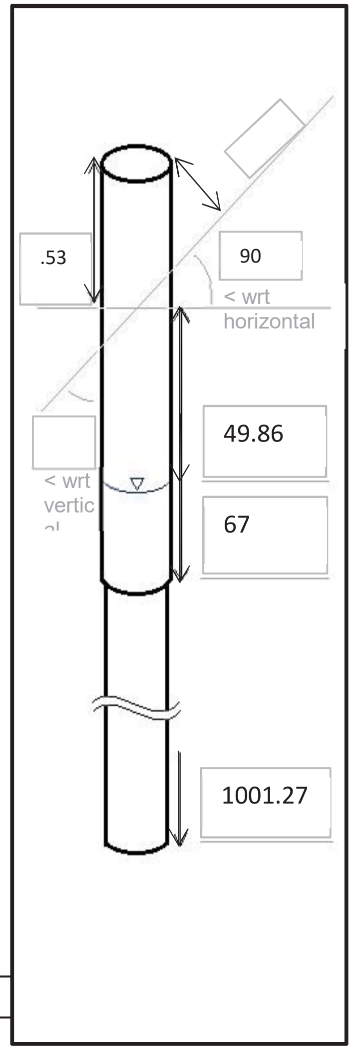
Back up to reference 1.49

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
6.1	2PIA QA/QC	2680	1.01	0.05	4.5 m/min	400	500
6.2	2PIA	2680	1.01	0.05	4.5 m/min	64	1001
6.3	ABI QA/QC	154105	1.58	0.0021	1.5 m/min	800	900
6.4	ABI	154105	1.58	.0021	1.5m/min	0	1001
6.5	ABI	154105	1.58	.0021	1.5 m/min	998.11	890



Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)	40.45 mbgs (20:20h)	BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.1 Field Notes

Probe	2PIA-1000 Electromagnetic Induction (Apparent Conductivity)
Start Time	21:10
End Time	21:31
Run Direction	Up
Offset	1.01
Stick Up	0.53
Probe Point at Reference (start)	0.48
START (data)	500
END (data)	400
Probe Point at Reference (end)	1.28
File Name	IG-BH01_2PIA_QAQC_6-1_r0a
Initial Calibration	0 mS, 102 mS
Final Calibration	-20.10 mS, 79.10 mS

Comments:

Acclimatize probe in water @46.38 mbgs for 15 minutes prior to disc calibration.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.2 Field Notes	
Probe	2PIA-1000 Electromagnetic Induction (Apparent Conductivity)
Start Time	21:58
End Time	01:24
Run Direction	Up
Offset	1.01
Stick Up	0.53
Probe Point at Reference (start)	0.48
START (data)	1001.22
END (data)	63.96
Probe Point at Reference (end)	1.28
File Name	IG-BH01_2PIA_6-2_r0a
Initial Calibration	0 mS, 102 mS
Final Calibration	-20.10 mS, 79.10 mS

Comments:
Drift of approx. -30 mS/m by the bottom.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.3 Field Notes	
Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	3:57
End Time	5:10
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	900.02
END (data)	799.99
Probe Point at Reference (end)	
File Name	IG-BH01_ABI_QAQC_6-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.
Used 3 HQ centralizers. Centralizers bolstered to improve in 100mm diameter hole. Excellent centralization overall.
@2:17 Generator quit – lost power and probe free fell 78m. Generator required oil change. Running again at 2:30. Retrieve probe, unresponsive. Re-start system. Still unresponsive. Switch Matrix. Re-start system. Working.
Could not get ABI running in depth mode faster than 1.5m/min. ABI logging will take twice as long as proposed.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.4 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	5:29
End Time	6:25
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.10 (top of mud)
END (data)	861.66
Probe Point at Ref (end)	
File Name	IG-BH01_ABI_6-4_r0a
Initial Calibration	
Final Calibration	

Comments:
Run at azimuthal resolution of 144 pt/turn.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*21/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 6.5 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	6:37
End Time	7:59
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.11 (top of mud)
END (data)	890
Probe Point at Ref (end)	.93
File Name	IG-BH01_ABI_6-5_r0a
Initial Calibration	
Final Calibration	

Comments:

Run at azimuthal resolution of 288 pt/turn.

For repeating and overlap approx. 291 - 292 and also 893 good features

Pull out of Hole so DGI can access the hole

Approx. 227 errors

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN 22 - DAY DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

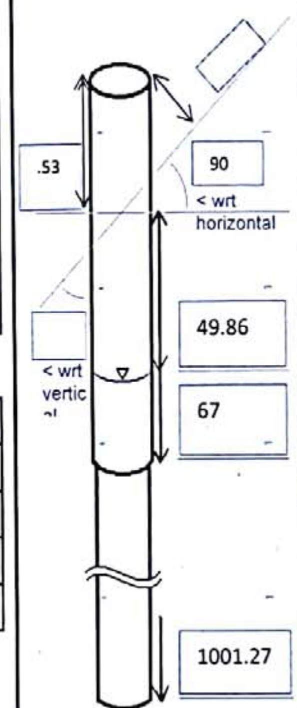
Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run Top	Expected Run Bottom
7.1	GDA	5172		0.025	1.7	982.90	995.00
7.2	GDA	5172		0.025	1.7	884.72	970.01
7.3	GDA	5172		0.025	1.7	830.97	896.04
7.4	GDA	5172		0.025	1.7	840.94	860.02
7.5	GDA	5172		0.025	1.7	660.25	860.01

TOL FILE

Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	1 of 6		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	JAN 22, 2018 SHIFT #7
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	Distributed By:	Email

Run 7.1	Field Notes
Probe	GDA - Focus Density - Gamma Gamma
Start Time	~~10:15 AM~~ 12:35 CM
End Time	
Run Direction	Up. runs
Offset	See .Tol File for probe offsets.
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	995.00
END (data)	952.90
Probe Point at Reference (end)	N/A
File Name	IG-BH01_GDA_7.1u_rDa
Initial Calibration	Test In BARRIE
Final Calibration	Certificate Sent By DGI

Comments:

- Winch encoder wheel was loose and had to be fixed. Runs were unaffected.
- Mx winch motor was hot due to the force required to pull up the density probe. Motor required cooling with water and periodic stops.
- Lower logging speed was required to best mitigate telemetry issues with the probe.
-

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marshildon	Verified by:	
Page:	2 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan/22/2018 – Day DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 7.2 Field Notes	
Probe	GDA – Gamma Gamma
Start Time	
End Time	2:01 PM
Run Direction	up
Offset	see .tol File
Stick Up	0.53 m
Probe Point at Ref (start)	2.99
START (data)	970.01
END (data)	884.72
Probe Point at Ref (end)	N/A
File Name	IG-BH01_GDA_7.2u_r0a
Initial Calibration	Left In Barrie
Final Calibration	Certificate Sent By DGI

Comments:

- Mx winch motor was hot, had to manually cool it.
- Logging Speed of roughly 2.1m/min to 2.3m/min

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	3 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN/22/2018 DAY DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 7.3 Field Notes	
Probe	GDA – Gamma Gamma
Start Time	
End Time	2:48 PM
Run Direction	UP
Offset	
Stick Up	0.53
Probe Point at Ref (start)	2.99
START (data)	896.04
END (data)	830.97
Probe Point at Ref (end)	N/A
File Name	IG-BH01_GDA_7.3u_r0a
Initial Calibration	Test in Barrie
Final Calibration	Certificate Sent by DGI

Comments:

- Mx winch motor was hot and needed manual cooling.
- GDA Probe telemetry failed at 834m. Probe was restarted and resolved issue.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Macklinden	**Verified by:**	
Page:	4 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	JAN 22 DAY DGI
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches		
	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 7.4 Field Notes	
Probe	GDA - Gamma Gamma
Start Time	
End Time	3:22
Run Direction	up
Offset	See tol File
Stick Up	0.53m
Probe Point at Reference (start)	2.99m
START (data)	860.02
END (data)	840.94
Probe Point at Reference (end)	N/A
File Name	IG-BH01_GDA_7-4u_r0a
Initial Calibration	Test in shop in BARRIE
Final Calibration	Certificate Sent by DGI

Comments:

- Motor still hot
- GDA probe telemetry failed, restart resolved issue.
- Run only over laps 7.3 and 7.5

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	ChrisMartin	**Verified by:**	
Page:	5 of 6.		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN/22/2018 - Day DGI
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 7.5 Field Notes	
Probe	GDA - Gamma Gamma
Start Time	
End Time	5:31
Run Direction	up
Offset	See .tol file
Stick Up	0.53 m
Probe Point at Ref (start)	2.99
START (data)	860.01
END (data)	660.25
Probe Point at Ref (end)	22.06
File Name	IG-BH01_GDA_7-50_r0a
Initial Calibration	
Final Calibration	

Comments:

- Motor was hot
- Probe was run at 1.5m/min to 1.9m/min and seemed to help prevent telemetry failures.
- On the way out of hole, the Mx winch encoder wheel came loose and depth was lost. About 19m off our zero depth.

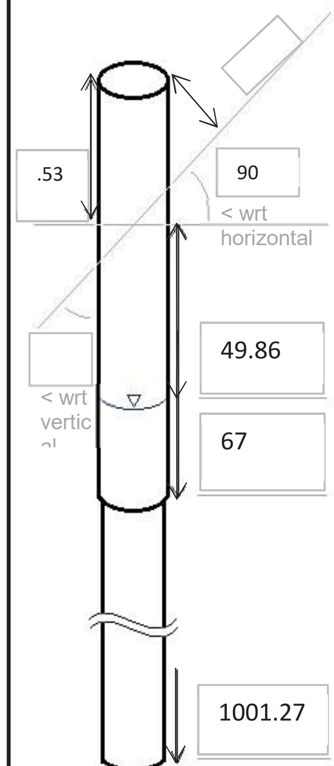
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chr. M...	**Verified by:**	
Page:	6 of 6.		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
8.1	ABI Down	154105	1.58	0.05	10 m/min	1	1001
2.2	ABI	154105	1.58	0.0021	1.4 m/min	232	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**~26 (low res ABI check)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 8.1 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	20:05
End Time	21:44
Run Direction	Down
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	1.05
END (data)	998.71 (into mud)
Probe Point at Reference (end)	
File Name	IG-BH01_ABI_Down_8-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*22/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 8.2 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	21:50
End Time	06:50
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Ref (start)	1.05
START (data)	998.72 (into mud)
END (data)	232.00
Probe Point at Ref (end)	0.80
File Name	IG-BH01_ABI_8-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Run at azimuthal resolution of 288 pt/turn.
Much less “bounce” in the data.

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

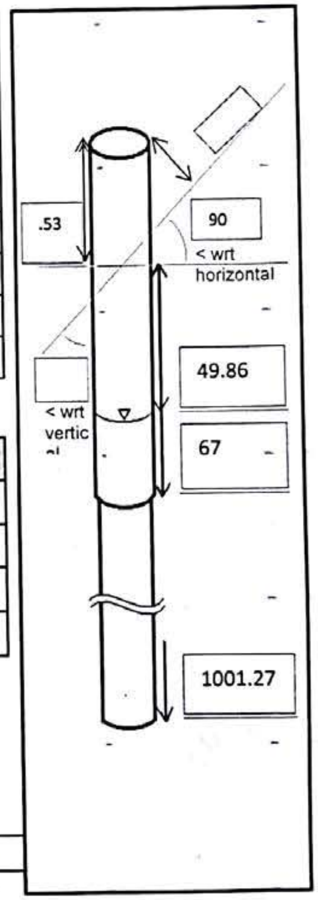
TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 23, 2018 Shift #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run Top	Expected Run Bottom
Cm U1	GDA Density	5172		0.025	1.6-1.8	553.73	735.01
Cm U2	GDA Density	5172		0.025	1.6-1.8	450.04	580.00

Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Mardiildon	**Verified by:**	
Page:	1 of 3		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAN 23/2018/Shift #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 9-1 Field Notes

Probe	2GDA - DENSITY 5172
Start Time	2:10 pm
End Time	3:55 Pm.
Run Direction	up Run #1
Offset	See tol file.
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	735.01
END (data)	553.73
Probe Point at Reference (end)	Did not come to surface. cm See tol file
File Name	~~[illegible]~~ IG-BH01-GDA-9-1u.rDa
Initial Calibration	REFER TO CERTIFICATES SENT FROM DGI
Final Calibration	" " " "

Comments:

* Run repeated with LAST Run From From yesterday. (up #5)
* HAD to stop FilE due to bandwith spike.
* Sent tool BACK downhole 25m to ensure repeatability.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Macchildon	**Verified by:**	
Page:	2 of 3		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	JAn23/2018 ShiFT #9
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 9-2 Field Notes	
Probe	2GDA-Density 5172
Start Time	4:05 pm.
End Time	5:45 pm
Run Direction	up Run # 7 CM CM
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	2.99
START (data)	580.00
END (data)	450.04
Probe Point at Reference (end)	4.79
File Name	IG_BH01_GDA-9-2u.r0a
Initial Calibration	REFER TO CERTIFICATES SENT by Email FROM DGI
Final Calibration	

Comments:

* STARTED up Run #7 but as I Reached 563m, we encountered another bandwidth spike with the tool.
* we simply override the U7 Run previously Recorded with a new up 7 Run since we did not collect any new data.
* started new up7 file @ 4:26 pm.

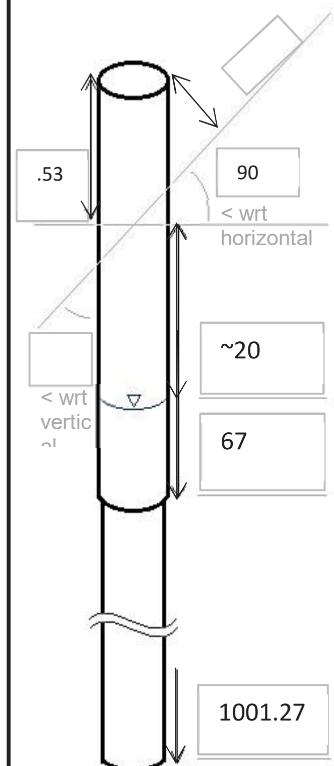
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris MARCHILDON	**Verified by:**	
Page:	CM 3of3		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
10.1	ABI	154105	1.58	0.0021	1.4 m/min	67	245
10.2	2PGA Gam	3991	0.65	0.025	2.25 m/min	500	600
10.3	2PGA Gam	3991	0.65	0.025	2.25 m/min	1.49	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**~20 (low res ABI check)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.1 Field Notes

Probe	ABI40-2G Acoustic Televiewer SN: 154105
Start Time	20:11
End Time	22:01
Run Direction	Up
Offset	1.58
Stick Up	0.53
Probe Point at Reference (start)	1.05
START (data)	245.00
END (data)	67.00
Probe Point at Reference (end)	1.35
File Name	IG-BH01_ABI_10-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Roll checked prior to mobilization. NOAA, NRCAN checked for geomagnetic activity; confirmed low.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.2 Field Notes	
Probe	2PGA Natural Gamma SN: 3991
Start Time	23:17
End Time	00:01
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	600.00
END (data)	499.83
Probe Point at Ref (end)	Did not return to surface
File Name	IG-BH01_2PGA_QAQC_10-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*23/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 10.3 Field Notes	
Probe	2PGA Natural Gamma SN: 3991
Start Time	00:30
End Time	7:51
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	1001.14
END (data)	1.49
Probe Point at Ref (end)	1.49
File Name	IG-BH01_2PGA_10-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

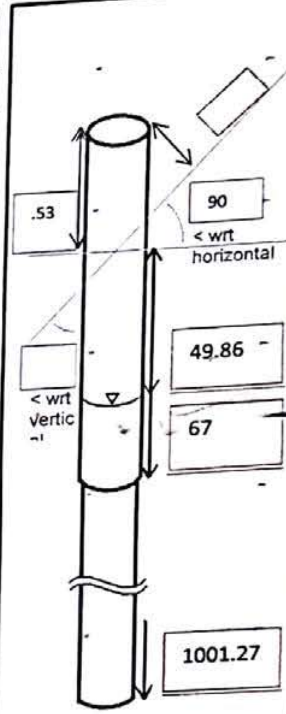
Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run Top	Expected Run Bottom
11.1	GDA	5172	See tol	0.025	1.7m/min	475.11	97.17
11.2	GDA	5172	See tol	0.025	1.7m/min	122.03	3.32
11.3	GDA	5172	See tol	0.025	1.7m/min	200.05	99.95
cm ~ 11.~~3~~4	Neutron	3312	.33	0.025	2.5m/min	300.00	1.00

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	1 of ~~4~~ 5 cm		

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 11.1 Field Notes	
Probe	GDA Density
Start Time	9:05 Am
End Time	12:35 Pm
Run Direction	up
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	~~2.44~~ CM Not top of Hole
START (data)	475.11
END (data)	97.17
Probe Point at Ref (end)	N/A
File Name	I6-BH01_GDA_11-~~1~~u_r0a CM
Initial Calibration	Done offsite
Final Calibration	

Comments:

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	~~2 of~~ 2 of 5 CM		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 1,2 Field Notes	
Probe	GDA Density
Start Time	12:45 PM
End Time	1:45 PM
Run Direction	up
Offset	See tol file
Stick Up	0.63
Probe Point at Reference (start)	2.99
START (data)	122.03
END (data)	3.32
Probe Point at Reference (end)	3.32
File Name	IG-BH01-GDA_11-20-r0a
Initial Calibration	Done offsite CM
Final Calibration	

Comments: .33 @ Ref Point.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	3 of 5		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 11.3 Field Notes	
Probe	GDA Density
Start Time	2:00PM
End Time	2:50PM
Run Direction	UP
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	2.99
START (data)	200.05
END (data)	CM ~~3.10~~ 99.95
Probe Point at Ref (end)	3.10
File Name	IG-BH01-GDA-11.3QAQC_r0a CM
Initial Calibration	DONE OFSITE
Final Calibration	

Comments: .11 @ Ref Point

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	~~2 of~~ 4 of 5 CM		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches		
	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 11.4 Field Notes	
Probe	Neutron
Start Time	3:35PM
End Time	5:50
Run Direction	Up
Offset	See tol file :33
Stick Up	0.53m
Probe Point at Reference (start)	0.98
START (data)	300.00
END (data)	1.00
Probe Point at Reference (end)	1.00
File Name	IG-BH01_Neutron-11-4u-r0a
Initial Calibration	Done of site
Final Calibration	

Comments:

Probe ran great, no errors

.02 at Ref Point.

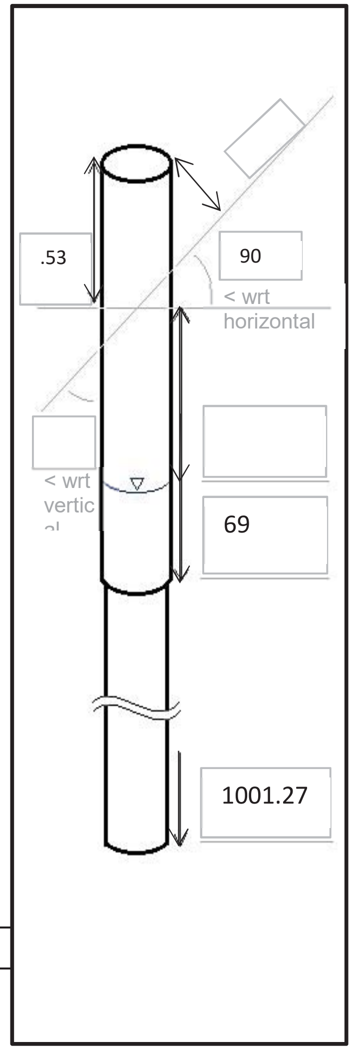
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	5 of 5		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
12.1	FWS50	074301	1.84	0.05	1.5 m/min	400	500
12.2	FWS50	074301	1.84	0.05	1.5 m/min	199	1000

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 12.1 Field Notes

Probe	FWS50 Full Waveform Sonic SN: 074301
Start Time	20:47
End Time	21:51
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	500.00
END (data)	400.00
Probe Point at Reference (end)	
File Name	IG-BH01_FWS50_QAQC_12-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Pre-use check conducted below water, in rock. Response good.
Needed to adjust discriminators mid-run. Turned off automatic, manually set positive, negative and gain.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*24/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 12.2 Field Notes

Probe	FWS50 Full Waveform Sonic SN: 074301
Start Time	22:28
End Time	06:58
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	999.80
END (data)	198.80
Probe Point at Reference (end)	2.63
File Name	IG-BH01_FWS50_12-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

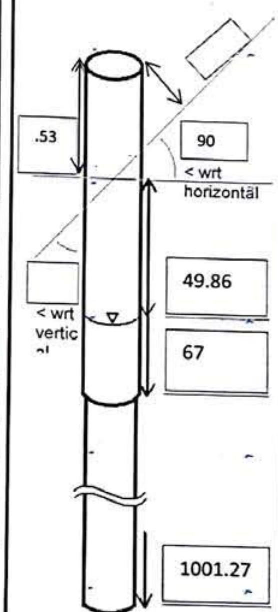
Comments:

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 25, 2018 / Shift #13
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider		
		Distributed By:	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
CM 13.1	Neutron	3312		0.025	2.5	274.85	995.02
13.2	Neutron	3312		0.025	2.5	190.00	375.00
13.3	Resistivity.	6360		0.05	3 CM	~~[illegible]~~	~~[illegible]~~
						68.84	305.31



Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		

Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	1 of 4		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 25, 2018. Shift #13
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 31 Field Notes	
Probe	Neutron
Start Time	9:00 am
End Time	1:55 pm
Run Direction	up 1
Offset	see tol file
Stick Up	0.53 m
Probe Point at Reference (start)	0.98 m
START (data)	995.02 m
END (data)	274.85 m
Probe Point at Reference (end)	1.50 m
File Name	IG-BH01-Neutron-13-~~14~~ 1u CM -r0a
Initial Calibration	REFER TO DGI CERTIFICATES SENT THROUGH EMAIL
Final Calibration	" " " "

Comments:

* MADE IT DOWNHOLE WITH NO ISSUES.
* UP RUN WENT WELL!
* BROUGHT TOOL ALL THE WAY UP TO SURFACE TO RE-ZERO before sending back down for QA QC RUNS.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	2 of 4		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	Date / Shift:	Jan 25, 2018 Shift #3
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	Distributed By:	Email

Run 13.2 Field Notes	
Probe	Neutron
Start Time	2:40 pm
End Time	3:31 pm
Run Direction	UP2
Offset	see tol file
Stick Up	0.53 m
Probe Point at Reference (start)	0.98 m
START (data)	315.00 m
END (data)	190.00 m
Probe Point at Reference (end)	1.01 m
File Name	IG-BH01-Neutron-13-~~xx~~ 2uQAQC rDa CM
Initial Calibration	REFER TO DGI CERTIFICATES SENT THROUGH EMAIL
Final Calibration	

Comments:

QA QC RUN

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	3 of 4		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	Jan 25, 2018 / Shift # 13
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run 13.3 Field Notes	
Probe	Resistivity
Start Time	5:00 pm
End Time	6:25 pm
Run Direction	UP
Offset	See tol File
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	~~300~~ 305.31m
END (data)	68.84m
Probe Point at Reference (end)	10.04
File Name	~~IG-BH01~~ Resistivity – 13-3u – r0a
Initial Calibration	
Final Calibration	

Comments:

* pre + post Run calibration checks were completed. under file name IG-BH01-Resistivity-13-precheck.r1a
IG-BHO-Resistivity-13-post runcheck.r1a

* 1ohm setting in post check was ~~different~~ giving errors 100%. when calibrator removed from CM transmitter, the tool worked 100%. well/Functional.

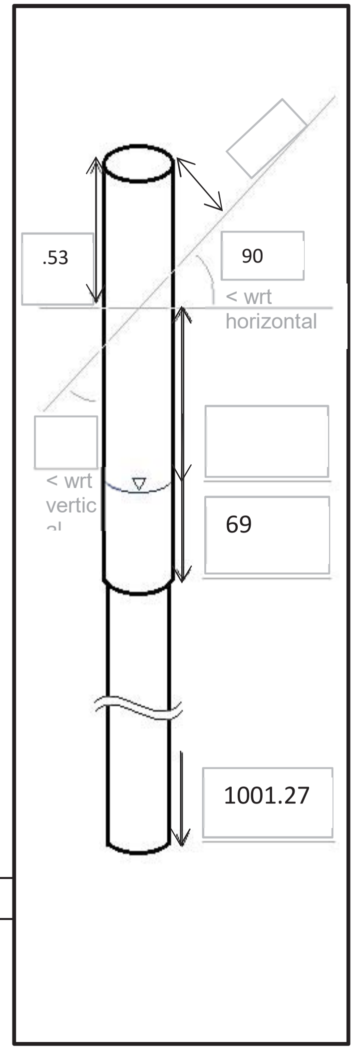
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	4 of 4		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**		
						Top	**Bottom**	
14.1	2PCA	5032	1.41	0.01	2 m/min	900	1001	
14.2	2PCA	5032	1.41	0.01	2 m/min	65	1001	

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 14.1 Field Notes	
Probe	2PCA-1000 Mechanical Caliper SN: 5032
Start Time	23:23
End Time	00:04
Run Direction	Up
Offset	1.41
Stick Up	0.53
Probe Point at Reference (start)	0.88
START (data)	1001.13
END (data)	900.00
Probe Point at Reference (end)	1.07
File Name	IG-BH01_2PCA_QAQC_14-1_r0a
Initial Calibration	10.2 cm, 15.2 cm
Final Calibration	9.85 cm, 14.69 cm

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*25/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 14.2 Field Notes	
Probe	2PCA-1000 Mechanical Caliper SN: 5032
Start Time	00:15
End Time	06:22
Run Direction	Up
Offset	1.41
Stick Up	0.53
Probe Point at Reference (start)	0.88
START (data)	1001.12
END (data)	64.58 (into casing)
Probe Point at Reference (end)	1.07
File Name	IG-BH01_2PCA_14-2_r0a
Initial Calibration	10.2 cm, 14.2 cm
Final Calibration	9.85 cm, 14.69 cm

Comments:

Golder Associates RECORD OF GEOPHYSICAL LOGGING

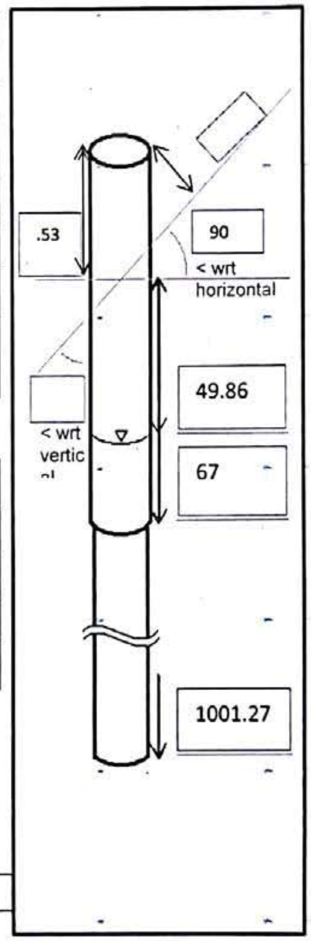
TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Tool Data

Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
15.1u	Resistivity	6360		0.05	3	500	600
15.2u	Resistivity	6360		0.05	3	823	999
15.3d	Resistivity	6360		0.10	10	823	967
15.4u	Resistivity	6360		0.05	3	271	967
15.5u	Restistivity	6360		0.05	3	841	932

Borehole Data

Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchilden	**Verified by:**	
Page:	1 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón Sarah Hirschorn	**Date / Shift:**	
		Work Package:	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches Joe Carvalho George Schneider	**Distributed By:**	Email

Run/5.1 Field Notes	
Probe	Resistivity
Start Time	8:15
End Time	9:15
Run Direction	Up
Offset	See tol file
Stick Up	0.53m
Probe Point at Ref (start)	9.85
START (data)	600.09
END (data)	500.00
Probe Point at Ref (end)	N/A
File Name	I6-BH01_Resistivity_15-1uQAQC-rDa
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- QAQC run went well.
- Pre Calibration Checks were done on 10,000/1,000/100/1 ohms.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	
Page:	2 of 6		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 15.2 Field Notes	
Probe	Resistivity
Start Time	9:55
End Time	11:00
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	9.85
START (data)	999.41
END (data)	823.74
Probe Point at Ref (end)	N/A
File Name	IG-BH01_Resistivity_15-2u_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

-Probe experienced low resistivity values from ~904m to ~860 m, which caused telemetry issues. Little to no data collected in this section.

-File was stopped shortly after so we could attemp to re-survey this section of hole to see if errors continued.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	3 ~~2~~ of 6 CM		

Golder Associates RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	Date / Shift:	
	Sarah Hirschorn	Work Package:	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	Distributed By:	Email

Run 15.3 Field Notes	
Probe	Resistivity
Start Time	11:05
End Time	11:20
Run Direction	Down
Offset	See tol file
Stick Up	0.53
Probe Point at Ref (start)	9.85
START (data)	823.74
END (data)	967.13
Probe Point at Ref (end)	N/A
File Name	IG-BH01_Resistivity_15-3d_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- Down run with 10cm increments at 10m/min.
- File was recorded to help confirm low resistivity and telemetry issue at 870m to 904m.

Client:	NWMO	Job Number:	1671632
Location:	Ignace – BH01	Project:	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	Verified by:	
Page:	4 of 6		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 15.4 Field Notes	
Probe	Resistivity
Start Time	11:20
End Time	3:45
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	967.13
END (data)	271.54
Probe Point at Reference (end)	9.87
File Name	IG-BH01_Resistivity_15-4u_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

- Run repeats low resistivity and error section with the two previous runs.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchillon	**Verified by:**	
Page:	5 of 6 (cm)		

Golder Associates **RECORD OF GEOPHYSICAL LOGGING**

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
CC:	Aaron DesRoches		
	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 15.5 Field Notes	
Probe	Resistivity
Start Time	5:10
End Time	5:40
Run Direction	Up
Offset	See tol file
Stick Up	0.53
Probe Point at Reference (start)	9.85
START (data)	932.40
END (data)	841.48
Probe Point at Reference (end)	10.31
File Name	IG-BH01_Resistivity_15-5u_r0a
Initial Calibration	Yes
Final Calibration	Yes

Comments:

Tuned telemetry and was able to get valid data for almost all of this section.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marhilder	**Verified by:**	
Page:	6 of 6		

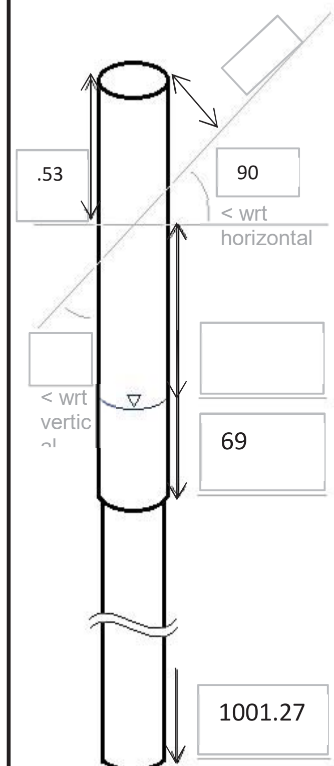
Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data								
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
16.1	2SNA	4116	1.22	0.025	2.25 m/min	400	500
16.2	2SNA	4116	1.22	0.025	2.25 m/min	1	1001

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 16.1 Field Notes

Probe	2SNA-1000 Spectral Gamma SN: 4116
Start Time	20:33
End Time	21:18
Run Direction	Up
Offset	1.22
Stick Up	0.53
Probe Point at Reference (start)	0.69
START (data)	500.00
END (data)	399.89
Probe Point at Reference (end)	0.96
File Name	IG-BH01_2SNA_QAQC_16-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*26/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 16.2 Field Notes

Probe	2SNA-1000 Spectral Gamma SN: 4116
Start Time	22:32
End Time	05:54
Run Direction	Up
Offset	1.22
Stick Up	0.53
Probe Point at Reference (start)	0.69
START (data)	1000.02
END (data)	0.96
Probe Point at Reference (end)	0.96
File Name	IG-BH01_2SNA_16-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

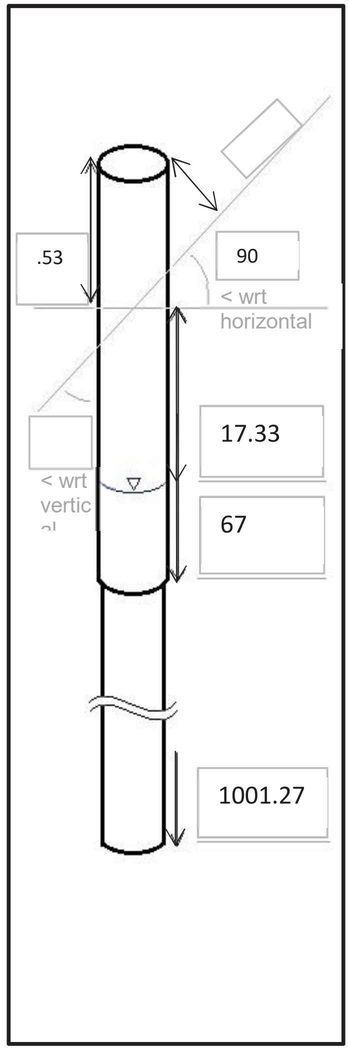
Comments: Got "fetching parameters from tool failed" error after getting poor response on first attempt. Re-start system, no change. Switch Matrix. Re-set some settings to default. Ascend probe 10m, re-boot. Good response. Start at 1000m bgs.

Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
17.1	2CAA-F	5040	1.89	0.05	4.0	1	1001
17.2	2CAA-F	5040	1.89	0.05	4.0	100	200
17.3	2BSF-1000	3800	1.42	0.05	4.5	299	402
17.4	2BSF-1000	3800	1.42	0.05	4.5	958	1001
17.5	2BSF-1000	3800	1.42	0.05	4.5	586	1001
17.6	2BSF-1000	3800	1.42	0.05	4.5	0	595
17.7	2BSF-1000	3800	1.42	0.05	4.5	60	80



Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**17.33 (9:08)**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		

Zones of instability / Zones noted during Survey (m bgs):

533 BGL increase it conductivity

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.1 Field Notes	
Probe	2CAA-F-1000 Fluid Temperature Resitivity SN: 5040
Start Time	8:19
End Time	12:26
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	1.36
START (data)	1.36
END (data)	1001
Probe Point at Reference (end)	1.90
File Name	IG-BH01_FTR_5040_17-1d_r0a.tfd
Initial Calibration	26.4 Ohm.m, 15.7 Ohm.m
Final Calibration	22.84 Ohm.m, 12.46 Ohm.m

Comments:
Saved preuse and post use file using 2 solutions that we used to calibrate. Also recalibrated the FTR prior to use. Let probe acclimatize for 90 seconds.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.2 Field Notes

Probe	Fluid Temperature Resistivity 2CAA-1000
Start Time	13:32
End Time	13:58
Run Direction	Down
Offset	1.89
Stick Up	0.53
Probe Point at Reference (start)	1.36
START (data)	100.00
END (data)	200.05
Probe Point at Reference (end)	1.90
File Name	IG-BH01_FTR_5040_17-1d_QAQC_r0a.tfd
Initial Calibration	26.4 Ohm.m, 15.7 Ohm.m
Final Calibration	22.84 Ohm.m, 12.46 Ohm.m

Comments: **Asked to do a QAQC log from 100 down to 200 m. More than average errors. Likely due to running fast up the hole to top.**

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.3 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	15:44
End Time	16:04
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Reference (start)	0.89
START (data)	402.04
END (data)	299.89
Probe Point at Reference (end)	0.97
File Name	IG-BH01_2BSF_QAQC_17-3_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments: Recalibrated in the hole with lowest negative still gave negative numbers will pull out of hole and walk out side yard with probe. And recalibrate
.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.4 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	17:50
End Time	18:05
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	1001.01
END (data)	958.04
Probe Point at Ref (end)	n/a
File Name	IG-BH01_2BSF_17-4_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Done with calibration outside of fence held in the Air

Point in the hole 566.61 = -42.27 average

Probe 100% bandwidth usage rebooted matrix working now depth not working.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.5 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	18:23
End Time	19:55
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	1001.02
END (data)	586.68
Probe Point at Ref (end)	-0.25
File Name	IG-BH01_2BSF_17-5_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Dropped probe down 40 from previous run. Stopped (maxed bandwidth) at 586.68m. Re-start./

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.6 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	20:00
End Time	22:12
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	595.00
END (data)	-0.26
Probe Point at Ref (end)	-0.25
File Name	IG-BH01_2BSF_17-6_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

Comments:

Overlap by ~10m.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C. Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 17.7 Field Notes

Probe	2BSF-1000 Magnetic Susceptibility SN: 3800
Start Time	22:19
End Time	22:27
Run Direction	Up
Offset	1.42
Stick Up	0.53
Probe Point at Ref (start)	0.89
START (data)	80.00
END (data)	60.00
Probe Point at Ref (end)	0.86
File Name	IG-BH01_2BSF_17-7_r0a.tfd
Initial Calibration	0 CGS, 180 CGS
Final Calibration	-22.7 CGS, 181.57 CGS

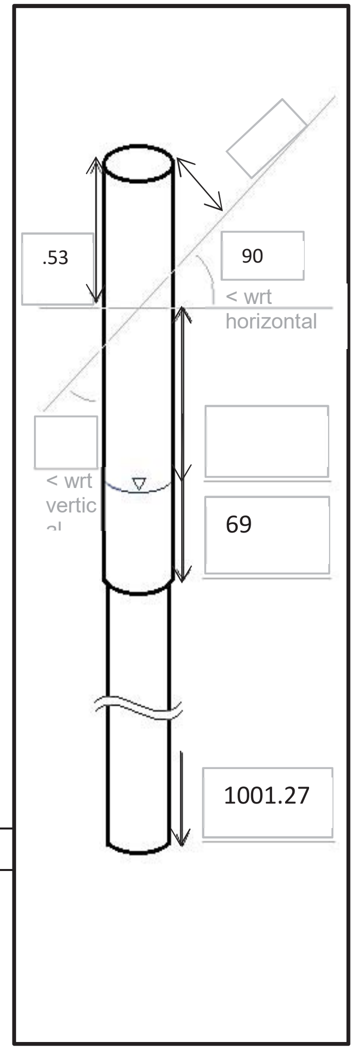
Comments: Level depth at casing re-set to 0.89 before running. This log will be used to tie-in previous logs.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
18.1	OBI40 – 2G	160403	1.62	0.0017	1.8 m/min	10.99	18.27
18.2	OBI40 – 2G	160403	1.62	0.0017	1.3 m/min	68.44	75.00

Borehole Data			
Depth Reference	Ground Surface	Casing Diameter (mm)	100
Stickup (m)	0.53	Inclination	Vertical
Water Level (m bgs)		BH Winch Offset From Borehole (m)	3
Borehole Total Depth (m bgs)	1001.27		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 18.1 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	23:48
End Time	23:59
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	10.99
END (data)	18.27 (under water)
Probe Point at Reference (end)	1.09
File Name	IG-BH01_OBI_18-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Tested with Kodak colour can before use. Run down to show transition from dry to wet.
Got "fetching parameters from tool failed" error when booting, though probe still gave data. Note: there are no settings I have found that will allow running at more than 1.5-1.7 m/min while sampling 1.7mm & 360 pt/turn. Image window shows lots of blanks even when error rate / bandwidth usage is low. "Workload" and "Frame Rate" bars are very high when running above 1m/min.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*27/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 18.2 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	00:10
End Time	00:15
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	75.00
END (data)	68.43 (into casing)
Probe Point at Reference (end)	1.09
File Name	IG-BH01_OBI_18-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Tried running at 180 pt/turn – too coarse to see detail. Ran at 360 pt/turn, 1.7mm. Lots of errors / blanks in image at 1.4 m/min. Image no better than first gen televiewer. Water appears clear.

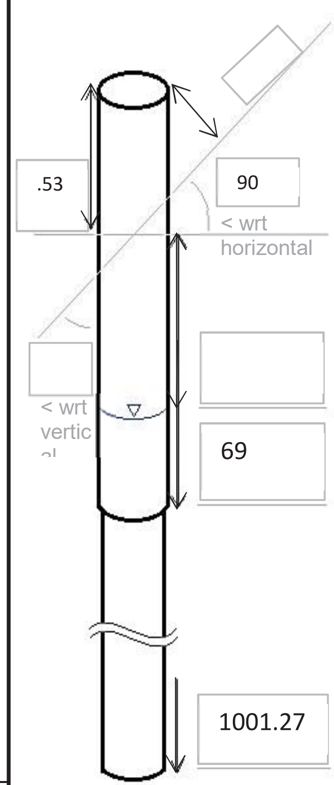
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
19.1	OBI40 – 2G Deviation Run	160403	1.62 (1.51)	.1	10	.98	998.65
19.2	OBI40 – 2G	160403	1.62 (1.51)	0.00125	4	.98	998.65

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 19.1 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	12:25
End Time	14:10
Run Direction	Down
Offset	1.62 (1.51)
Stick Up	0.53
Probe Point at Reference (start)	.98
START (data)	.98
END (data)	998.65
Probe Point at Reference (end)	1.62
File Name	IG-BH01_OBI_Deviation_19-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 19.2 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	14:12
End Time	18:21
Run Direction	Up
Offset	1.62 (1.51)
Stick Up	0.53
Probe Point at Reference (start)	.98
START (data)	998.65
END (data)	1.62
Probe Point at Reference (end)	1.62
File Name	IG-BH01_OBI_Deviation_19-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Running at .00125 sampling with 600 pts per turn

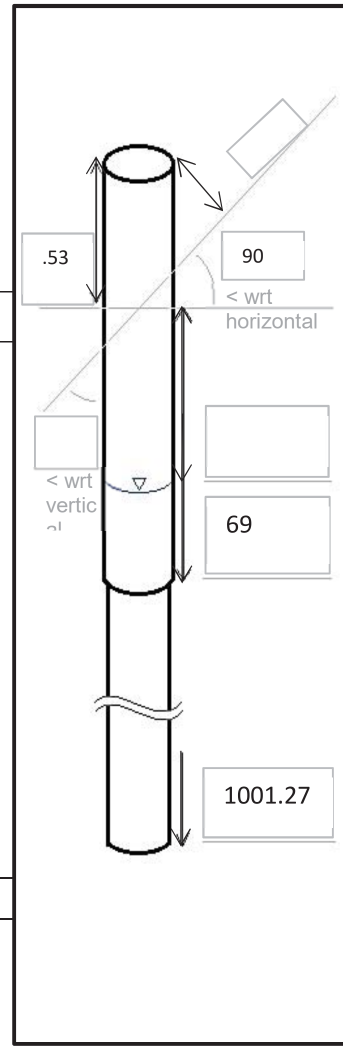
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
20.1	OBI40 – 2G	160403	1.62	0.00125	4 m/min	320	420
20.2	OBI40 – 2G	160403	1.62	0.00125	4 m/min	65	320
20.3	HFP2293	4736	0.85	20	N/A	40	620

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.1 Field Notes	
Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	20:29
End Time	20:55
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	420.00
END (data)	320.00
Probe Point at Reference (end)	1.15
File Name	IG-BH01_OBI_QAQC_20-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.2 Field Notes

Probe	OBI40 – 2G Optical Televiewer SN: 160403
Start Time	20:56
End Time	22:23
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	320.00
END (data)	67.5
Probe Point at Reference (end)	1.15
File Name	IG-BH01_OBI_20-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

Run at 2.5 -2.7 m/min to minimize errors.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*28/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 20.3 Field Notes	
Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	01:35
End Time	06:24
Run Direction	Down
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	40.00
END (data)	620.00
Probe Point at Reference (end)	1.07
File Name	IG-BH01_HPFM_20-3_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Difficulty getting HPFM to stabilize on start-up. Bring to surface – troubleshoot in bucket. Calibration values tested under known pumping conditions in casing prior to use. Had to allow WL to recover after pumping to avoid detecting upward flow in casing.

Brought back to surface to re-pack cable head after 620m – signal would no longer stabilize.

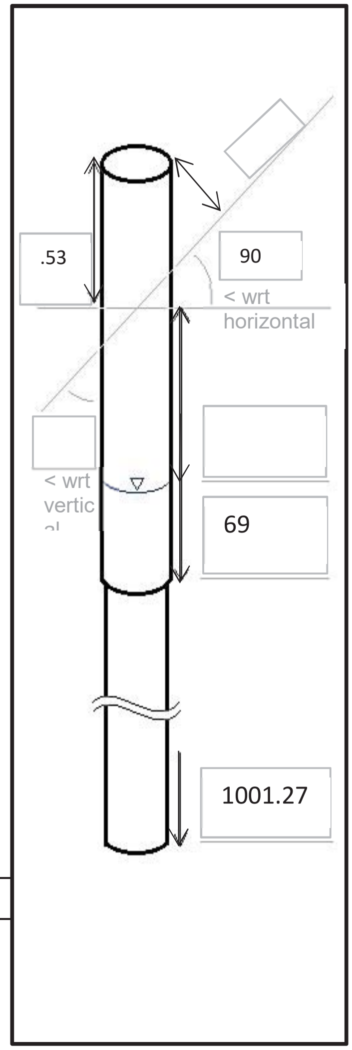
Golder Associates

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
21.1	HFP2293	4736	0.85	20	N/A	620	980
21.2	HFP2293	4736	0.85	10	N/A	920	880

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 21.1 Field Notes

Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	8:56
End Time	14:25
Run Direction	Down
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	620
END (data)	980
Probe Point at Reference (end)	1.45
File Name	IG-BH01_HPFM_21-1_r0a.mh
Initial Calibration	
Final Calibration	Factory Calibrated

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 21.2 Field Notes

Probe	HFP2283 Heat Pulse Flowmeter SN: 4736
Start Time	15:31
End Time	16:30
Run Direction	Up
Offset	0.85
Stick Up	0.53
Probe Point at Reference (start)	0.32
START (data)	920
END (data)	880
Probe Point at Reference (end)	1.45
File Name	IG-BH01_HPFM_21-2_r0a.mh
Initial Calibration	
Final Calibration	Factory Calibrated

Comments: tried to do next file could not it was never stabilizing had to pull up and repack and check probe at 17:00 hrs pulled up from 720

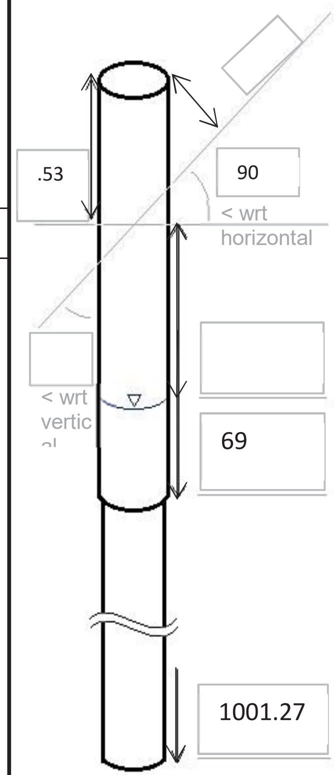
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	Probe Name	Serial Number	Tool Offset (m)	Sampling Interval (m)	Logging Speed (m/min)	Expected Run	
						Top	Bottom
22.1	FWS40	060102	1.84	0.05	1.5 m/min	55	250
22.2	2PGA	3991	0.65	0.025	2.25 m/min	0	100
22.3	2DVA	3957	0.64	0.01	2.5 m/min	0	

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.1 Field Notes	
Probe	FWS40 Full Waveform Sonic SN: 060102
Start Time	22:56
End Time	00:59
Run Direction	Up
Offset	1.84
Stick Up	0.53
Probe Point at Reference (start)	1.31
START (data)	250.01
END (data)	55.00
Probe Point at Reference (end)	1.10
File Name	IG-BH01_FWS40_22-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments: Pre-use test in casing. Probe in working order. Overlap previous FWS log by 50m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.2 Field Notes	
Probe	2PGA Natural Gamma SN: 3991
Start Time	01:43
End Time	02:28
Run Direction	Up
Offset	0.65
Stick Up	0.53
Probe Point at Ref (start)	0.12
START (data)	100.01
END (data)	0.14
Probe Point at Ref (end)	0.16
File Name	IG-BH01_2PGA_22-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*29/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 22.3 Field Notes	
Probe	2DVA-1000 Deviation SN: 3957
Start Time	03:20
End Time	07:25
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Ref (start)	0.11
START (data)	0.11
END (data)	644.93
Probe Point at Ref (end)	
File Name	IG-BH01_2DVA_Down_22-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Tool offset taken to be midway between centralizers.

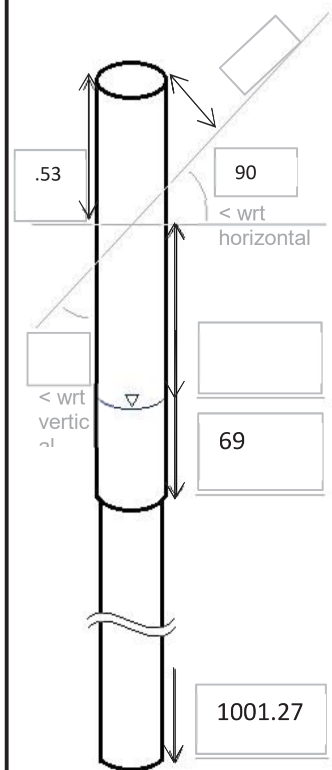
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
23.1	2DVA	3957	.64	.01	2.5	630.00	665.00
23.2	2DVA	3957	.64	.01	2.5	660.01	1001.03
23.3	2DVA	3957	.64	.01	2.5	1001.02	820.02
23.4	2DVA	3957	.64	.01	2.5	860.03	635.04
23.5	2DVA	3957	.64	.01	2.5	650	617.67
23.6	2DVA	3957	.64	.01	2.5	630.02	-.31

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)		**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.1 Field Notes

Probe	2DVA-1000 Deviation SN: 39572
Start Time	9:00
End Time	9:15
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	630.00
END (data)	665.00
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-1_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:
Backed up and started at 630. We did lose power for a moment at shift change. Had some issues with matrix when starting up again. Bandwidth usage was 100 %. Did reboots etc.. was unresponsive on the field laptop

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.2 Field Notes

Probe	2DVA-1000 Deviation SN: 39572
Start Time	9:20
End Time	11:40
Run Direction	Down
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	660.01
END (data)	1001.01
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-2_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: had some issues with matrix and communicating. The depth counter all of a sudden showed 0. Restarted everything and backed up to 660 m.

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.3 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	11:41
End Time	12:55
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	1001.02
END (data)	820.02
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-3_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments: Stopped log dropped down to 860

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.4 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	13:01
End Time	14:33
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	860.03
END (data)	635.04
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-4_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.5 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	14:36
End Time	14:55
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	650
END (data)	617.67
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-5_r0a
Initial Calibration	Calibrated in factory
Final Calibration	
Comments:	

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Day*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 23.6 Field Notes	
Probe	2DVA-1000 Deviation SN: 39572
Start Time	14:55
End Time	18:33
Run Direction	Up
Offset	0.64
Stick Up	0.53
Probe Point at Reference (start)	0.11
START (data)	630.02
END (data)	55.99
Probe Point at Reference (end)	-.31
File Name	IG-BH01_2DVA_Down_23-6_r0a
Initial Calibration	Calibrated in factory
Final Calibration	

Comments:

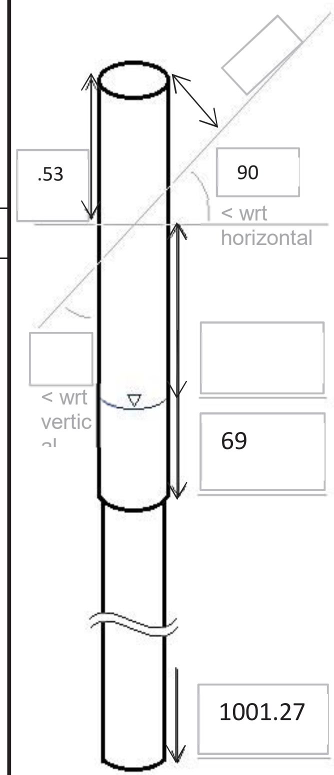
Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Chris Marchildon	**Verified by:**	C.Marchildon
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Tool Data							
Run	**Probe Name**	**Serial Number**	**Tool Offset (m)**	**Sampling Interval (m)**	**Logging Speed (m/min)**	**Expected Run**	
						Top	**Bottom**
24.1	OBI40-2G	160403	1.62	0.05	10 m/min	1	1001
24.2	OBI40-2G	160403	1.62	0.0012	3.5 m/min	1	1001
24.3	BHFS	6359	0.63	545	N/A	545	545

Borehole Data			
Depth Reference	**Ground Surface**	**Casing Diameter (mm)**	**100**
Stickup (m)	**0.53**	**Inclination**	**Vertical**
Water Level (m bgs)	**17.8**	**BH Winch Offset From Borehole (m)**	**3**
Borehole Total Depth (m bgs)	**1001.27**		



Zones of instability / Zones noted during Survey (m bgs):

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.1 Field Notes	
Probe	OBI40-2G Optical Televiewer SN: 160403
Start Time	20:12
End Time	21:53
Run Direction	Down
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	1.09
END (data)	997.84
Probe Point at Reference (end)	1.40
File Name	IG-BH01_OBI_24-1_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.2 Field Notes	
Probe	OBI40-2G Optical Televiewer SN: 160403
Start Time	21:56
End Time	02:32
Run Direction	Up
Offset	1.62
Stick Up	0.53
Probe Point at Reference (start)	1.09
START (data)	999.47
END (data)	1.40
Probe Point at Reference (end)	1.40
File Name	IG-BH01_OBI_24-2_r0a
Initial Calibration	Factory Calibrated
Final Calibration	

Comments:

RECORD OF GEOPHYSICAL LOGGING

TO:	Maria Sánchez-Rico Castejón	**Date / Shift:**	*30/01/2018 / Night*
	Sarah Hirschorn	**Work Package:**	WP5 – Borehole Geophysical Logging
	Aaron DesRoches		
CC:	Joe Carvalho		
	George Schneider	**Distributed By:**	Email

Run 24.3 Field Notes	
Probe	BHFS Fluid Sampler SN: 6359
Start Time	04:00 (5 min pressure test)
End Time	05:32 (Sample)
Run Direction	N/A
Offset	0.63
Stick Up	0.53
Probe Point at Reference (start)	0.10
START (data)	545 (5 min pressure test)
END (data)	545 (sample)
Probe Point at Reference (end)	0.22
File Name	N/A
Initial Calibration	Electronic valve tested on surface, seals tested at depth.
Final Calibration	

Comments: Probe left closed at 545m bgs for 5 min. Return to surface – no seal leakage.

Client:	NWMO	**Job Number:**	1671632
Location:	Ignace – BH01	**Project:**	WP5 Borehole Geophysical Logging
Prepared by:	Adam Ramer	**Verified by:**	A.Ramer
Page:	1 of 6		

APPENDIX C

Geophysical Logs

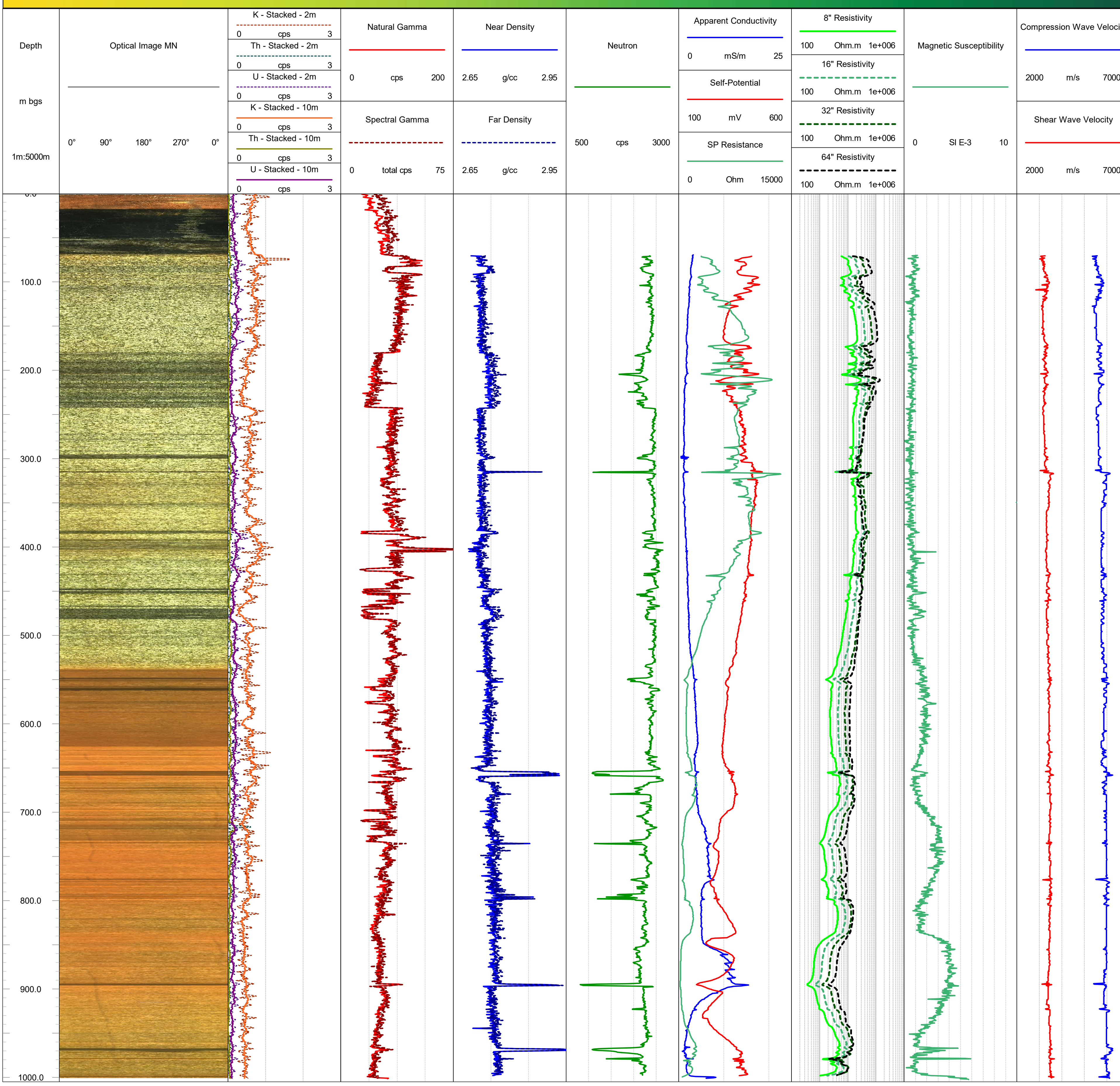
GOLDER

Geophysical Record of Borehole: IG_BH01

Log Title: Lithology Log
Project Number: 1671632-1500
Client: Nuclear Waste Management Organization
Date: January 2019

Datum:	NAD83, UTM Zone 15N	**Depth Reference:**	"0" at Ground	**Casing Depth:**	68.6 m bgs	**Location:**	Ignace, Ontario
Easting:	555,943.35 m	**Drilled Depth:**	1001.18 m bgs	**Water Level:**	Variable	**Log Date:**	Jan 19-30, 2018
Northing:	5,486,016.45 m	**Borehole Diameter:**	97 mm	**Borehole Inclination:**	Vertical		
Elevation:	430.72 m asl	**Casing Diameter:**	102 mm	**Borehole Azimuth:**	N/A	**Logged By:**	AR/CM

Notes:

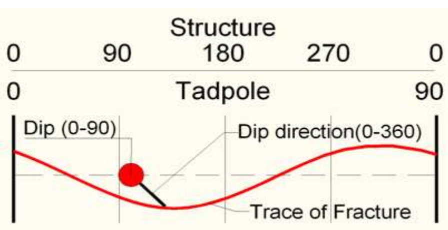


GOLDER

Geophysical Record of Borehole: IG_BH01

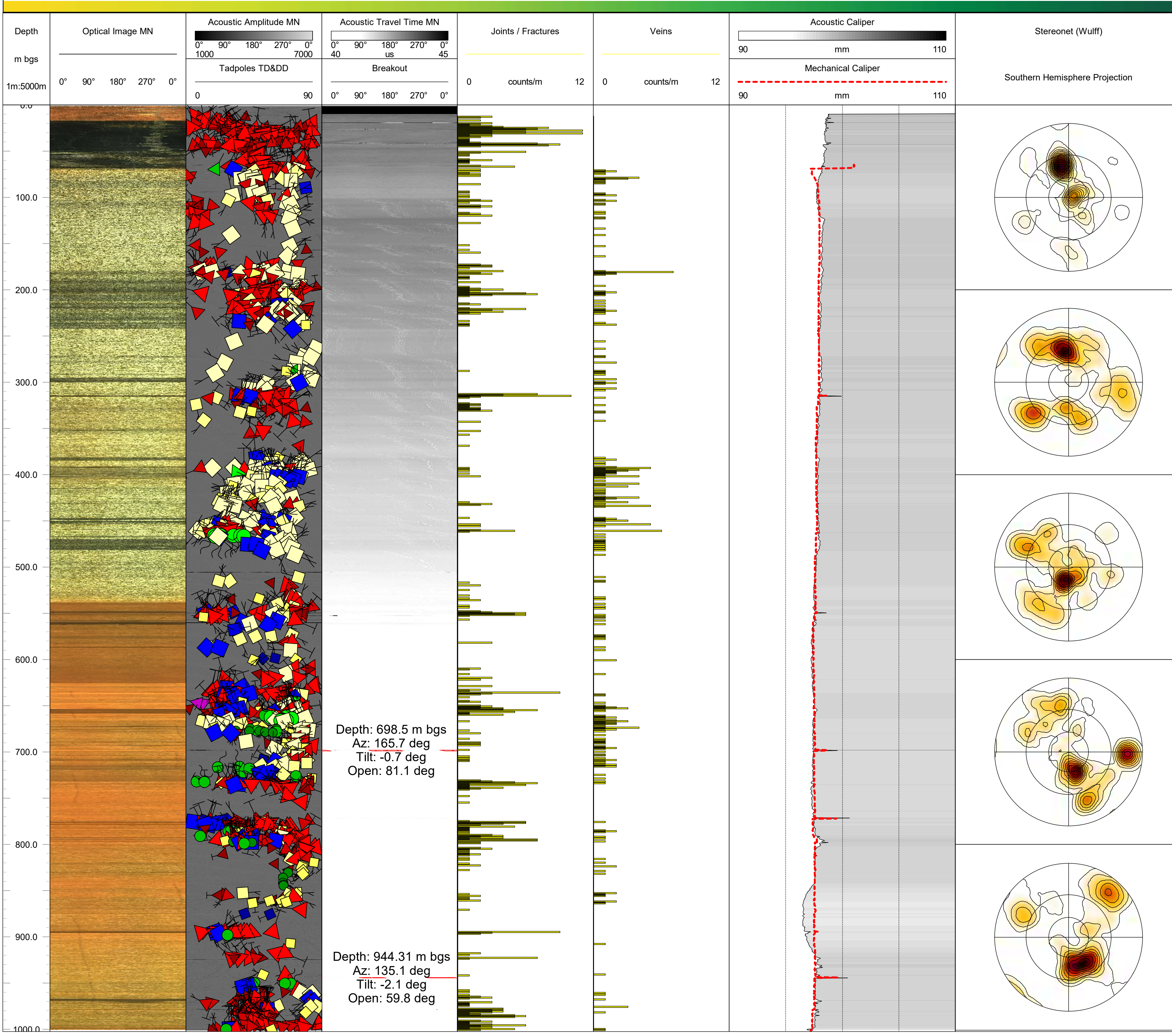
Log Title:	Structural Log
Project Number:	1671632-1500
Client:	Nuclear Waste Management Organization
Date:	September 2018

Datum:	NAD83, UTM Zone 15N	**Depth Reference:**	"0" at Ground	**Casing Depth:**	68.6 m bgs	**Location:**	Ignace, Ontario
Easting:	555,943.35 m	**Drilled Depth:**	1001.18 m bgs	**Water Level:**	Variable	**Log Date:**	Jan 19-30, 2018
Northing:	5,486,016.45 m	**Borehole Diameter:**	97 mm	**Borehole Inclination:**	Vertical		
Elevation:	430.72 m asl	**Casing Diameter:**	102 mm	**Borehole Azimuth:**	N/A	**Logged By:**	AR/CM



- Foliation (High)
- Foliation (Medium)
- Foliation (Low)
- Vein (High)
- Vein (Medium)
- Vein (Low)
- Fracture (High)
- Fracture (Medium)
- Joint - Broken (High)
- Joint - Broken (Medium)
- Joint - Broken (Low)
- Joint - Intact (High)
- Joint - Intact (Medium)
- Joint - Intact (Low)
- Fault - Intact (Medium)
- Intact Fracture Zone - Broken (Medium)
- Contact - Broken (High)
- Contact - Broken (Medium)
- Contact - Intact (High)
- Contact - Intact (Medium)
- Contact - Intact (Low)

Notes: Optical televiewer image combined from two separate runs to fully image borehole. Zone of second image from 538.47 to 625.54 metres.
Acoustic televiewer image combined with log run in top 100m prior to casing installation.

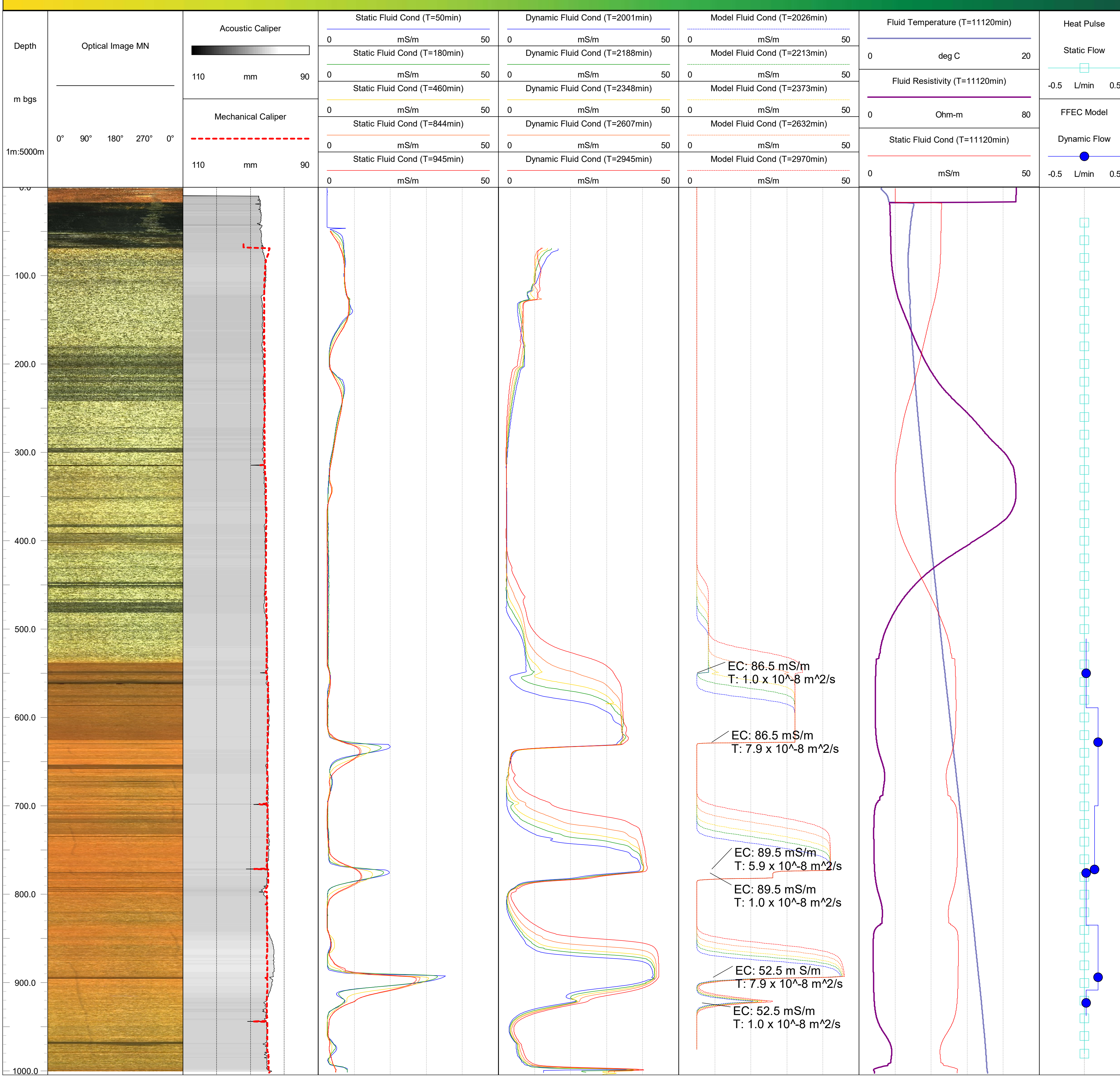


Geophysical Record of Borehole: IG_BH01

Log Title: Hydrogeology Log
Project Number: 1671632-1500
Client: Nuclear Waste Management Organization
Date: September 2018

Datum:	NAD83, UTM Zone 15N	**Depth Reference:**	"0" at Ground	**Casing Depth:**	68.6 m bgs	**Location:**	Ignace, Ontario
Easting:	555,943.35 m	**Drilled Depth:**	1001.18 m bgs	**Water Level:**	Variable	**Log Date:**	Jan 19-30, 2018
Northing:	5,486,016.45 m	**Borehole Diameter:**	97 mm	**Borehole Inclination:**	Vertical		
Elevation:	430.72 m asl	**Casing Diameter:**	102 mm	**Borehole Azimuth:**	N/A	**Logged By:**	AR/CM

Notes: Fluid conductivity measurements lose accuracy below 10 mS/m.
Borehole flushing finished at T=-710min
Final drilling rods were removed at T=-60min
Pumping began at T=1185min
Pumping rate maintained at between 0.9 and 1.1 L/min during dynamic testing.
Final FTR log run 11,120min after first static test, 5 days after end of pumping.

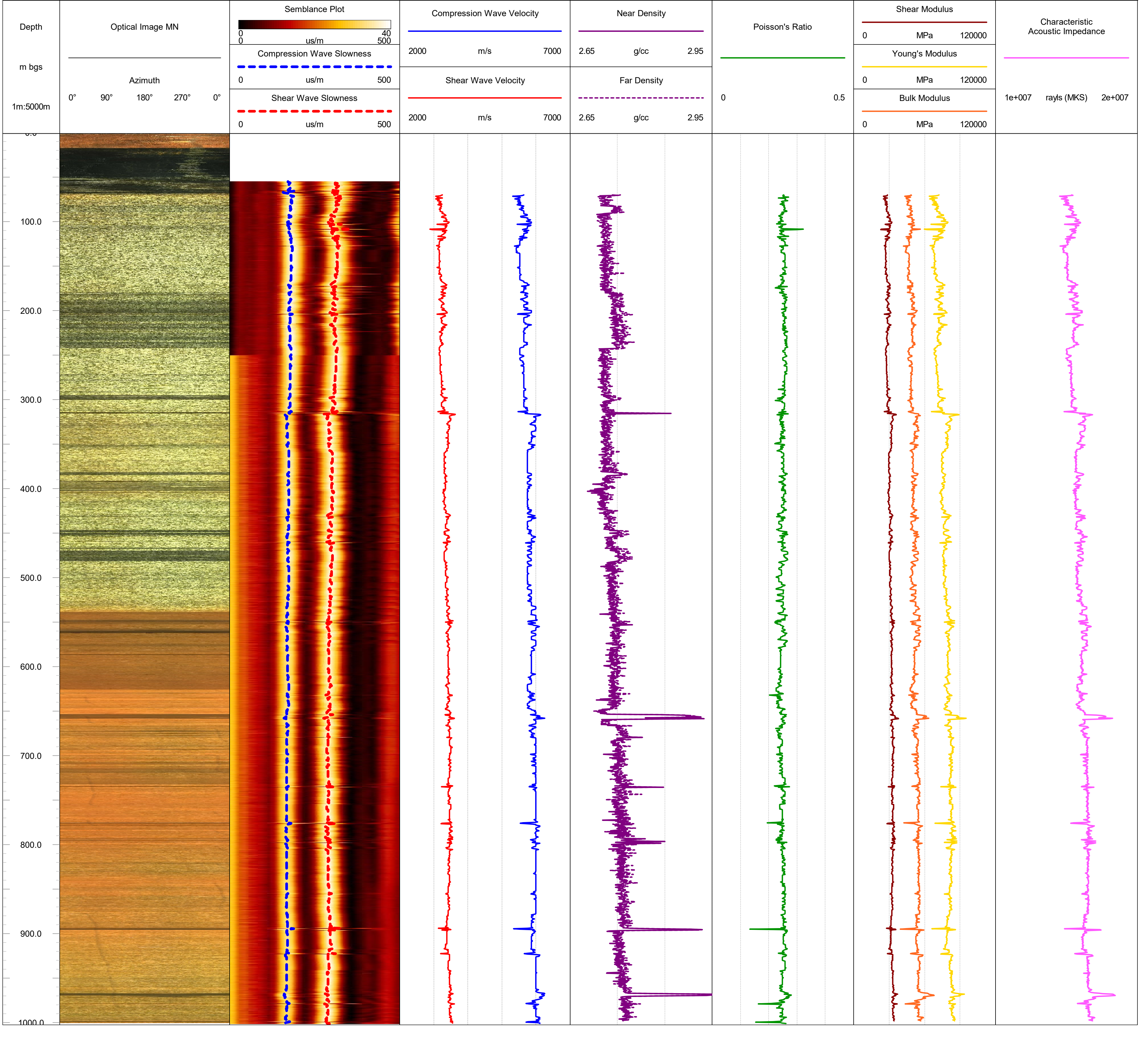


Geophysical Record of Borehole: IG_BH01

Log Title:	Engineering Log
Project Number:	1671632-1500
Client:	Nuclear Waste Management Organization
Date:	September 2018

Datum:	NAD83, UTM Zone 15N	**Depth Reference:**	"0" at Ground	**Casing Depth:**	68.6 m bgs	**Location:**	Ignace, Ontario
Easting:	555,943.35 m	**Drilled Depth:**	1001.18 m bgs	**Water Level:**	Variable	**Log Date:**	Jan 19-30, 2018
Northing:	5,486,016.45 m	**Borehole Diameter:**	97 mm	**Borehole Inclination:**	Vertical		
Elevation:	430.72 m asl	**Casing Diameter:**	102 mm	**Borehole Azimuth:**	N/A	**Logged By:**	AR/CM

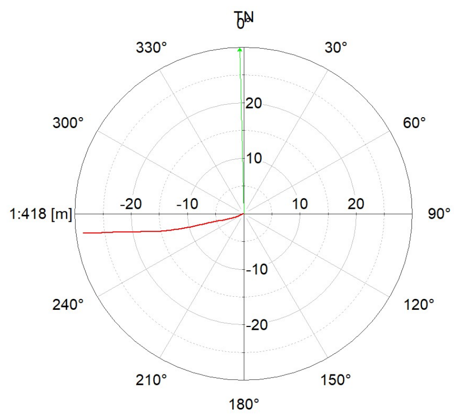
Notes: Depths presented on logs are along the borehole and do not represent true vertical depth.
Televiewer image is oriented to Magnetic North, as denoted by the MN on the log.



Geophysical Record of Borehole: IG_BH01

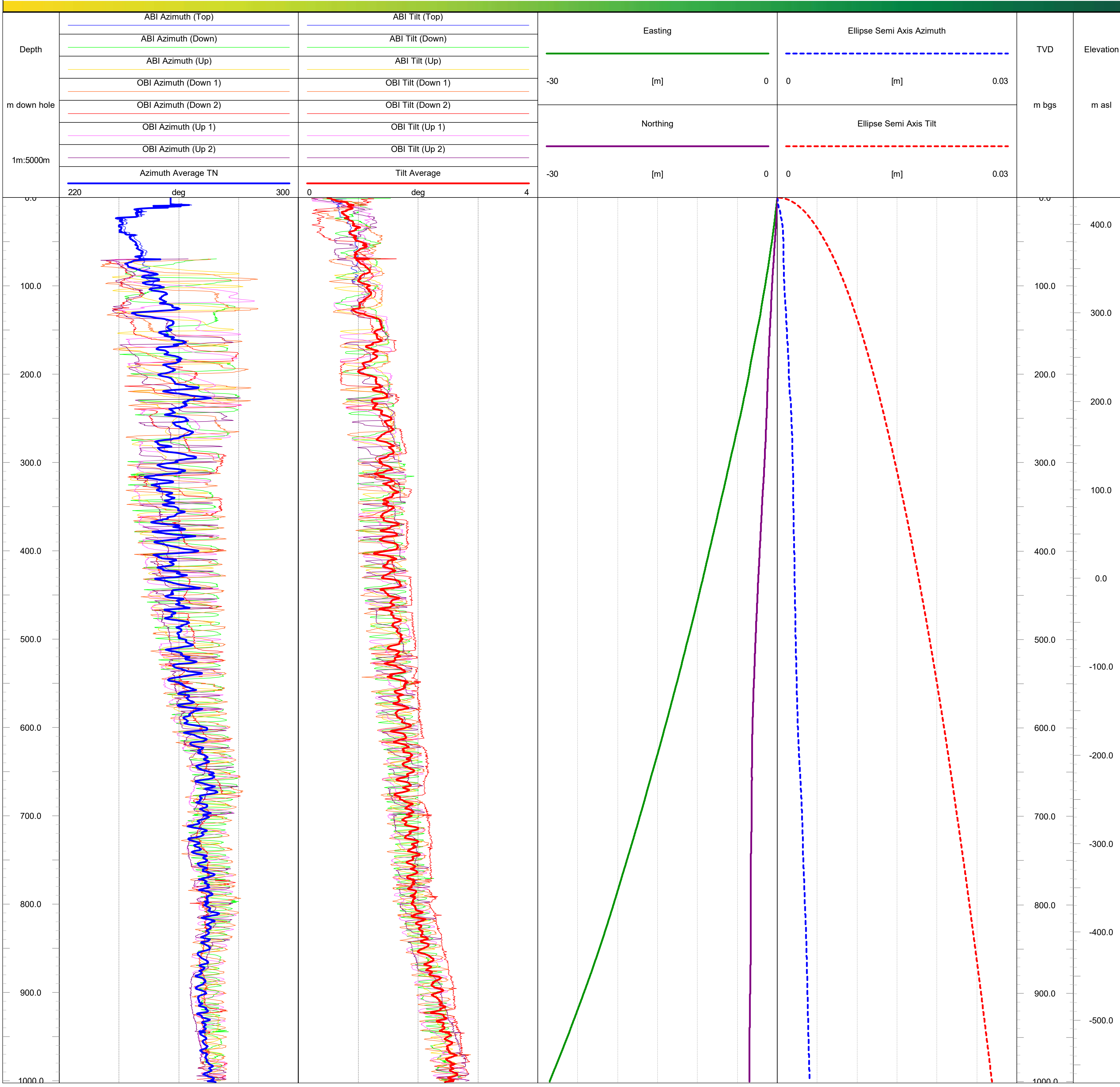
Log Title: Deviation Log
Project Number: 1671632-1500
Client: Nuclear Waste Management Organization
Date: September 2018

Bull's Eye



Datum:	NAD83, UTM Zone 15N	**Location:**	Ignace, Ontario
Easting:	555,943.35 m	**Log Date:**	Jan 19-30, 2018
Northing:	5,486,016.45 m	**Logged By:**	AR/CM
Elevation:	430.72 m asl		
		Depth Reference:	"0" at Bedrock Surface
Mean Inclination:	1.65 deg	**Drilled Depth:**	1001.18 m bgs
Mean Azimuth (TN):	261.43 deg	**Borehole Diameter:**	97 mm
		Casing Diameter:	100 mm
		Casing Depth:	68.6 m bgs
		Static Water Level:	Variable

Notes: Magnetic Declination calculated to be 1.361 degrees West for the site during the period of measurement.
Magnetic North indicated by green arrow on Bull's Eye plot.
Geomagnetic activity was mornitored daily and no anomalies were reported.
Acoustic and Optical Televiewer deviation package accuracy is +/- 1.2 degrees for Azimuth and +/- 0.5 degrees for Tilt.



APPENDIX D

FFEC Modelling Report

Dilution logs from Borehole IG_BH01

Fluid column logs (fluid column resistivity or temperature or some combination of both) have long been used to characterize flow in and around boreholes (Hearst et al., 2000). A combination of fluid column and borehole flow logs is especially useful in characterizing flow into and adjacent to boreholes in fractured rocks because fluid column logs provide precise indications of the depth of inflow, while flow logs provide measurements of the rate of flow along the borehole between inflow depth stations (Long et al., 1996; Leborgne et al., 2006). Dilution logging is a method used to identify the location of inflow into boreholes by running fluid resistivity (or its inverse, fluid electrical conductivity, FEC) column logs that is especially effective in boreholes where inflow rates are expected to be very small under planned test conditions (Tsang et al., 1990; Mastraciccio et al., 2011). In this method, the fluid column is replaced by water of a known FEC that is expected to provide a significant contrast with the FEC of inflowing water under ambient conditions, or during production tests. The depth or depths where inflow occurs is indicated by excursions from the initial baseline FEC of the column that expand and migrate along the borehole under the influence of flow. Dilution logging is effective under low flow conditions where the time required to generate the fluid column profile is short compared to the time for flow to migrate a substantial distance as the fluid column profile evolves over time.

Analysis of fluid column FEC logs obtained during dilution tests consists of identifying the precise depth or depths where inflow is indicated on the profile, and then fitting the profile to a flow model to estimate the rate of inflow at each such depth, along with the FEC of the incoming water. The rate of inflow under measured drawdown can be used to estimate the transmissivity of each such inflow depth (Paillet, 1998). If flow under ambient conditions is also measured before the start of the test, the combination of ambient and pumped inflows can be used to estimate the hydraulic head differences driving the ambient flow (Paillet, 2000; Day Lewis et al., 2011). That method was designed for the analysis of flow profiles obtained using either a heat pulse or electromagnetic flowmeter but can be applied to any situation where steady inflow under a known drawdown is given. Differences in the estimated FEC or measured temperature of inflowing water inferred from fluid column logs among multiple zones contributing inflow can sometimes be used to interpret flow paths in the surrounding formation (Chatelier et al., 2011).

Modeling of the evolution of FEC column profiles during dilution testing is based on a numerical code described by Paillet (2012). This code is a one-dimensional, mass-conservation method with a constant longitudinal dispersion coefficient assumed to be determined by mixing induced by the repeated passage of the logging probe. Model boundary conditions consist of an initial FEC distribution in the column input as a piecewise continuous profile, and steady inflow of water of a specified FEC at a given volumetric rate applied at a specified number of discrete inflow depth points. Inflow rates are given as constant throughout the measurement period as the evolution of the FEC profile in the column is computed for a specified number of given time steps under the influence of a known, quasi-steady drawdown. In this experiment, the mixing volume for dispersion was given as 30 cm of borehole (approximately 0.4 liter) and the time step was one minute. The performance of the code was verified by its use to estimate flow and FEC values at a fractured bedrock study site where flow conditions were well known, and where estimates of flow made with the code could be compared to results given by a heat pulse flowmeter (Paillet and Romanowicz, 2010). The one important limitation in use of this code is the time required to log a borehole to produce a profile that will be compared to a computed profile representing a single point in time (typically taken as the half-way time during the logging period).

Dilution logging procedures were planned for the IG_BH01 borehole under the assumption that inflowing water from deep fractures encountered by the borehole would have significantly greater FEC values than fresh water used to flush the borehole after drilling to provide a recognizable signature. The flushing water was expected to have an FEC value of less than 10 mS/m on the basis of the assumed solute content of typical tap water. Potable fresh water might have a dissolved solids content of less than 100 mg/l, corresponding to an FEC of about 7 mS/m (Fishman and Friedman, 1989). Since this was just an educated guess, the number was rounded off to 5 mS/m. Many borehole probes used to measure fluid column FEC lose accuracy when FEC is very low. The Mt Sopris combination fluid-resistivity-temperature probe used in this study has a stated calibration range of 0-100 ohm-meters, while the estimated 5 mS/m fresh-water baseline would correspond to 200 ohm-meters. That would be just outside of the stated calibration range, but formation water FEC would be well within the calibration range and small inaccuracy related to the baseline of the profiles would have little effect on the ability to model profiles that lie mostly within the given calibration range. As shown below, the analysis of the profile data is based on the depth point where abrupt shifts in profile FEC occur, the rate at which FEC interfaces move up the borehole under pumping, and the FEC plateau achieved by the inflow as a result of the movement of water up borehole. None of these parameters would be affected by slight inaccuracy in the baseline used in the model.

Previous experience with deep bedrock boreholes in and around the Canadian Shield suggested that natural ground water would have a dissolved solids content of at least several hundred mg/l, corresponding to an FEC of 40 mS/m or more. Preliminary estimates of total borehole permeability indicated that flow rates of less than 1.0 l/min could be expected during pumping at about 35 m of drawdown on the basis of water level recovery measured during drilling operations. Runs of the dilution modeling code using such values showed that measurable contrasts on FEC profiles would be generated, and that the time required to log the borehole at typical rates (10 m/min or more than an hour in 1000 m of borehole) would not allow significant evolution of the profile during the logging period. The test was planned to allow for about a day to determine if measurable flow could be detected under ambient conditions, and then at least another day to track the evolution of inflow under a pumping rate of about a liter per minute.

The dilution test in borehole IG_BH01 consisted of 6 down and 5 up profiles obtained over a period of about 19 hours under ambient (static) conditions, and then another 6 down and 6 up profiles under quasi-steady pumping at a rate of less than 1 l/min producing a drawdown of about 35 m over about 30 hours after the start of pumping. Logs were run down at 10 l/min and up at 20 l/min. Because sensors are located at the bottom of the probe and thus pushed into undisturbed column as the probe moves, and because of the lower logging speed, the down runs are considered the more reliable of the two data sets.

The FEC profiles obtained under static conditions after flushing the borehole with fresh water show the presence of pulses of higher FEC water above a steady, low-FEC baseline corresponding to six inflow locations (Table 1). The measured baseline fluctuates from 3.0 to about 6.0 mS/m which was steady enough to be approximated by a 5.0 mS/m baseline used to model the FEC profiles. The pulses appear strongest on the first of the static profiles and mostly seem to dissipate thereafter (Figure 1). The dilution code used here has the ability to model horizontal flow across the well bore, but horizontal flow would have caused the pulses to grow and expand with time in response to that flow. Here they seem to broaden and fade with time, suggesting that formation water was brought into the column by some transient effect related to the removal of the drill string and flushing of the borehole. Any horizontal flow would have been undetectable within the inflow induced by this transient disturbance. The data do show a barely perceptible shift in the pulses downward for all but the lower two flow zones. Ambient downflow driven by hydraulic head differences would be indicated by a shift in the centroid of the pulse of formation water on the FEC log over time. The downward shift appears to move the centroid from 5 to 10 meters down over the 19-hour period of static monitoring. With such a small shift, it is difficult to read the exact distance within the broadening of the pulses caused by longitudinal dispersion. This downward drift of formation water would correspond to a flow rate of at most 1 liter per hour. The downward shift is not evident in the lowermost two zones, indicating that there is weak downward flow from zones above exiting at this depth interval. Using the transmissivity values for individual flow zones determined in the subsequent pumping part of the experiment, this flow would have corresponded to a hydraulic head difference of no more than about 5 m between the inflow zones listed in Table 1.

The FEC profiles obtained at various times after the start of pumping in borehole IG_BH01 are shown in Figure 2 (downhole) and Figure 3 (uphole) which clearly indicate formation water moving up the borehole over time from six entry points. Time labels associated with each profile represent the elapsed time in minutes after the start of pumping for the midpoint of the logging run. Each of the entry depths can be identified as a specific fracture indicated on the televiewer log (see main report, Appendix C). The excursion at the very bottom of the borehole does not change over time and probably represents stagnant formation water not flushed from the borehole during column emplacement with fresh water. Other excursions above 300 m also do not change over time and may represent response of the probe to metal inadvertently left in the borehole during drilling, or, more likely, the presence of conductive minerals in the borehole wall at those depths. These excursions do not move up the borehole under the influence of pumping as they would if representative of the FEC of the water in the column. The movement of the inflowing water uphole can be modeled to yield estimates of the rate of inflow and the FEC of the inflowing water for each of the six inflow depths. Modeling efforts concentrated on fitting the model to the profiles obtained logging down because these were considered to be more definitive than the profiles obtained logging upward. The rate of upflow increases moving up the column as each additional inflow adds to the total flow. The maximum FEC value for the conductivity pulses near the bottom of the borehole (923 and 894 meters) indicates the FEC of the water inflowing there where it completely replaces the flushed water in a stagnant part of the column. The FEC values associated with the other inflows appear to decrease, but this is an artifact of the flow profile. The maximum FEC in the pulses uphole appears to step down with decreasing depth because the inflowing water is mixed with fresh water being pushed up the column from below. The model fit FEC values in Table 1 show that FEC of inflowing water increases for the zones at 776 and 772 meters and is only slightly lower than that value for the zones at 628 and 550 meters. These differences could indicate three separate flow paths for water produced from these three pairs of zones. The bottom entry in Table 1 gives an estimate of total borehole transmissivity and an estimate of the FEC of water that would be produced after all of the flushing water had been washed out of the column – which would have required additional days of pumping to achieve at the observed flow rate.

Paillet (1989) and other studies at the US Geological Survey Mirror Lake fractured rock study site (Long et al., 1996) showed that measurements of flow in such boreholes have a dynamic range problem in that the most productive zones dominate the measurement, allowing for (under the best experimental conditions) a resolution of about two orders of magnitude. The inflow zones here consist of three pairs of zones, one being about one order of magnitude more productive than the other. Under those conditions, the model fit for the less productive zones have an uncertainty of more than 50% because the error bars associated with the more productive zones apply to these weaker zones (see the sensitivity analysis below). The value of 0.02 l/min for the estimated inflow gives a good approximation to the amplitude of the central response peak of the weaker zones as they evolve over time where they are otherwise enveloped by the much larger excursions from the adjacent zone. It is a coincidence that all three weak zones give the same inflow rate, and this is due in part to the sensitivity of the model where differences in input are only meaningful to two decimal places. This value produced a slightly better fit in each case than either 0.01 or 0.03 l/min. The same applies to the estimated FEC of the secondary zones which are the same as the FEC of the zones with which they are paired. Furthermore, the televiewer images of the fractures associated with these inflow zones indicate dipping fractures that are likely to intersect near the borehole, suggesting that each fracture pair intercepts the same groundwater flow path. Otherwise, the model fitting approach had been to assume the same inflow FEC value for all zones and then adjust those values accordingly to obtain a good fit to the data. Thus, the "exact" inflow value of 0.02 l/min for the three weak zones is an artifact of the resolution of the data, whereas the similarity of the inflow values at 894 m and 628 m is simply coincidence. The fact that each of the inflow zones in each of the pairs have the same FEC value stems from the lack of resolution in data for weaker zones, although there is good reason to believe that such closely spaced inflow zones share the same water quality source and would have equal FEC values for that reason.

The one place where the model could not reproduce the shape and amplitude in the downward logging FEC profiles in Figure 2 is between the two lowermost zones. The code specifies inflow locations as discrete depth points rather than distributed inflow intervals because the code was designed for fractured rock applications where inflow would occur at the mouths of individual fractures. The code provides some mixing of inflowing and flushed column waters by accounting for longitudinal dispersion. For the relatively low flows expected in the intended dilution log application, this dispersion would be driven by the repeated passage of the logging probe and would be essentially the same along the full length of the borehole. The dispersion constant used in the modeling for Figure 2 allows a good fit to the shape of the upward interface of inflow responses everywhere except just above the lowermost (923 m) flow zone. The observed filling in of the FEC profile between the two lower zones could possibly be accounted for by a distributed inflow not concentrated at discrete depth stations. However, the televiewer log indicates isolated individual fractures in this depth interval that would have produced recognizable peaks in at least the earliest FEC profiles. No such peaks are observed. All that can be said about this observation is that the longitudinal mixing appears to be different from that of other parts of the profile in the 894-923 m interval. This discrepancy has no effect on the ability of the model to give estimates of inflow and FEC of inflowing water for the six flow zones.

Borehole flow data obtained from fractured bedrock boreholes can be modeled using a borehole flow model (Paillet, 1998) and this technique can be used to estimate the transmissivity of each producing zone identified on flow logs (Paillet, 2000; Day-Lewis et al., 2011). Using this method and the observed drawdown of 35 m during pumping, estimates for the transmissivity of each of the six zones are given in Table 1. Uncertainty in the transmissivity estimates results from uncertainty in the inflow rates derived from the FEC profile modeling. Weak ambient downflow may have been present in the borehole and significant differences between the hydraulic heads associated with individual producing zones can bias transmissivity estimates. These head differences, if present, were much smaller than the drawdown used in the pumping phase of the dilution tests because any drift downward of the FEC pulses under static conditions was barely detectable if present at all and would have a negligible effect on the transmissivity values given in the table.

Sensitivity analysis

The model fit parameters in Table 1 (zone inflow rates and inflowing water FEC) are derived by fitting a numerical transport model to the FEC profiles obtained after flushing borehole BG_01 with fresh water and pumping at a steady rate as formation water refilled the borehole. Uncertainty arises from several different sources. The profiles were obtained over an extended period required to log the borehole, and this differed from the instantaneous profile provided by the model. Measurement scatter in probe response also departs from the smooth profiles given by the model. Additional uncertainty was introduced by the low transmissivity of the inflow zones which made it difficult to maintain a steady drawdown during the extended pumping period as assumed by model boundary conditions. The model assumes quasi-steady pumping and drawdown, whereas there may have been some variation in pumping rate associated with efforts to maintain steady drawdown during the experiment. These concerns raise the question of the sensitivity of the model fit values presented in Table 1 to small departures from the specified initial conditions.

Here the model fit includes three pairs of water-producing zones, each consisting of a more transmissive zone adjacent to a much less transmissive zone. The model fit consists of matching the “plateau” in the FEC deflections that are associated with each zone pair, and the rate at which the “piston” of flow associated with the zone moves up the column over time. The plateau value for the lowermost pair can be directly related to the FEC of the inflowing water because there is no mixing with flow coming from below for that zone. The other two pairs mix with water coming up from below so that the model is needed to relate the value read from the plateaus for these two zone pairs to the FEC of the inflow. The sensitivity of the model interpretation can be investigated by considering how much of a difference is made by small changes to the model input parameters, and then comparing those differences to the amount of uncertainty in reading the rate of piston movement uphole and the plateau value for the upper two pairs. For each pair, the sensitivity of the more productive zone also applies to the less productive zone, significantly increasing the relative uncertainty in the model fit for that zone.

The sensitivity of the model is illustrated using small variations in input values around the model fit values in Table 1 for the 772-m inflow zone (Table 2). Since all three of the more productive zones are about the same, the uncertainty associated with this one zone applies to the others as well. Piston movement is measured by reading the depth of the predicted half-way point for the modeled decline between the plateau and the 5-m/Sm baseline. Small changes ranging from 1% to 10% in the inflow rate produce small changes in the position of the half-way decline of the moving FEC interface, with the interface moving uphole a few meters as the model-input flow increases from -10% to +10%. Increasing flow also increases the value of the FEC plateau slightly. Small changes in the FEC of the inflow zone in the model have no effect at all on the interface position, which is determined entirely by the inflow rate. However, small changes in the FEC of the inflowing water do have an effect on the plateau value, which increases proportionately as the inflow FEC increases.

The flow profiles obtained on the last downward logging profile provide the best estimates of inflows and inflowing FEC because that profile provides for the integration of a possibly varying rate of inflow related to variable drawdown over the time of the experiment. That profile also comes closest to the asymptotic level of the FEC in the borehole column. Inspection of that profile shows that the halfway point in the position of inflow interface can be picked with precision from the smooth shape of the curve. However, with inflow of about 0.1 l/min, about 1.2 liters of volume per meter of borehole, and a logging period of about 60 minutes to cover the entire column, the interface could move several meters during the logging period. Thus, there could be an uncertainty of as much as 5 meters in matching an instantaneous model profile to the data acquired over the extended logging period, along with an uncertainty in picking the asymptotic plateau value of about 3 mS/m. A change in model input of 10% introduces +/- 3 meters of shift in the interface, so that an estimated 5 meters in uncertainty corresponds to an uncertainty in model fit of somewhat less than +/- 10% (corresponding to +/- 3 meters for the model). The observed uncertainty in the plateau values of about 3 mS/m corresponds with about a +/- 5% shift in plateau values in the model. This level of uncertainty is given for the model parameters listed in Table 1. This leaves no doubt that the 37 mS/m difference in the model prediction of inflowing FEC between the two lowermost flow zone pairs (923 and 894 meters versus 776 and 772 meters) is significant and denotes a meaningful difference in water quality between the zones. The 3 mS/m difference between the FEC for the two uppermost pairs is close to the estimated uncertainty in the data. However, it was noted that initial attempts to fit the model to data under the assumption that all four of the uppermost zones had the same inflowing water FEC did not appear satisfactory, and that difference in model fit could also indicate a significant difference in the quality of respective inflowing water, even if right at the level of uncertainty in the data.

Table 1 - Summary of parameters used to model FEC profile data to produce model profiles as illustrated in Figures 2 and 3.

Depth (m)	Inflow (l/min)	FEC (mS/m)	Transmissivity (m^2/sec)
550	0.02 +/- 0.01	86.5 +/-3.0	1.0 $x10^{-8}$ +/-1.0 $x10^{-8}$
628	0.15 +/- 0.01	86.5 +/-3.0	7.9 $x10^{-8}$ +/-1.0 $x10^{-8}$
772	0.11 +/- 0.01	89.5 +/-3.0	5.9 $x10^{-8}$ +/-1.0 $x10^{-8}$
776	0.02 +/- 0.01	89.5 +/-3.0	1.0 $x10^{-8}$ +/-1.0 $x10^{-8}$
894	0.15 +/- 0.01	52.5 +/-3.0	7.9 $x10^{-8}$ +/-1.0 $x10^{-8}$
923	0.02 +/- 0.01	52.5 +/-3.0	1.0 $x10^{-8}$ +/-1.0 $x10^{-8}$
Total inflow	0.47 +/- 0.01	75.1 +/-3.0	2.5 $x10^{-7}$ +/-1.0 $x10^{-8}$

Table 2a - Sensitivity of the model FEC profile fit to changes in prescribed inflow as input for the 772-meter flow zone; FEC of inflowing water is held constant at 89.5 mS/m. The half-decline depth decreases slightly (moves uphole) and the plateau FEC increases slightly as the model input inflow increases.

Percent change %	Inflow l/min	Half decline depth meters	Plateau FEC mS/m
-10	0.102	705.7	40.1
-5	0.107	704.5	41.1
-2	0.111	703.4	41.6
-1	0.112	703.3	41.8
Model	0.113	703.2	42.0
+1	0.115	702.8	42.2
+2	0.116	702.4	42.3
+5	0.120	701.2	42.9
+10	0.125	700.6	43.7

Table 2b - Sensitivity of the model FEC profile fit to changes in prescribed inflow zone FEC as input for the 772-meter flow zone; inflow rate is held constant at 0.113 l/min. The half-decline depth is not affected by the FEC of the inflowing water, and an increase of the inflowing-water FEC increases the plateau FEC accordingly.

Percent change %	Inflow zone FEC mS/m	Half decline depth meters	Plateau FEC mS/m
-10	80.6	703.2	38.1
-5	85.0	703.2	40.1
-2	87.7	703.2	41.2
-1	88.6	703.2	41.6
Model	89.5	703.2	42.0
+1	90.4	703.2	42.4
+2	91.3	703.2	42.8
+5	94.0	703.2	44.0
+10	98.5	703.2	45.9

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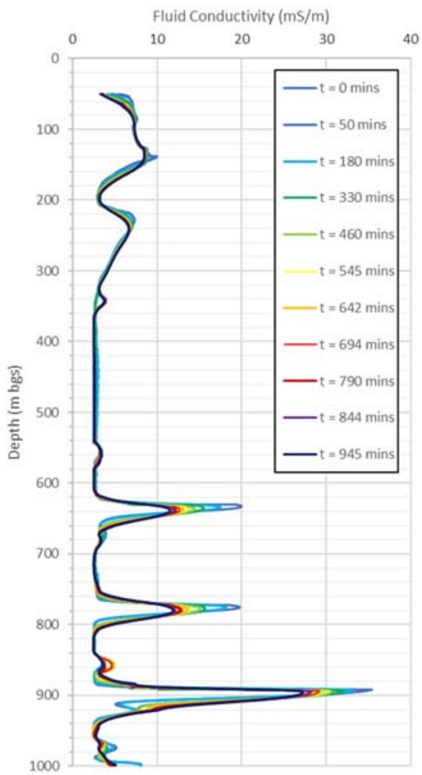


Figure 1 - FEC profiles obtained in borehole IG_BH01 under static conditions at various times after flushing of the column with fresh water (times given in minutes after beginning of the first test).

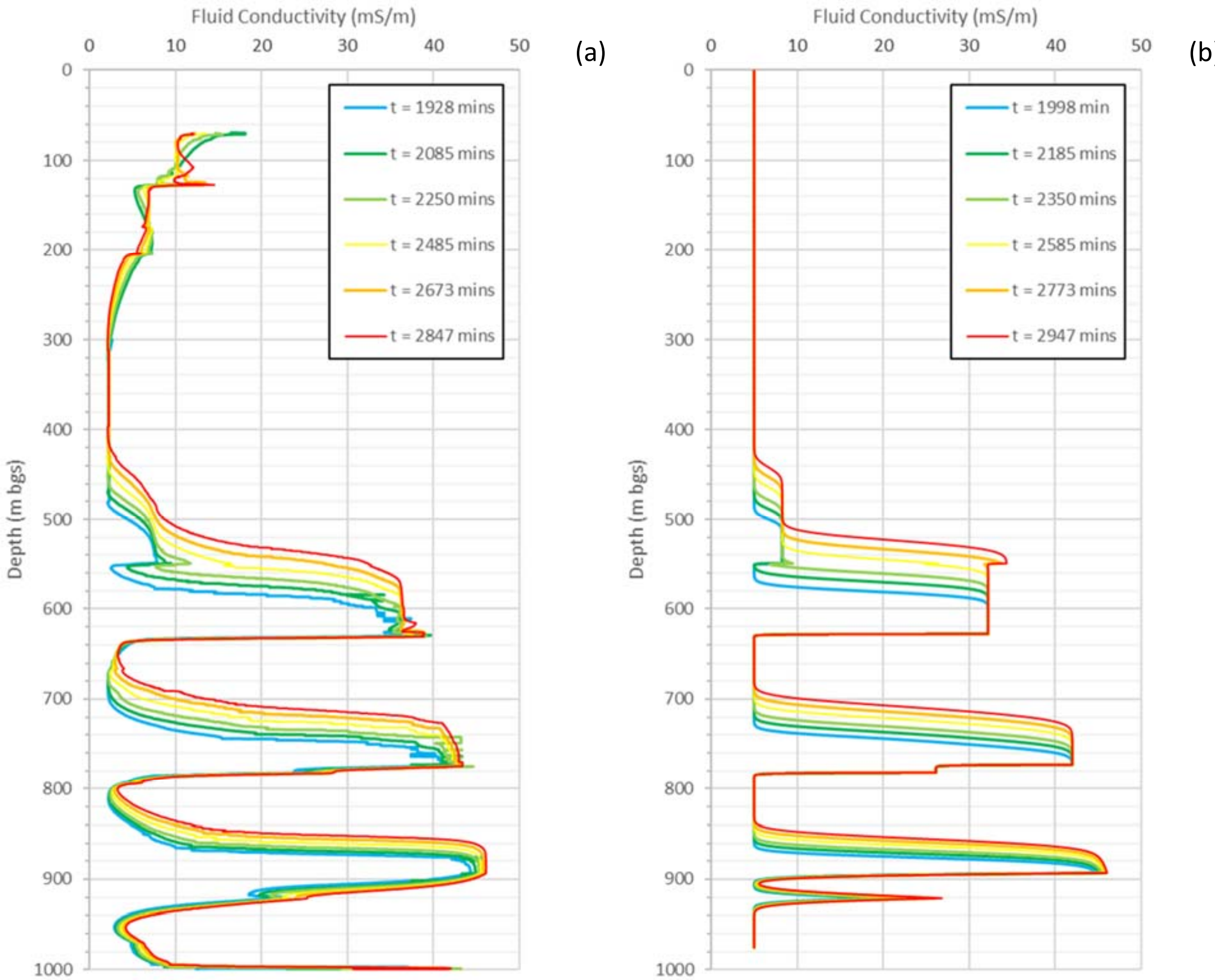


Figure 2 - FEC profiles obtained by running the probe downward in borehole IG_BH01, with times corresponding to the beginning of the log in minutes after the start of logging (a) compared to mass-balance model runs using the parameters listed in table 1 for times corresponding to the half-way point of runs taking approximately 100 minutes (b).

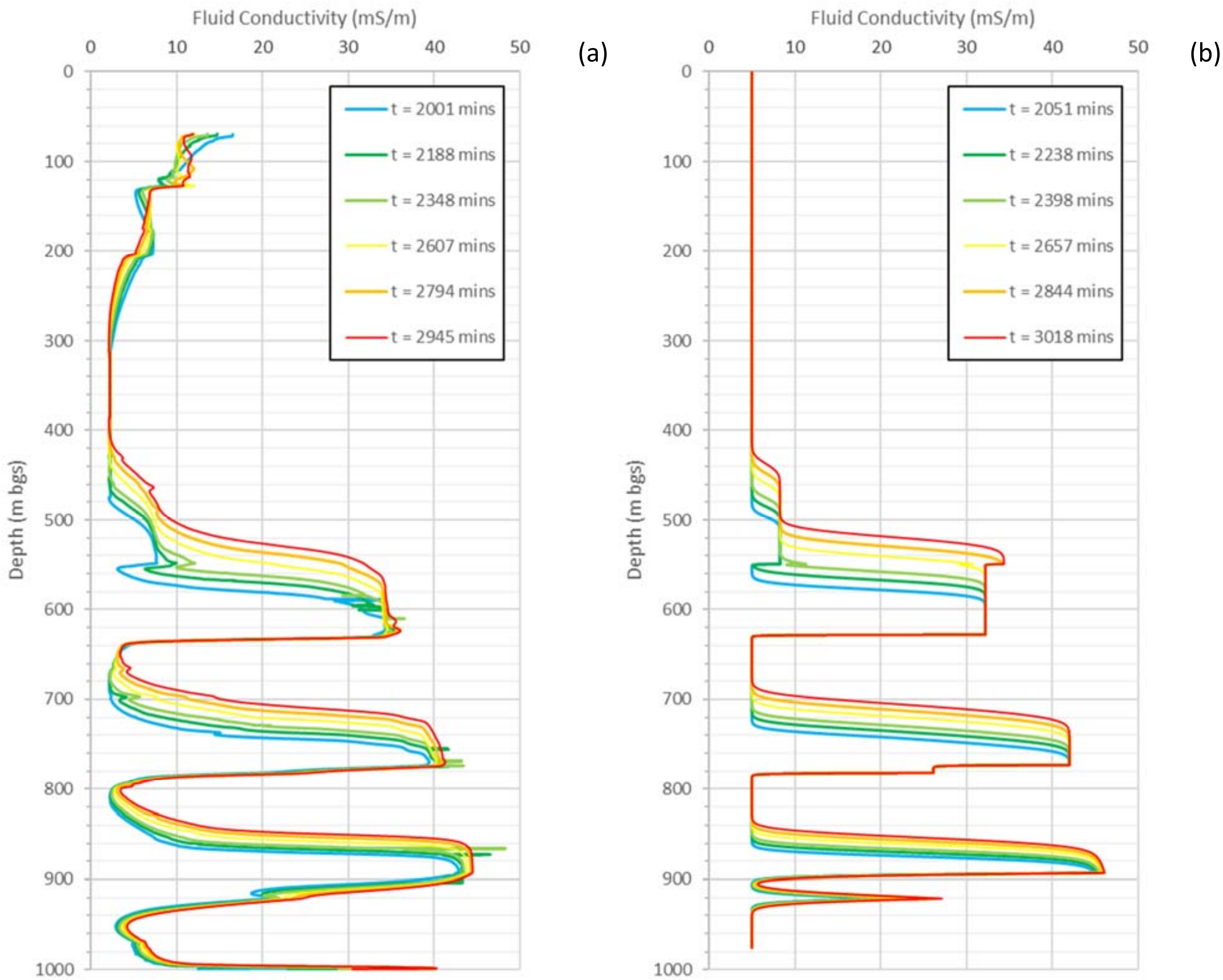
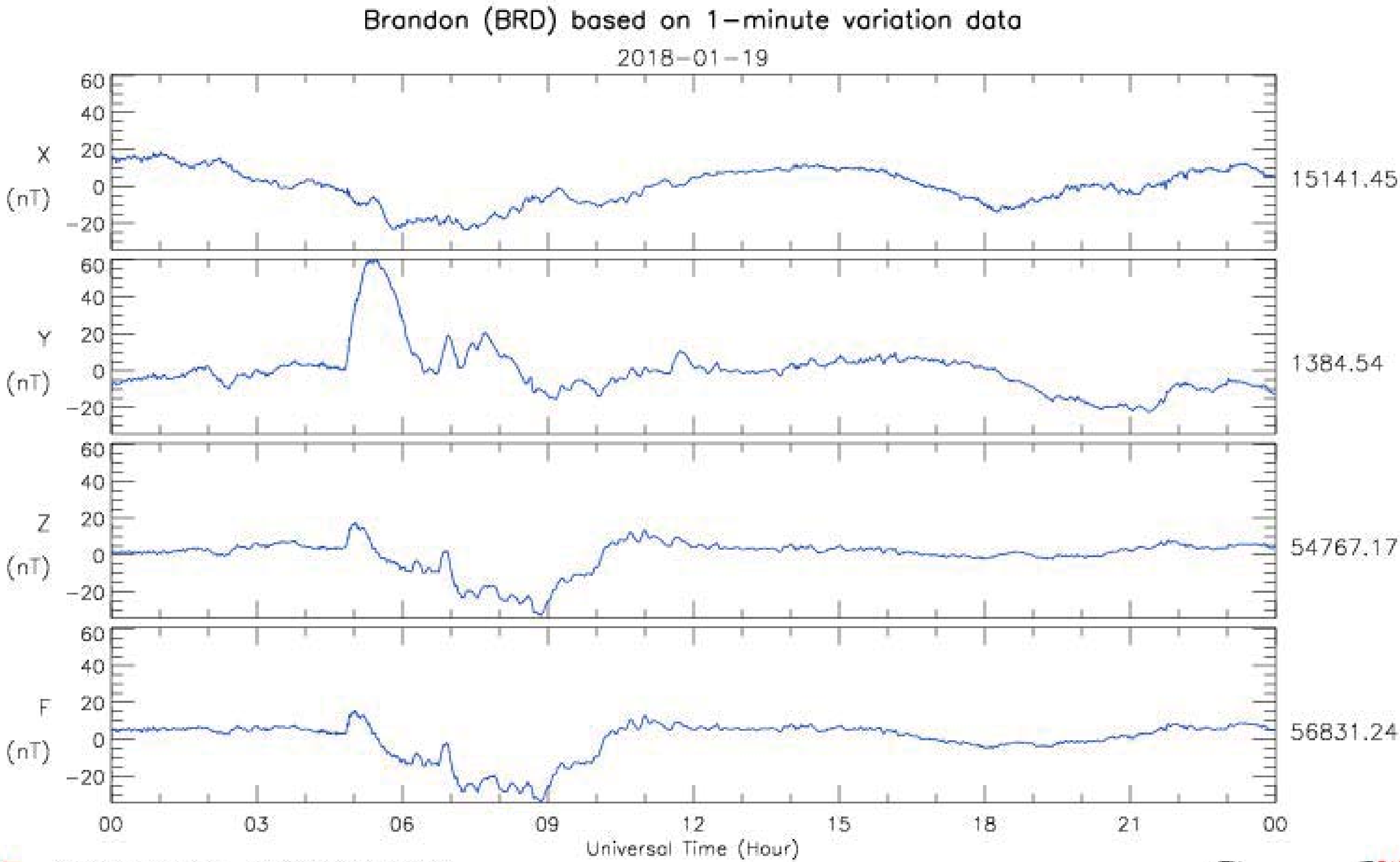


Figure 3 - FEC profiles obtained by running the probe upward in borehole IG_BH01, with times corresponding to the beginning of the log in minutes after the start of logging (a) compared to mass-balance model runs using the parameters listed in table 1 for times corresponding to the half-way point of runs taking approximately 200 minutes (b).

APPENDIX E

NRCAN Geomagnetic Field Strength Report



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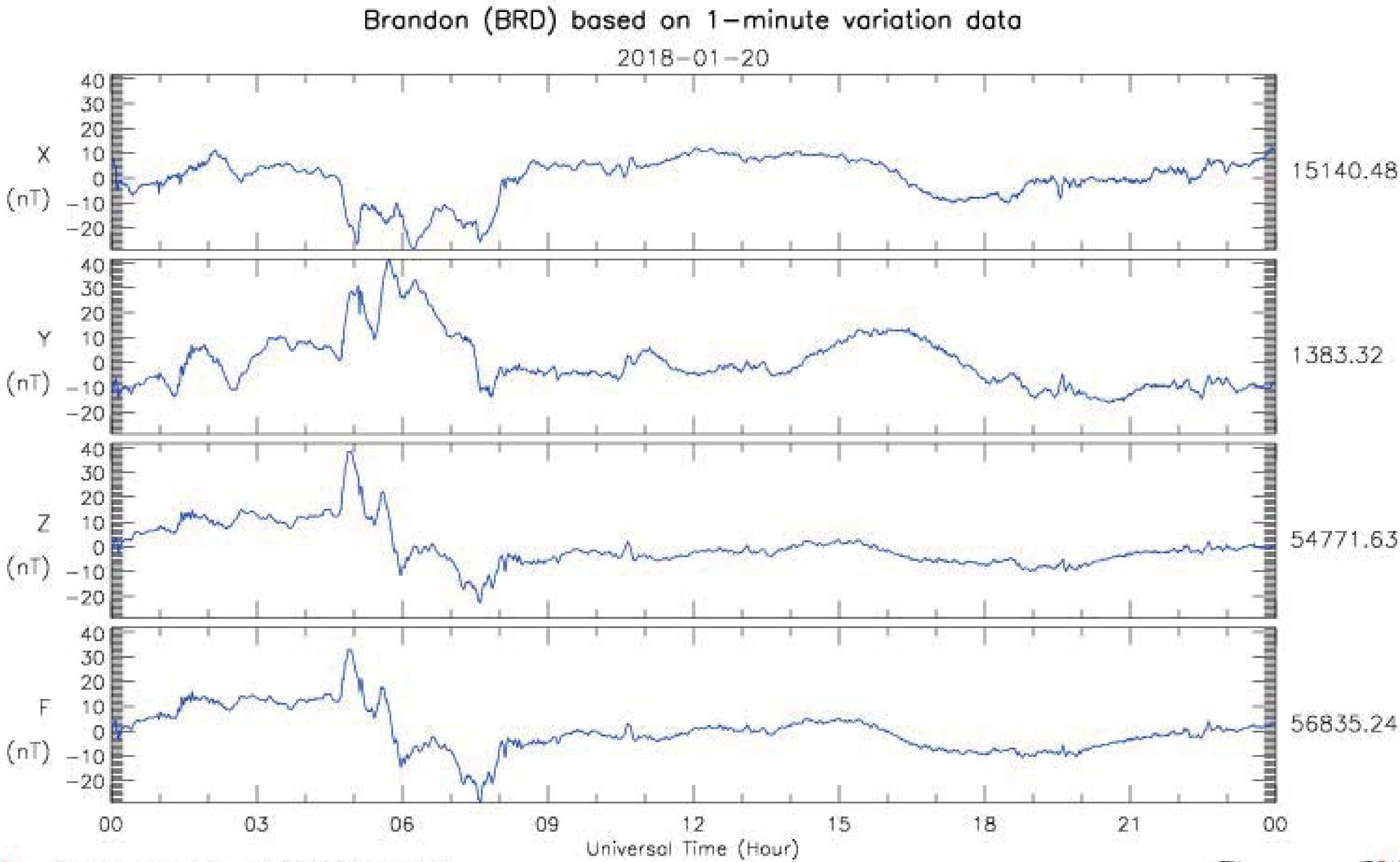

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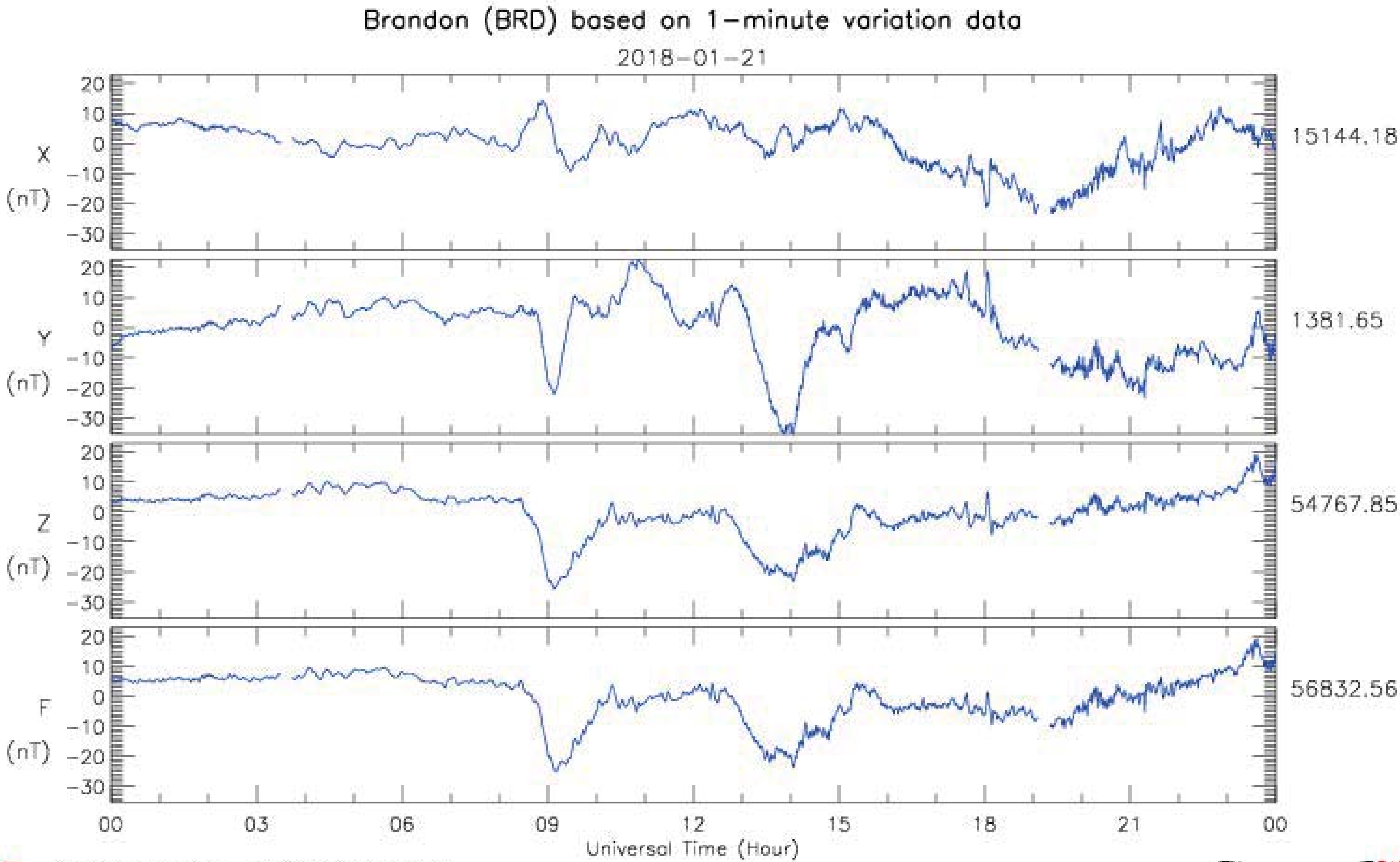

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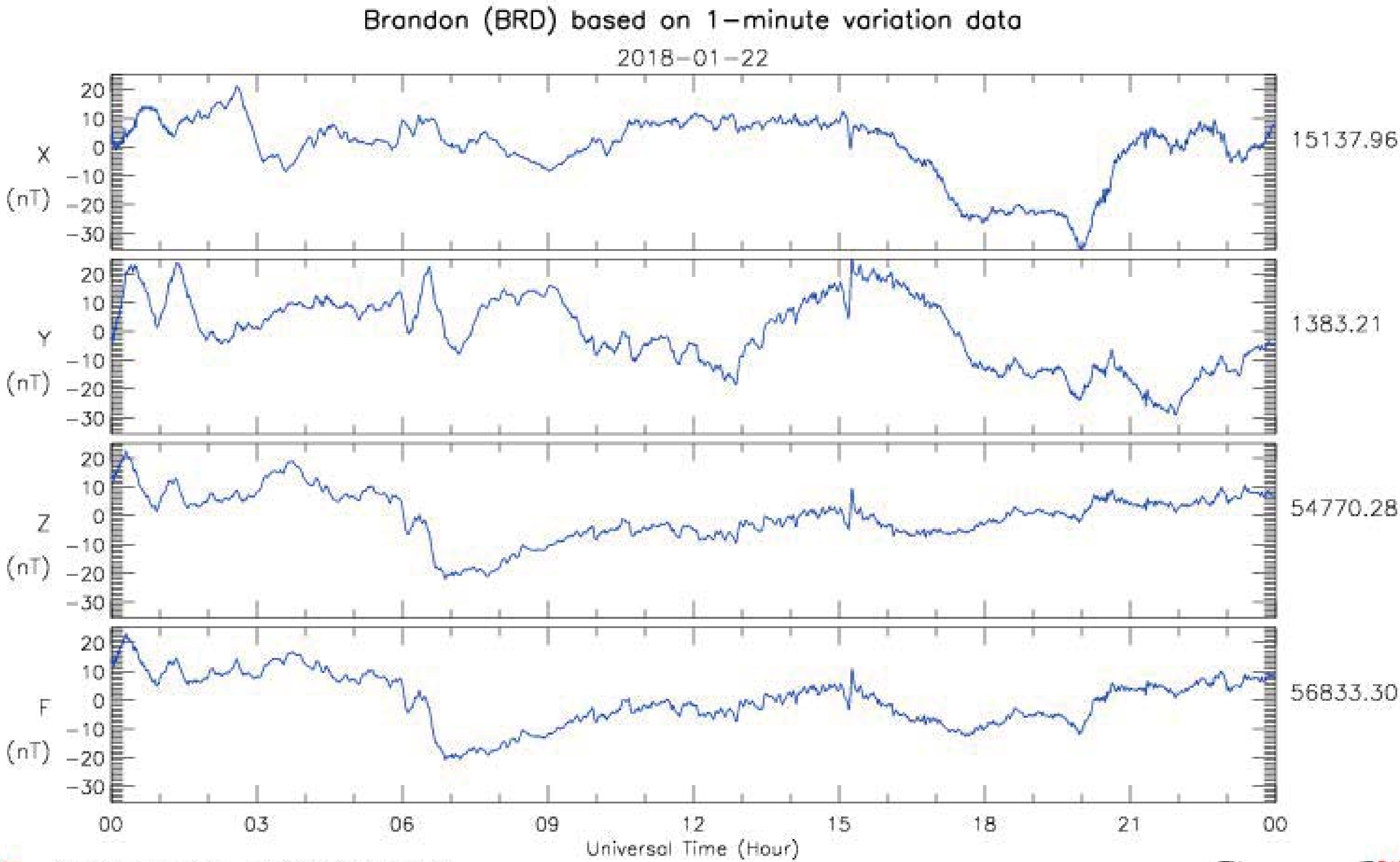

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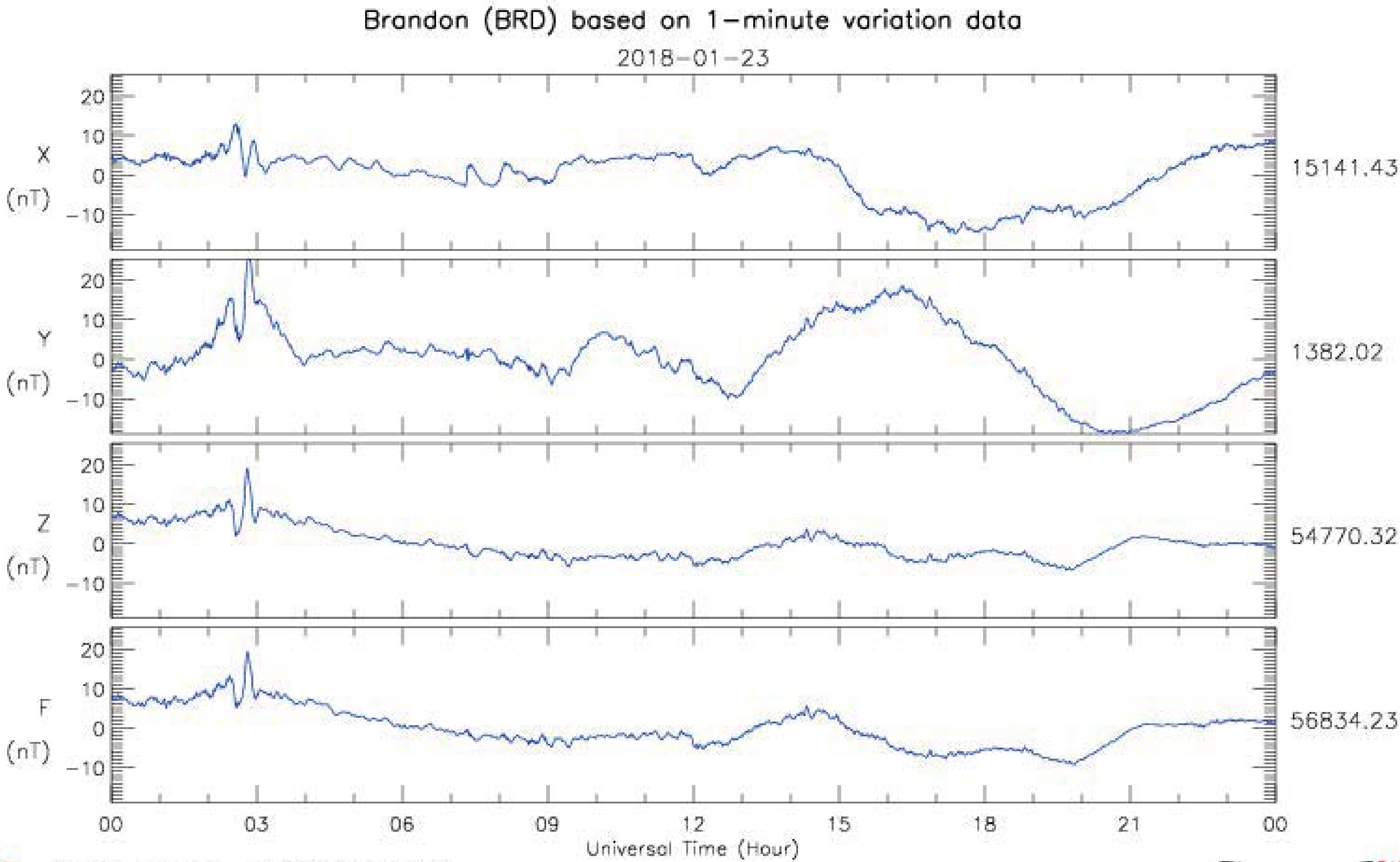

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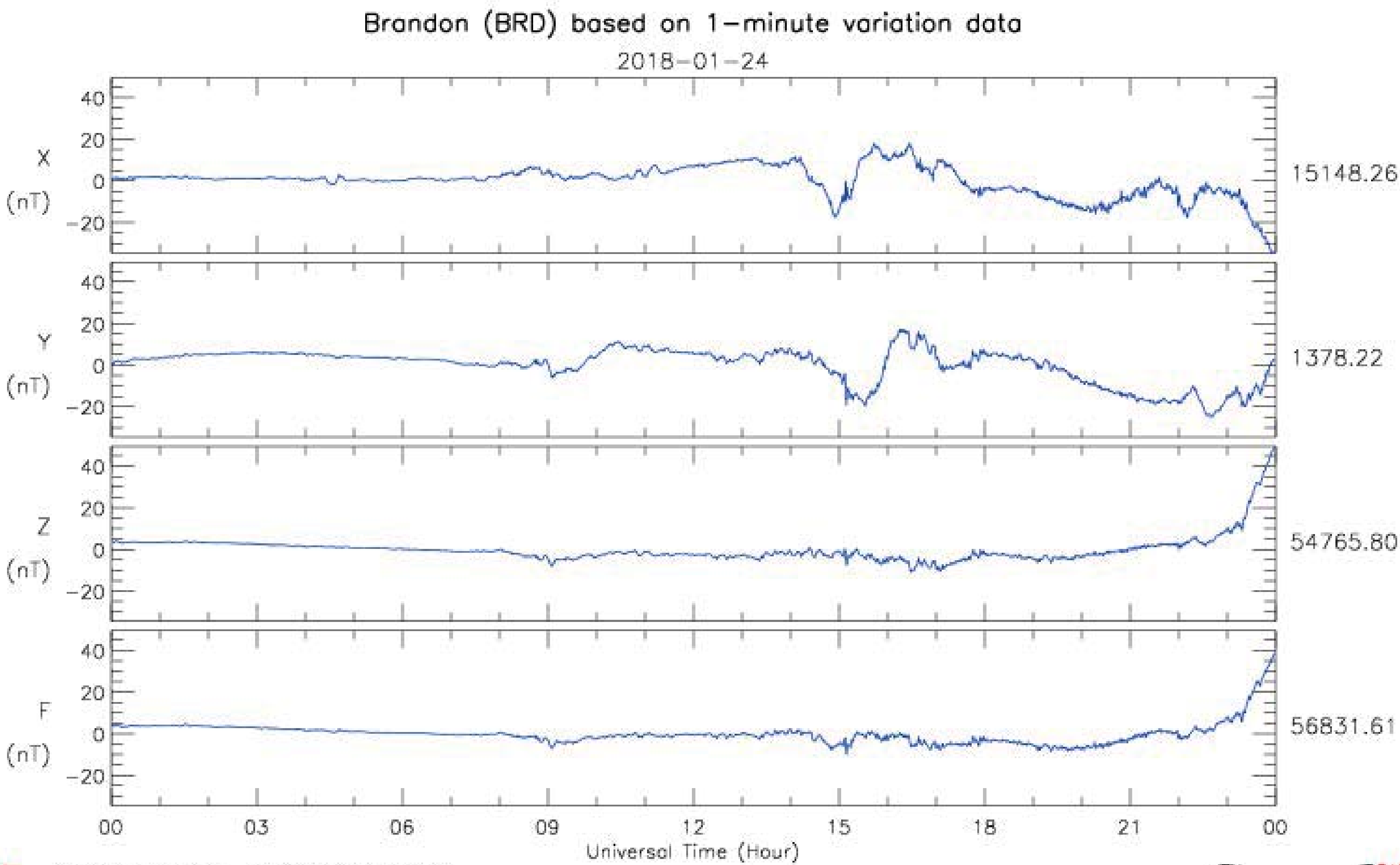

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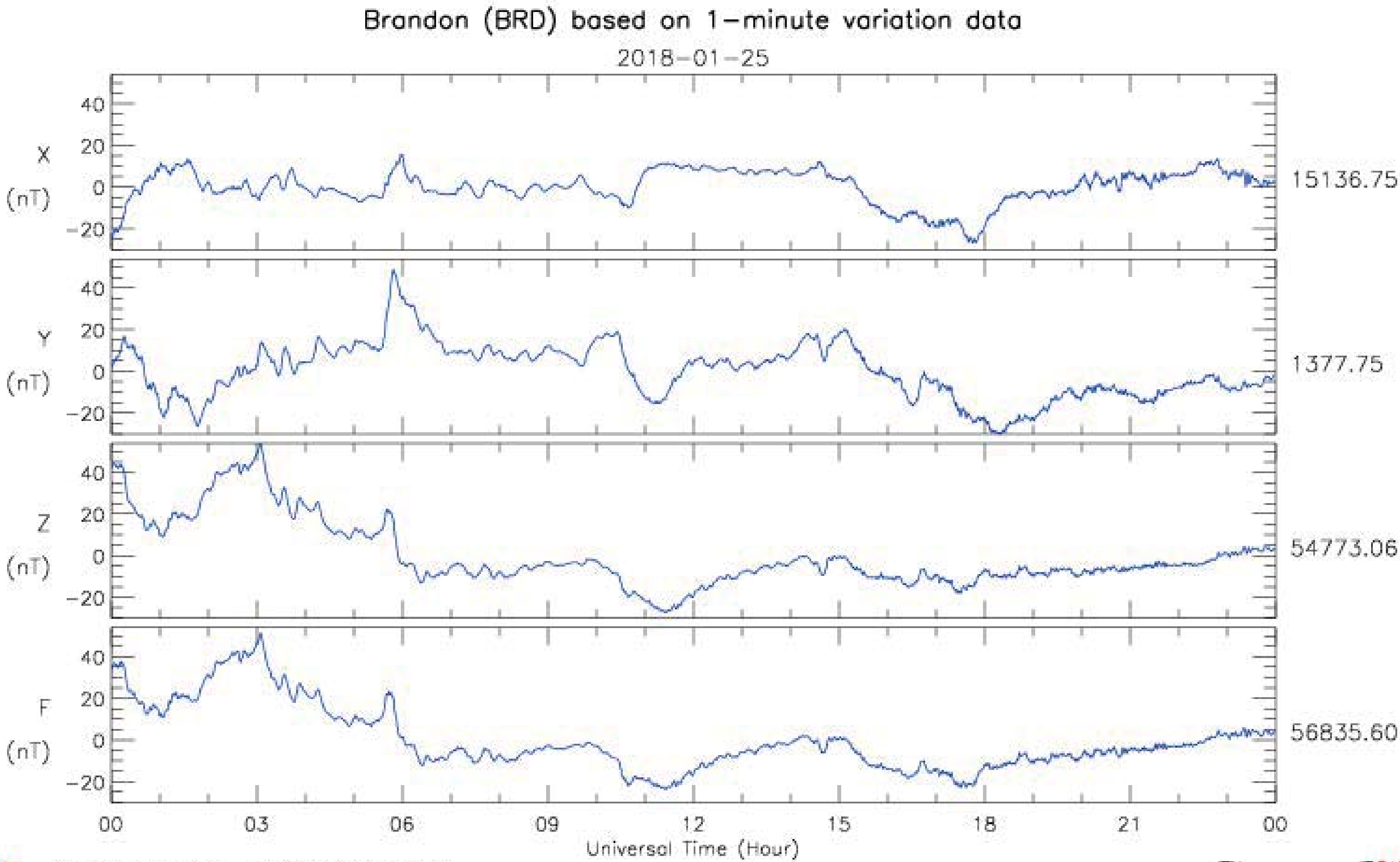

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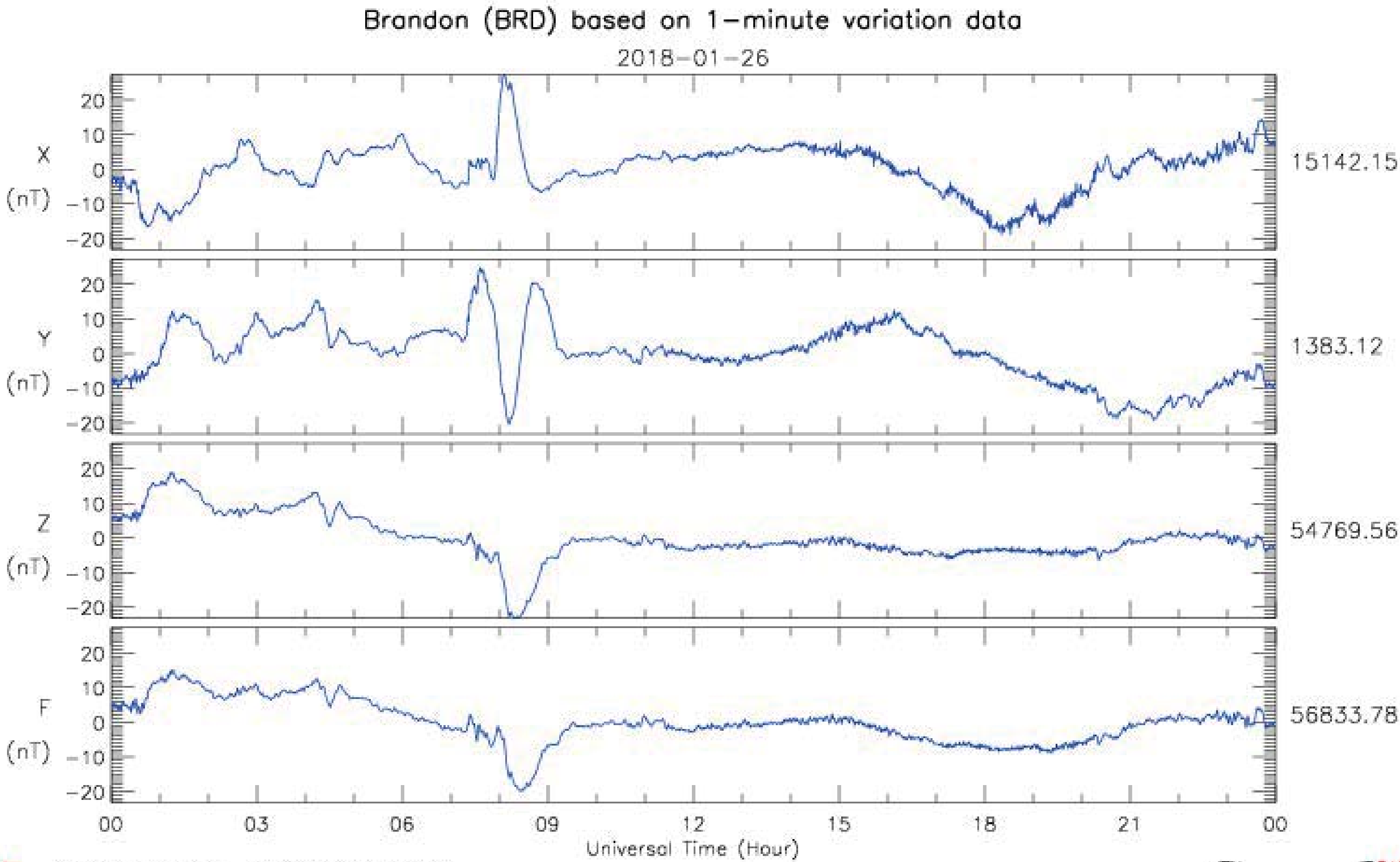

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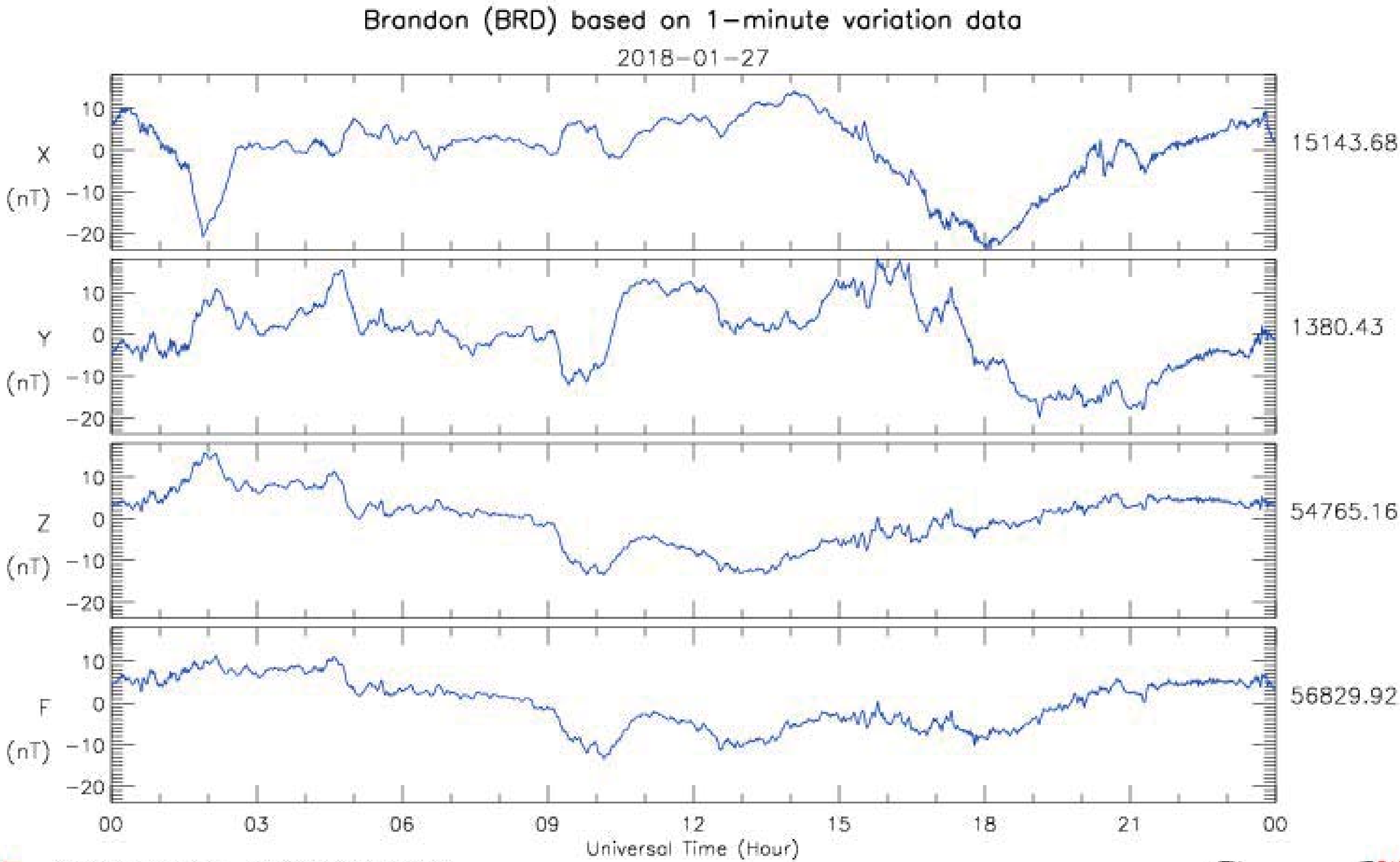

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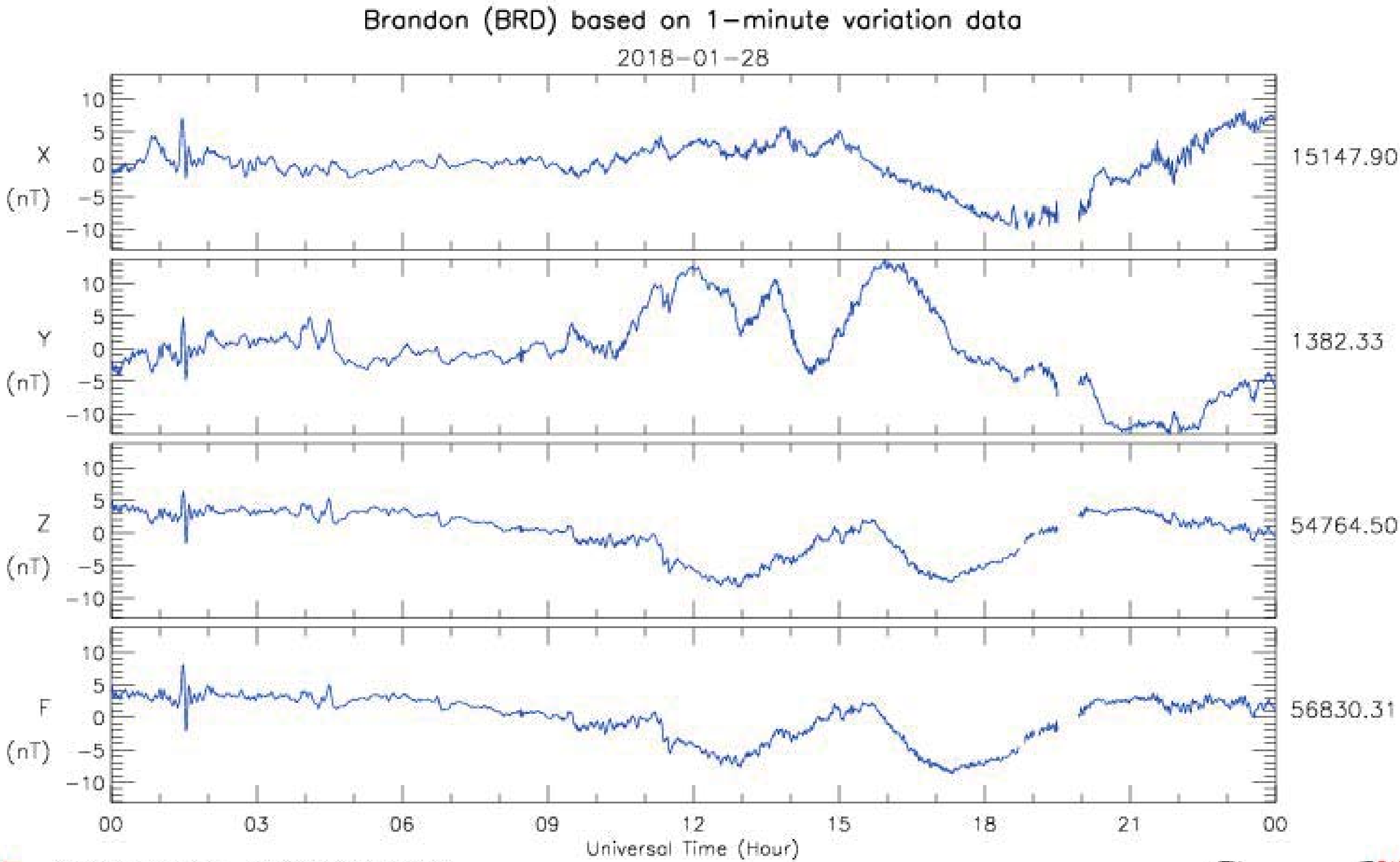
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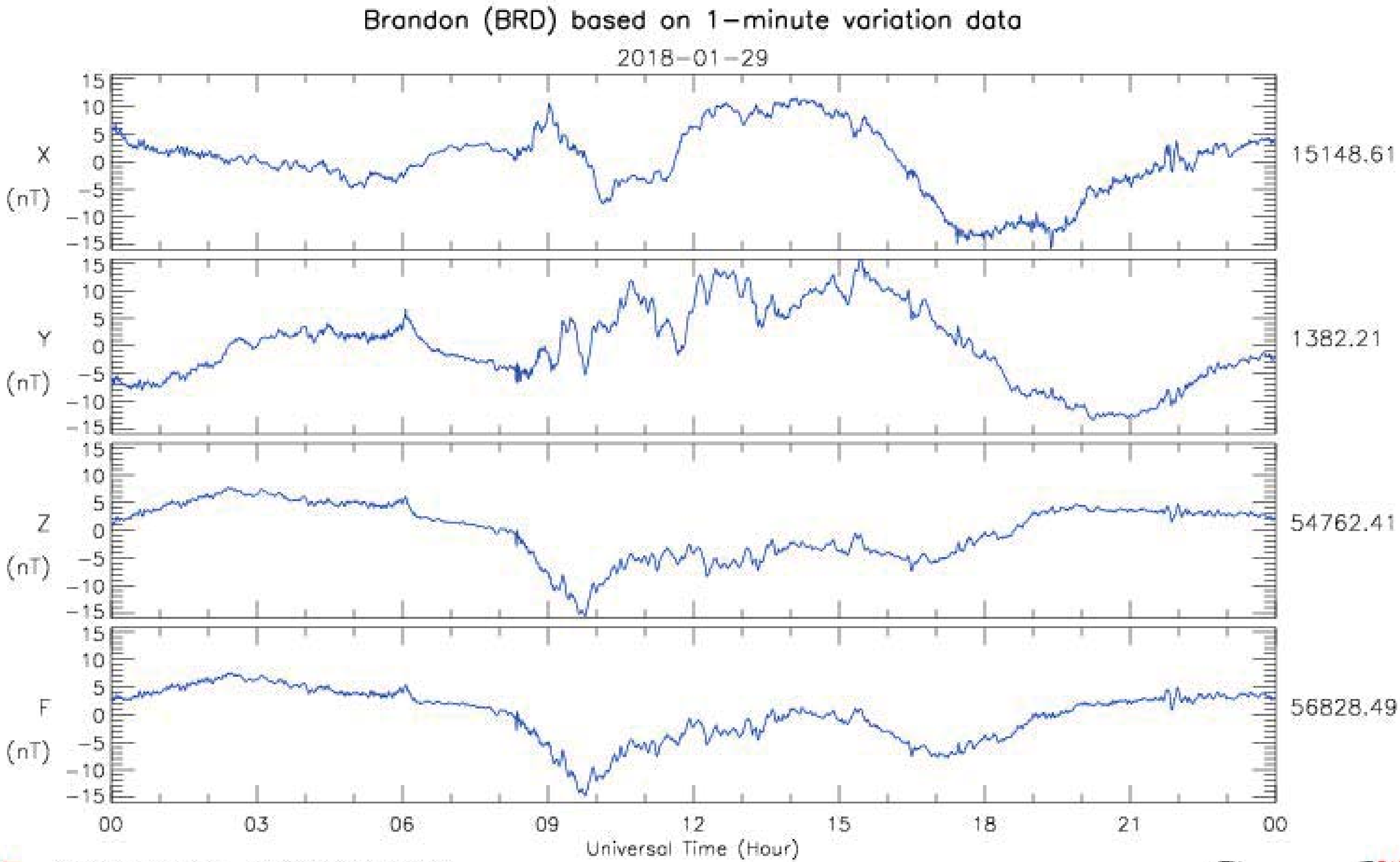

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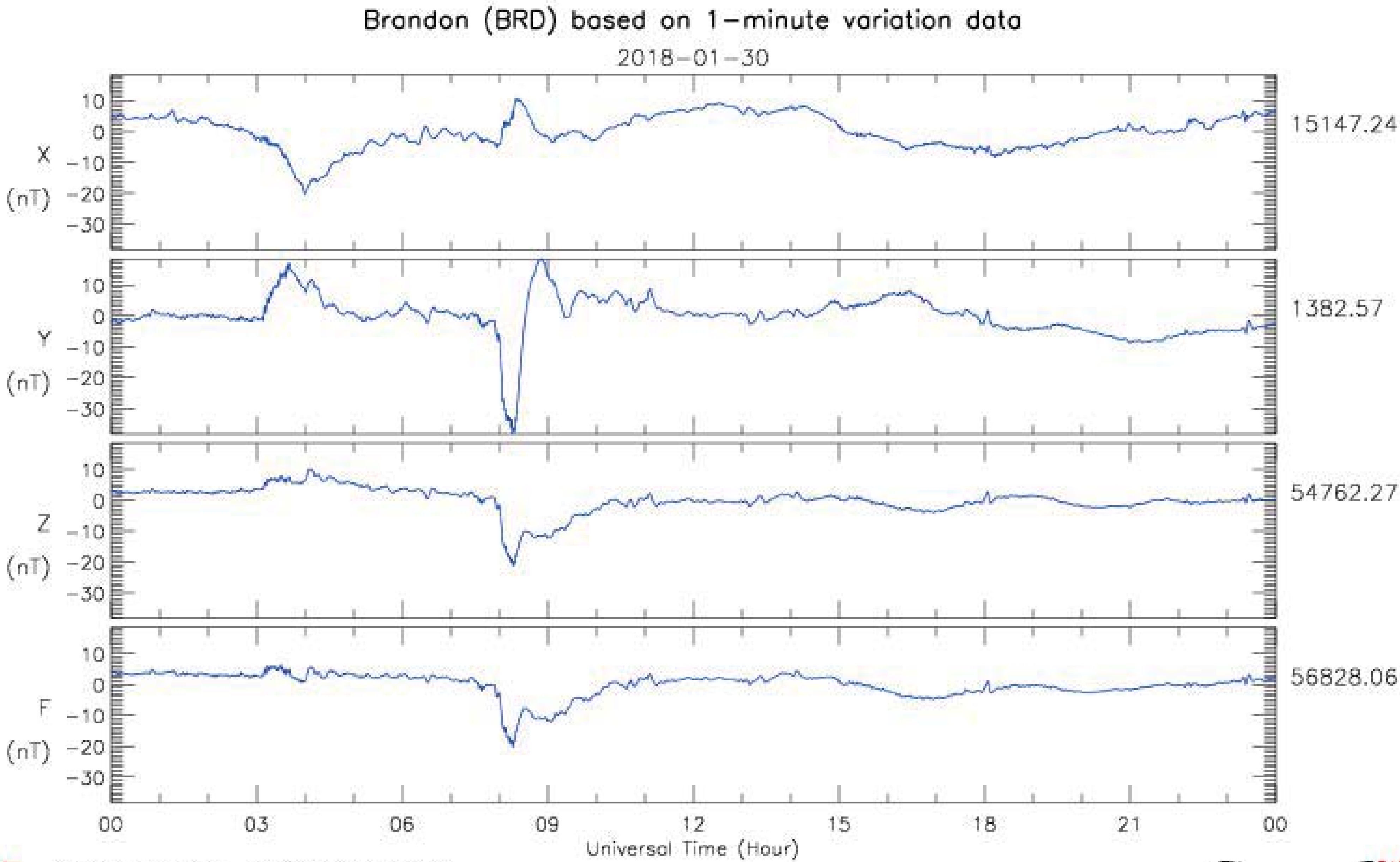
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