PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, IGNACE AREA

WP07 Data Report – Opportunistic Groundwater Sampling for IG_BH02

APM-REP-01332-0254

April 2021

Golder Associates Ltd.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Nuclear Waste Management Organization
22 St. Clair Avenue East, 4th Floor
Toronto, Ontario
M4T 2S3
Canada

Tel: 416-934-9814
Web: www.nwmo.ca

REPORT

Phase 2 Initial Borehole Drilling and Testing, Ignace Area

WP07 Data Report - Opportunistic Groundwater Sampling for IG_BH02

Submitted to:

Nuclear Waste Management Organization
4th Floor
22 St. Clair Avenue East
Toronto, Ontario, M4T 2S3

Submitted by:

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario, L5N 7K2 Canada

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OPPORTUNISTIC GROUNDWATER SAMPLING FOR IG_BH02

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22 St. Clair Avenue East, Fourth Floor
Toronto, Ontario
M4T 2S3

Client Contact: Alexander Blyth and Maria Sánchez-Rico Castejón
Telephone: 647-259-3021; 647-259-3720
Email: ablyth@nwmo.ca and msanchez@nwmo.ca

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SIGNATURES

Prepared by: ______________________

Natalie Solis, P.Eng.
Geological Engineer

____

Bret Timmis, M.Sc., P.Geo.
Geochemist

Reviewed by: Michael D. Lemon

Michael Lemon, B.Sc.
Geological Specialist - Associate

Approved by: Ken DeVos

Ken De Vos, M.Sc., P.Geo.
Senior Hydrogeochemist – Principal

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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 three deep boreholes within the northern portion of the Revell batholith. The third drilled borehole, IG_BH02, is located a direct distance of approximately 21 km southeast of the Wabigoon Lake Ojibway Nation and a direct distance of 44 km northwest of the Town of Ignace. Access to the IG_BH02 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, activities and results for Work Package 7 (WP07): Opportunistic Groundwater Sampling for IG_BH02, which includes: identification of permeable intervals during drilling (WP02 and WP03) and hydraulic testing (WP06), collection and in-field analysis, and laboratory analysis of samples. This report also describes the analysis of the fresh water and drill water collected as part of Work Package 2 (WP02): Borehole Drilling and Coring for IG_BH02. IG_BH02 is an inclined borehole, all depths referred to in this report are in meters below ground surface along the length of the borehole (mbgs along hole), rather than true vertical depth.

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. Based on geophysical modelling, the batholith is approximately 2 km to 3 km thick through the center of the northern portion (SGL 2015). The batholith is surrounded by supracrustal rocks of the Raleigh Lake (to the north and east) and Bending Lake (to the southwest) greenstone belts (Figure 2).

IG_BH02 is located within an investigation area of approximately 19 km^2 in size, situated in the northern portion of the Revell batholith. Bedrock exposure in the area is generally 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. Local water courses tend to flow to the southwest towards Mennin Lake (Figure 1).

Four main rock units are identified in the supracrustal rock group: mafic metavolcanic rocks, intermediate to felsic metavolcanic rocks, metasedimentary rocks, and mafic intrusive rocks (Figure 2). Sedimentation within the supracrustal rock assemblage was largely synvolcanic, although sediment deposition in the Bending Lake area may have continued past the volcanic period (Stone 2009; Stone 2010a; Stone 2010b). All supracrustal rocks are affected, to varying degrees, by penetrative brittle-ductile to ductile deformation under greenschist- to amphibolite-facies metamorphic conditions (Blackburn and Hinz 1996; Stone et al. 1998). In some locations, primary features, such as pillow basalt or bedding in sedimentary rocks are preserved, in other locations, primary relationships are completely masked by penetrative deformation. Uranium-lead (U-Pb) geochronological analysis of the supracrustal rocks produced ages that range between 2734.6 +/-1.1 Ma and 2725 +/-5 Ma (Stone et al. 2010).

Three main suites of plutonic rock are recognized in the Revell batholith, including, from oldest to youngest: a Biotite Tonalite to Granodiorite suite, a Hornblende Tonalite to Granodiorite suite, and a Biotite Granite to Granodiorite suite (Figure 2). Plutonic rocks of the Biotite Tonalite to Granodiorite suite occur along the southwestern and northeastern margins of the Revell batholith. The principal type of rock within this suite is a white to grey, medium-grained, variably massive to foliated or weakly gneissic, biotite tonalite to granodiorite. One sample of foliated and medium-grained biotite tonalite produced a U-Pb age of 2734.2+/-0.8 Ma (Stone et al. 2010). The Hornblende Tonalite to Granodiorite suite occurs in two irregularly-shaped zones surrounding the central core of the Revell batholith. Rocks of the Hornblende Tonalite to Granodiorite suite range compositionally from tonalite through granodiorite to granite and also include significant proportions of quartz diorite and quartz monzodiorite. One sample of coarse-grained grey mesocratic hornblende tonalite produced a U-Pb age of 2732.3+/-0.8 Ma (Stone et al. 2010). Rocks of the Biotite Granite to Granodiorite suite underlie most of the northern, central and southern portions of the Revell batholith. Rocks of this suite are typically coarse-grained, massive to weakly foliated, and white to pink in colour. The Biotite Granite to Granodiorite suite ranges compositionally from granite through granodiorite to tonalite. A distinct potassium (K)-Feldspar Megacrystic Granite phase of the Biotite Granite to Granodiorite suite occurs as an oval-shaped body in the central portion of the Revell batholith (Figure 2). One sample of coarse-grained, pink, massive K-feldspar megacrystic biotite granite produced a U-Pb age of 2694.0+/-0.9 Ma (Stone et al. 2010).

The bedrock surrounding IG_BH02 is composed mainly of massive to weakly foliated felsic intrusive rocks that vary in composition between granodiorite and tonalite, and together form a relatively homogeneous intrusive complex. Bedrock identified as tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed (SRK and Golder 2015; Golder and PGW 2017). Massive to weakly foliated granite is identified at the ground surface to the northwest of the feldspar-megacrystic granite. The granite is observed to intrude into the granodiorite-tonalite bedrock, indicating it is distinct from, and younger than, the intrusive complex (Golder and PGW 2017).

West-northwest trending mafic dykes interpreted from aeromagnetic data extend across the northern portion of the Revell batholith and into the surrounding greenstone belts. One mafic dyke occurrence, located to the northwest of IG_BH01, is approximately 15-20 m wide (Figure 2). All of these mafic dykes have a similar character and are interpreted to be part of the Wabigoon dyke swarm. One sample from the same Wabigoon swarm produced a U-Pb age of 1887+/-13 Ma (Stone et al. 2010), indicating that these mafic dykes are Proterozoic in age. 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.

Regional observations from mapping have indicated that structural features are widely spaced (typical 30 to 500 cm spacing range) and dominantly comprised of sub-vertical joints with two dominant orientations, northeast and northwest trending (Golder and PGW 2017). Interpreted bedrock lineaments generally follow these same dominant orientations in the northern portion of the Revell batholith (Figure 2; DesRoches et al. 2018). Minor sub-horizontal joints have been observed with minimal alteration, suggesting they are younger and perhaps related to glacial unloading. One mapped regional-scale fault, the Washeibemaga Lake fault, trends east and is located to the west of the Revell batholith (Figure 2). Ductile lineaments, also shown on Figure 2, follow the trend of foliation mapped in the surrounding greenstone belts. Additional details of the lithological units and structures found at surface within the investigation area are reported in Golder and PGW (2017).

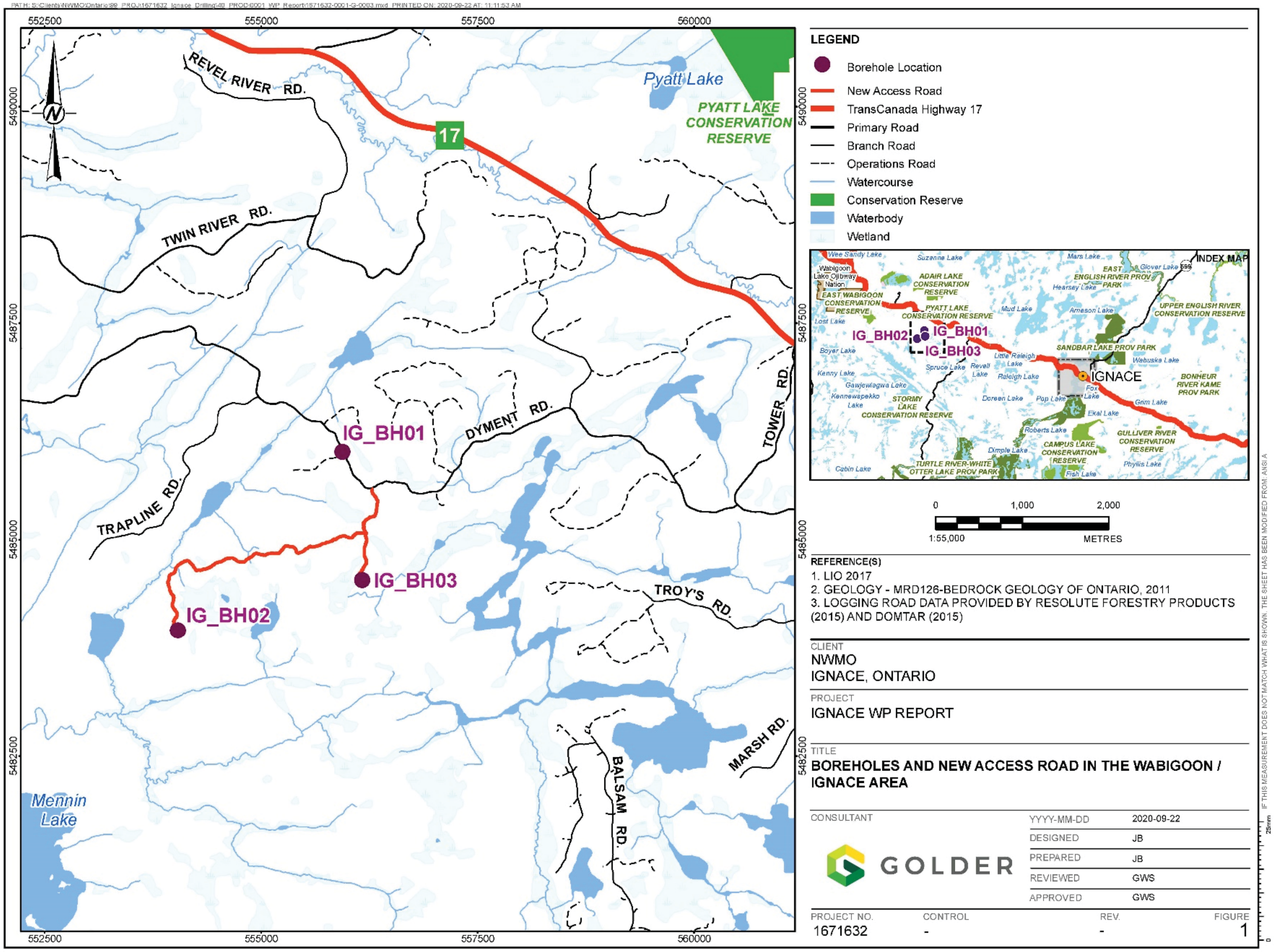

Figure 1: Location of IG_BH02 in Relation to the Wabigoon / Ignace Area

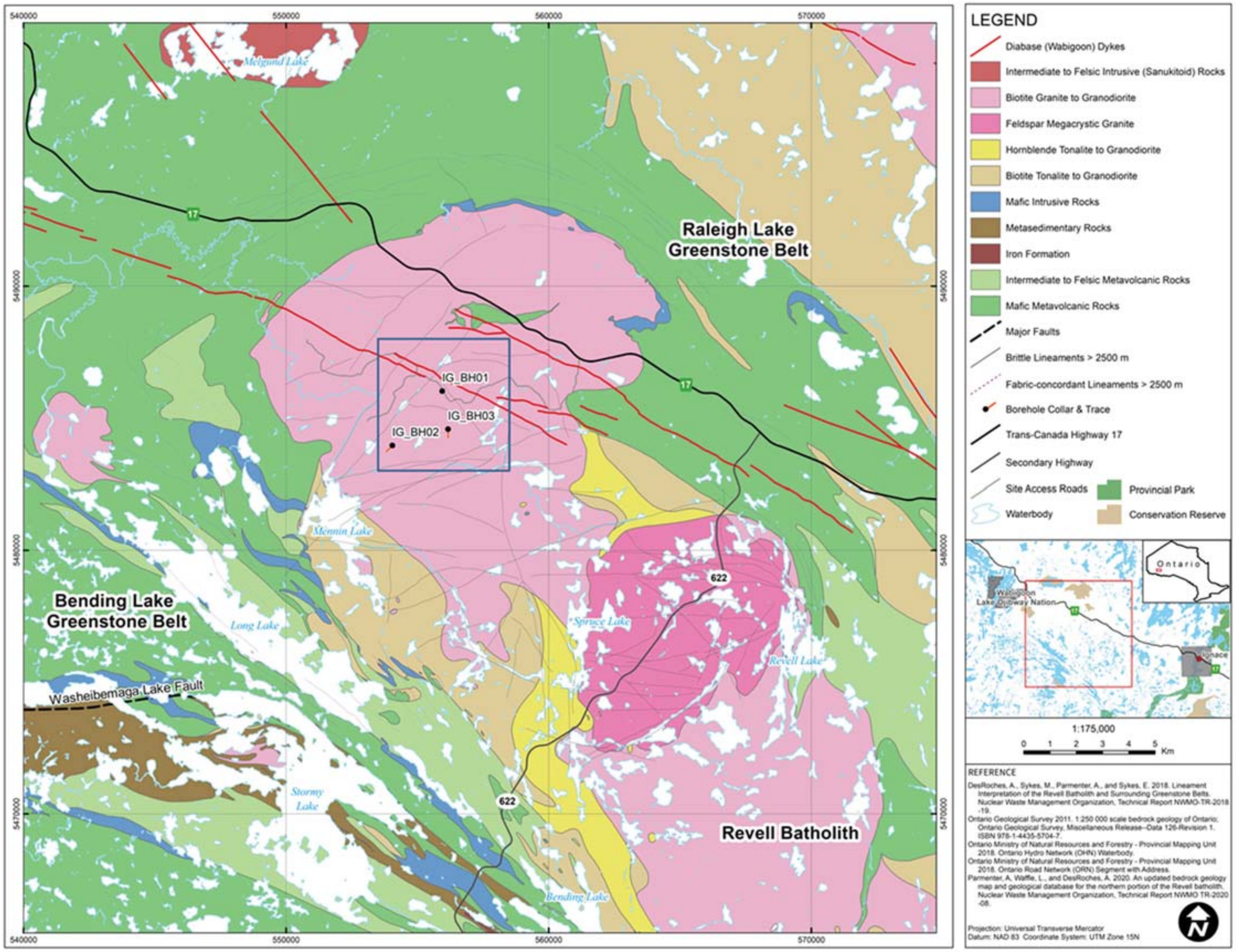

Figure 2: Geological setting and location of boreholes IG_BH01, IG_BH02 and IG_BH03 in the northern portion of the Revell batholith

3.0 DESCRIPTION OF ACTIVITIES

3.1 Types of Samples Collected

The following samples were collected for laboratory analysis, in-field geochemistry and microbiology research and development as described in the following section.

- Water source samples – These were collected under WP02 to characterize the source water prior to introducing it to the drill system. They were denoted IG_BH02_WSXXX (“water source”) and included laboratory analyses, in-field parameters and in-field geochemistry analyses.
- Drilling water return, designated IG_BH02_DWXXX, included the following types of samples:
  - Archive samples of the drill water return were collected under WP02 every 50 m during drilling;
  - Drill water samples associated with groundwater samples were collected for laboratory analyses, in-field parameters, in-field geochemistry and microbiology analysis; and
  - Samples were specifically collected for microbiology research and development at corresponding core intervals and included laboratory analyses, in-field parameters and microbiology analysis.
- Opportunistic Groundwater (OGW) samples and attempted samples collected during drilling included laboratory analyses, in-field parameters, in-field geochemistry and microbiology analyses, as well as QA/QC samples for laboratory analyses.
- No post drilling sample collection was attempted due to the low available purge rates for all intervals assessed under WP06.

A summary description and details of all analyses for all fluid samples collected for IG_BH02 can be found in Table A-1 (Appendix A). OGW sample intervals are individually described with results presented and discussed in Section 4.0.

3.2 Technical Objectives

The technical and scientific objectives of WP07 sampling were the following:

- Identification, while drilling and post-drilling during WP06 packer testing, of permeable intervals for collecting OGW samples;
- Collection and preservation of OGW sample volumes for geochemical analysis;
- Measurement of field parameters (tracer concentrations [fluorescein], temperature, pH, oxidation-reduction potential [ORP], electrical conductivity [EC] and turbidity) and in-field analysis (alkalinity, dissolved oxygen [DO], total dissolved sulphide, and ferrous iron);
- Laboratory analysis of collected OGW samples;
- Determining chemical and isotopic character of groundwater with depth; and
- Identify the presence or absence of recent, older post-glacial and glacial recharge, interglacial recharge and very old pre-glacial groundwater with depth.

In the crystalline rock of the Revel Batholith, groundwater was expected to be encountered through fractures in the bedrock. A maximum of 10 sample intervals were planned, following the depth guidelines below:

- 1 sample in the upper 100 m;
- 3 samples in the upper 400 m (including the 1 sample in the upper 100 m); and
- 7 samples in the potential repository zone (400 to 800 m) or below the repository horizon if active or flowing features were encountered.

3.3 Methodology

3.3.1 Roles and Responsibilities

Golder drilling supervisors, with assistance from the WP03 core loggers also on site, were responsible for all activities associated with WP07 on site sampling, including:

- Equipment decontamination;
- Lowering the wireline packer assembly to isolate the sample interval;
- Purging the sample interval;
- Collection of the OGW sample;
- Sample in-field geochemistry analyses; and
- Laboratory analysis of collected samples by Bureau Veritas Laboratories (BV) and Isotope Tracer Technologies (IT2).

The Golder WP07 Lead corresponded with the NWMO WP07 Lead and provided direction to the field staff on confirmation to proceed with purging assessments and sample collection.

Data Delivery

The data delivery was provided to the NWMO and contains the following components, referred to throughout this report:

- DQC workbooks for each sample (these include all notes associated with in-field and laboratory activities, instrument calibration records and purging data for opportunistic groundwater samples);
- Chain of custody records and sample submission reports from BV and IT2; and
- Certificates of analyses for all samples from BV and IT2.
- Calculation file for charge balance and alkalinity speciation of water samples;
- Raw downhole pressure data collected during purging for groundwater samples; and
- Importer template file (csv) containing results from analytical laboratory testing.

3.3.2 Source Water and Water Tracing

Fresh water was brought from a municipal source in Ignace. Municipal water in Ignace is sourced from Michel Lake and treated to adhere to Ontario drinking water standards; the water undergoes filtering processes and is chlorinated. Once water was collected from Ignace and brought to site, it was stored in designated tanks. As described in the Work Package 2 (WP02) Drilling and Coring Report (Golder, 2020a), samples were collected from these fresh water tanks (water source samples) for initial characterization before a fluorescein tracer was added to achieve the desired concentration of 100 ppb for drilling and flushing activities. After sampling and tracer addition, the fresh water was introduced to the borehole and drill fluid system with approval from the Golder drilling supervisor.

All drill fluid parameters (fluorescein concentration, temperature, pH, EC, ORP, DO, turbidity and density) were measured from the return fluid at the completion of each run so that run to run changes could be observed. This data is presented in the WP02 Data Report and is included in the acQuire data delivery (DE-07). As described in the WP02 report (Golder, 2020a), the drill fluid volume change was measured on a run to run basis either through use of totalizing flowmeters, or through manual measurements of the drill fluid system. The drill fluid recycling system used a centrifuge to remove solid cuttings from the return fluid. All drill fluid data and observations are presented in the WP02 Drilling and Coring Report (Golder, 2020a).

3.3.3 Interval Selection

During drilling, potential opportunistic groundwater sample intervals were identified by a combination of the following:

- Indications from core sample descriptions, such as fractured zones, weathered or stained fractures, large fracture apertures;
- Drilling fluid circulation measurements, such as fluid loss or gain, changes in drilling fluid parameters (see Table 1);
- Drill pump pressure changes that may indicate loss of circulation or the presence of a water producing feature; and
- Drilling performance indicators, such as rod drops, changes in advance rates, or changes in drive head torque.

The observed criteria to initiate WP07 are described in the “Justification to Initiate WP07” tab of the DQC workbooks.

Table 1: Drill Fluid Field Parameters Measured, and Triggers Observed to Initiate WP07

Field Parameter	Instrument	Trigger to Initiate WP07
Fluorescein dye (tracer)	Aquafluor Handheld Fluorimeter/Turbidimeter	20% decrease in concentration from previous drill fluid source. Note: Minimum detection limit of the fluorimeter (0.4 ppb)
Turbidity	Horiba U52-2, multi-probe	10% change from previous drill fluid source
Dissolved Oxygen		10% change from previous drill fluid source
Electrical conductivity		10% change from previous drill fluid source
pH		change of at least 0.5 from previous drill fluid source
Temperature		N/A
ORP		N/A
Density	Hydrometer	N/A

Potential post-drilling sample intervals were identified based on observations from borehole geophysical surveys (WP05), however preliminary hydraulic conductivity estimates while completing WP06 indicated that none of the intervals were capable of sustaining the required purge rate. Therefore, no post-drilling opportunistic groundwater samples were collected.

3.3.4 Interval Isolation

For sample intervals identified during drilling, an inflatable wireline packer tool was used to isolate the bottom of the borehole, with the configuration shown in Figure 3. Recorded measurements and calculations for the interval configurations can be found in the “Test Zone Specification” tab of the DQC workbooks for intervals identified during drilling.

For sample intervals identified during drilling, the interval’s ability to sustain the minimum required purge rate of 10 system volumes (borehole volume of isolated interval + volume of water in drill pipe) in 72 hours was assessed by performing a multiple step, constant rate pumping test, as documented in the “Purge Rate Assessment” tab of the DQC workbooks. The available purge rates for potential sample intervals identified during the post-drilling hydraulic testing were estimated based on preliminary field assessments of the intervals’ transmissivity.

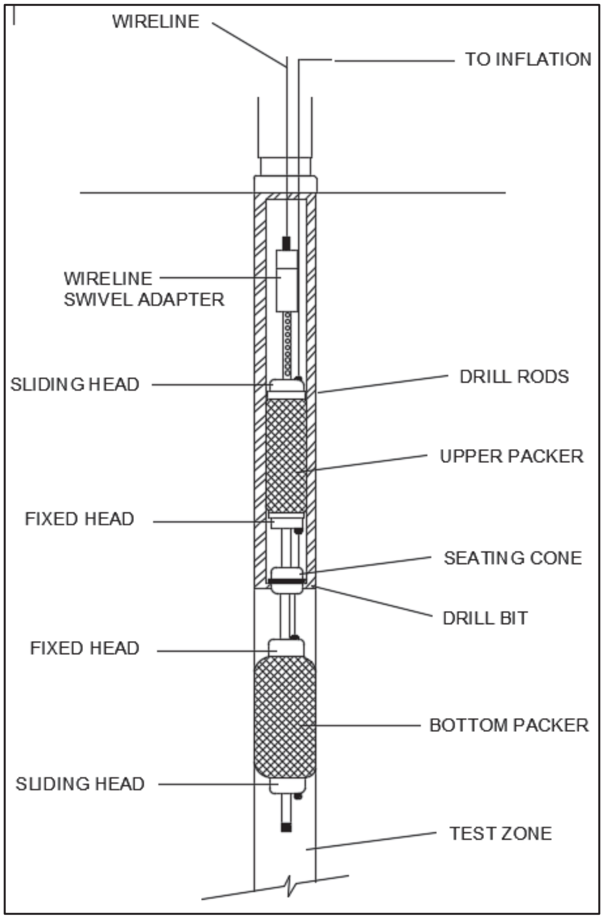

Figure 3: Wireline packer schematic

3.3.5 Purging

Once sample collection from the selected interval was determined to be feasible, purging was carried out to remove the drill fluid from the drill rods, the sample interval and the rock formation to obtain a groundwater sample that was representative of the isolated interval. For all samples, interval purging was achieved using a Grundfos Redi-Flo2 pump, lowered into the drill rods. Purged water was conveyed to surface via 12.7 mm diameter poly tubing connected to the pump. The purge rate was recorded every 30 minutes in the 'Purge Water Volume and Field Parameters' tab of the DQC workbook provided to the NWMO in the data deliverable.

3.3.6 Collection of Field Parameters

During purging, the drill fluid field parameters (fluorescein concentration, pH, ORP, DO, EC, turbidity and temperature) were monitored with a Horiba U52-2 multi-parameter water quality meter and recorded every 30 minutes. The Horiba was set up on surface during purging using a flow-through cell and readings were recorded in the 'Purge Water Volume and Field Parameters' tab of the DQC workbook.

Analytical in-field parameter measurements included alkalinity, total dissolved sulfide, DO (colorimetric method) and ferrous iron, with results recorded in the corresponding data tabs of the DQC workbooks, as well as the acQuire DE-07 Groundwater Sample object. The field procedures for these in-field analyses can be found in Appendix C.

3.3.7 Sample Collection

OGW sample collection was initiated once the monitored field parameters were within the specified range and confirmation to proceed with sample collection was given by the NWMO, as documented in the 'Sample Collection Data' tab of the DQC workbooks. The field parameter targets for groundwater sample collection are shown in Table 2.

Table 2: Field Parameter Targets for Groundwater Sample Collection Determination

Field Parameter	Instrument	Drilling Fluid Concentration (prior to purging)	Target to Initiate Sample Collection
Fluorescein dye (tracer)	Aquafluor Handheld Fluorimeter/Turbidimeter	≥100 ppb	<1% of drilling fluid concentration. Note: Minimum detection limit of the fluorimeter (0.4 ug/L)
Turbidity	Horiba U52-2, multi-probe	As measured at the start of purging	Stabilized within ± 10% or ± 5 NTU if <50 NTU
DO			Stabilized within ± 10%
Electrical conductivity			Stabilized within ± 10%
Temperature			Stabilized within ± 0.5 degrees C
ORP			Stabilized within ± 10%

Field Parameter	Instrument	Drilling Fluid Concentration (prior to purging)	Target to Initiate Sample Collection
pH			Stabilized within ± 0.1 standard pH units
Purge Volume	Electronic flow meter and totalizer	N/A	Ten system volumes or total drilling fluid loss or 72 hours, whichever is greater

OGW sample collection included the following components:

- Collection of groundwater for commercial laboratory analyses and in-field analysis of alkalinity using the Grundfos pump and via the flow-through cell outlet at surface; the samples for commercial analyses were submitted for major elements and metals, anions and nutrients, stable isotopes and radioisotopes (see Table 3 for complete list of parameters; exception is total dissolved sulphide as per below).
- Collection of groundwater for microbiology research and analysis from the Grundfos pump outlet on surface.
- Collection of groundwater using the Westbay Instruments MOSDAX Sampler Probe Model 2532 in-situ sample probe for commercial laboratory analysis of total dissolved sulphide and in-field analysis of total dissolved sulphide, DO and ferrous iron.

Table 3: Sample bottle requirements for Bureau Veritas Laboratories and Isotope Tracer Technologies

Parameter Group	Parameter List	Bottle Type Requirement	Sample Volume Requirement	Head Space Requirement	Field Filtering Requirement	Preservative Requirement
Major Elements & Metals (Bureau Veritas)	Na, K, Ca, Mg, Sr, Li, Si, S_{Total}, Fe_{Total}	HDPE plastic bottles	125 mL	Fill line	Yes, 0.45 µm filter	Trace grade nitric acid
	SiO_2	HDPE plastic bottles	250 mL	None	Yes, 0.45 µm filter	None
	S^{2-}_{Total}	HDPE plastic bottles	125 mL	Fill line	Yes, 0.45 µm filter	Zinc acetate & sodium hydroxide solution
Anions & Nutrients (Bureau Veritas)	Br, F, Cl, I, SO_4, PO_4, NO_3, NO_2, Alkalinity	HDPE plastic bottles	500 mL	None	Yes, 0.45 µm filter	None

Parameter Group	Parameter List	Bottle Type Requirement	Sample Volume Requirement	Head Space Requirement	Field Filtering Requirement	Preservative Requirement
	NH_4+NH_3, N_{Total}	HDPE plastic bottles	250 mL	Fill line	Yes, 0.45 µm filter	Trace grade sulphuric acid
	P_{Total}					
Stable Isotopes (IT2)	$\delta^{18}O$, $\delta^{2}H$	HDPE plastic bottles	30 mL	No headspace	Yes, 0.45 µm filter	None
	$^{87}Sr/^{86}Sr$	HDPE plastic bottle	1000 mL	No headspace	Yes, 0.45 µm filter	None
	$\delta^{13}C$ DIC	Glass vials, teflon cap	2 x 40 mL glass vials with septa caps	No headspace	Yes, 0.45 µm filter	None
Radioisotopes (IT2)	^{14}C-DIC	HDPE plastic bottle	500 mL	No headspace	Yes, 0.45 µm filter	None
	^{3}H	HDPE plastic bottle	500 mL	No headspace	Yes, 0.45 µm filter	None

3.3.8 QA/QC

For each sample or sample attempt, a Data Quality Confirmation (DQC) workbook was filled out by the field staff on site to record the sample interval details, equipment decontamination, purge rate assessment, Horiba calibration details and sample collection details. The DQC workbooks were completed over the duration of the sampling period, from identification of the potential interval to collection of the actual sample.

Instrument Calibration Checks

Instrument calibration checks were typically carried out for the Horiba probe and AquaFluor at the start of every dayshift during regular coring activities (WP02), and all records can be found in the WP02 data delivery.

Full manual calibration checks and calibrations of each sensor of the Horiba probe were carried out according to the manufacturer’s instructions prior to in-field geochemistry analyses for water source or drill water samples, and groundwater sample purging events. The appropriate reference solutions were used for each sensor’s calibration, as listed in the “pH, Eh, Cond, Turb, DO” tab of the DQC workbooks.

Drill Fluid Sampling

Drill fluid samples associated with the OGW samples were collected when potential sample intervals were identified, to provide baseline chemistry parameters. For the successful OGW sample intervals, Interval 1 (GW001), Interval 2 (GW028) and Interval 5 (GW033), this sample was collected from the centrifuge tank once WP07 was initiated. No drill fluid samples were collected for failed sample intervals.

Equipment Decontamination

All equipment lowered downhole was decontaminated prior to use. Field staff used new, powder-free latex or nitrile gloves while cleaning and handling decontaminated equipment. Alconox® powdered detergent was used with distilled water to remove any dirt, grease or residue from the equipment, followed by a thorough rinse with laboratory grade deionized water. The equipment was then laid on a clean surface and allowed to dry free from dust and contaminants before going downhole. If the equipment was cleaned pre-emptively, it was stored in new plastic bags until required for use. The packer assembly, water level tape indicator, RST pressure transducer, Grundfos submersible pump with electrical cable and Waterra tubing, the flow-through cell, and the in-situ sample probe were decontaminated as required, and recorded in the “Equipment Decontamination” tab of the DQC workbooks for each interval.

A rinsate blank sample (GW041) was collected from the Westbay in-situ sample probe by rinsing the decontaminated sample chamber in deionized water and collecting this rinse water in the appropriate laboratory bottles for BV and IT2. This QA/QC sample type was collected for Interval 5 (GW033).

Field Blanks

Three field blanks for laboratory analyses at BV and IT2 were collected with laboratory grade deionized water following the same sampling procedures used for the actual groundwater sample. One field blank (GW018) was collected for Interval 1, associated with GW001. Field blank samples (GW030 and GW040) for sulphide analysis by BV were collected for Intervals 2 and 5, associated with GW028 and GW033, respectively.

Duplicates

A full duplicate sample (GW017) including all parameters for the analytical laboratories was collected for Interval 1 (GW001). The duplicate sample was collected immediately subsequent to the actual groundwater sample using the same sampling procedures. Duplicate sulphide samples (GW029 and GW039) for analysis at BV were collected for Intervals 2 and 5, respectively.

Sample Handling and Laboratory Documentation

Both BV and IT2 adhere to the requirements of ISO 17025:2005. Chain of custody (COC) forms were filled out by site staff to ship all samples to the required laboratories. If multiple samples were sent in a single shipment, they were included on a single COC and all results that followed contained all samples that were shipped together in a single report. The DE-09 Chain of Custody object in acQuire was used to document COCs and reconcile samples sent to the laboratories with results received from the laboratories.

Sample bottle labels were filled out before the sample was collected in the bottles. Information included on sample bottle labels included the sample name, date and time collected, preservative and analysis required. Once the collected samples were transferred to the sample bottles as listed in Table 3, the bottles were temporarily stored in a refrigerator on site. As part of the WP03 daily quality confirmation checks, the temperature of the refrigerators was checked to ensure they remained at 4˚C. Sample bottles were packed in coolers with ice packs and the appropriate COC for shipment to the laboratories.

Upon receipt by BV and IT2, Golder was notified via email and a sample submission report was provided. Both labs included a copy of the COCs, verifying the received condition of the sample and confirming the analyses to be performed. The documented received sample condition from the laboratories included the temperature received and any broken bottles. Laboratory QA/QC is described in Section 4.5.

3.3.9 Methods of Chemical and Isotopic Analysis

For the commercial and in-field analyses, information on the chemical and isotopic analyses, including the method, accuracy, and method detection limit (MDL) for each parameter is attached in Appendix A (Table A-2).

3.3.10 Method to Calculate Drill Water Ratio in Ground Water samples

During drilling, pressurized drill water will enter aquifers or fractures from which groundwater samples are to be collected. The extent of drill water remaining in the water-bearing features can be reduced through purging prior to collection of a ground water sample. Fluorescein tracer was added to drill water to permit evaluation of the extent of drill water present in ground water samples. This evaluation requires measurement of the fluorescein concentration in both the drill water and groundwater sample. It is assumed that the initial fluorescein concentration in groundwater is zero. Equation 1 permits determination of the proportion of drill water by evaluating the difference in fluorescein concentrations. Equation 2 determines the proportion of groundwater in a sample, given a known proportion of drill water from equation 1. Finally, equation 3 permits correction of measured groundwater concentrations based upon the proportion of drill water and groundwater in a sample, and the measured concentration of a given parameter in drill water and groundwater. Equation 3 applies to any single parameter where the parameter was measured above detection limits in both drill water and groundwater. Equation 3 must be repeated for each parameter to be corrected in a given sample, whereas equations 1 and 2 will have a single result for each drill water and groundwater sample pair.

$$Proportion_{DW} = \frac{Fluorescein_{GW}}{Fluorescein_{DW}} \qquad (1)$$

$$Proportion_{GW} = 1 - Proportion_{DW} \qquad (2)$$

$$GW\ Conc_{actual} = \frac{GW\ Conc_{measured} - (DW\ Conc\ x\ Proportion_{DW})}{Proportion_{GW}} \qquad (3)$$

Where:
DW = Drill Water
GW = Groundwater

4.0 RESULTS

Sample intervals were expected to be identified during drilling from drill fluid volume losses or apparent gains and / or drill fluid parameter changes, as outlined in Table 1. During the drilling of IG_BH02, three intervals were encountered where there was sufficient inflow into the borehole for the purge volume requirements to be met and a groundwater sample to be collected. Two intervals where partial triggers were identified to attempt groundwater sample collection were not permeable enough to facilitate purging.

Golder drilling supervisors (WP02) were responsible for the field identification of potential sample intervals and corresponded with the Golder work package Lead for WP07 when these were identified. As discussed in the WP02 Drilling and Coring Data Report (Golder, 2020a), parameter triggers for DO, EC and pH were encountered with some frequency, but were typically attributed to the addition of fresh, traced water and subsequent equalizing in the drill system. The drill fluid was observed to become increasingly saturated with the drill cuttings as drilling progressed, which caused a gradual change of the drill fluid parameters with each run. Turbidity was not an indicator of permeable intervals since the measurements were above the Horiba multi-probe's measurement range for the majority of the program (turbidity was greater than 1000 NTU). In addition, inconsistency in the performance of the totalizers occasionally caused false volume triggers. These were verified with manual system volume checks and core observations to deduce where triggers were real.

Fluorescein concentration was found to generally decrease in the system as drilling progressed and cuttings were removed from the drill fluid with the centrifuge. Therefore, the drill water required the addition of fluorescein by directly mixing the fluorescein into the drill tank to bring the concentration back to the desired range. The system was also required to be topped up with fresh, traced water as the volume of the hole increased and drill fluid was lost to the rock formation. These two actions required time for the system to equalize and mix, which caused fluorescein concentration changes below the trigger threshold to be observed occasionally. Further trends related to the drill fluid parameters are discussed in the WP02 report (Golder, 2020a).

In an effort to assess the magnitude of the triggers identified in Table 1, partial triggers were used to select two zones for a purge rate assessment in IG_BH02. This was done to confirm that potential sample intervals were not being missed during drilling. These attempts were for Intervals 3 and 4, described in detail in Section 4.1. In both cases, the purge rate assessment indicated that the intervals were indeed low permeability intervals, and the required purge rate was not achievable. Volume loss, in combination with observations of the drill core were shown to be the most reliable indications of water bearing fractures in the crystalline rock.

A total of twenty (23) water samples were submitted for laboratory analysis in WP07. Of these, eight (8) were water source samples, supplied from the Town of Ignace municipal water supply. Six (6) samples of drill water return were collected. Three (3) OGW samples were collected, with six (6) associated QA/QC samples (blanks, duplicates and a rinsate blank).

Complete analytical results of water source, drill water, and drill water additive, are presented in Table A-3. Opportunistic groundwater samples and QA/QC samples are presented in Table A-4. Calculated values for ferric iron (via subtraction of field measured ferrous iron concentrations from laboratory reported dissolved iron concentrations) are not presented due to dissolved iron concentrations below detection limit in the majority of samples, and where both dissolved iron and ferrous was detected, the calculation yielded negative values for ferric iron. Calculated negative ferric iron concentrations may be due to heterogeneity in iron content of the water submitted for laboratory analysis versus that used for the field measurements or analytical uncertainty at concentrations close to the detection limit. Fluorescein concentrations were measured in field but not in the laboratory because no commercial laboratory was identified that was able to complete this analysis. Sulphide concentrations were reported below detection limit in all field and laboratory measurements; accordingly, calculated values for hydrogen sulphide and bisulphide are not presented.

The Hach instrument was not zeroed after reading the reagent blank value for the following in-field ferrous iron samples:

- IG_BH02_WS002
- IG_BH02_DW001
- IG_BH02_DW016
- IG_BH02_GW001

Per the manufacturer's instructions, the blank value is to be subtracted from the sample reading when this occurs. The corrected field measurement values are stated in Tables A-3 and B-1 (and in the acQuire DE-07).

4.1 Interval Selection and Purging

Sample Interval 1 (GW001)

During core run CR7, from 16.16 to 19.16 mbgs (along hole), a volume loss of 251 L was encountered, along with stained joints and two broken amphibolite dykes in the drill core indicating a possible location for collecting an OGW sample. This was communicated to the Golder work package Lead and the decision was confirmed with NWMO to isolate the interval and assess the achievable purge rate.

The drill string was pulled up, with the bit positioned at 13.12 mbgs (along hole), to position the single packer above the suspected water bearing fractures and isolate the interval from 14.36 to 19.16 mbgs (along hole).

With a system volume of approximately 82 litres, the minimum purge rate required to achieve 10 system volumes in 72 hours was 0.19 litres per minute (L/min). The interval was able to sustain this rate, and an average rate of approximately 0.3 litres per minute was sustained through the purge event. Purging was carried out for 67 hours before sampling was initiated, with a total purge volume of 1352 litres or 16.5 system volumes removed, and EC, ORP, DO and turbidity stabilized within 10% variability between readings, temperature within 0.5 degrees C, and 0.1 pH. Fluorescein concentration was approximately 5% of the source drill fluid and slowly dropping when the rest of the field parameters were within their targets. Sample collection was initiated at 5% fluorescein concentration with the decision confirmed by the NWMO, given the extended time it would take to get to the 1% specified in the Table 2.

Drill fluid sample IG_BH02_DW001 was collected from the centrifuge tank upon WP07 initiation and was sampled for laboratory analyses and in-field analyses. Archive samples of the purge water were collected at each system volume. The groundwater sample was collected with a suite of quality assurance / quality control (QA/QC) samples, including a field blank and a duplicate. Table A-1 in Appendix A contains the descriptions and full list of bottle sets and in-field parameters and analyses collected for Interval 1, with the results presented and discussed in Section 4.4.

Following collection of the OGW samples from the outlet of the flow-through cell, the Westbay in-situ sample probe was deployed twice in order to collect sufficient sample volume to perform the sulphide, DO, alkalinity and ferrous iron in-field analyses in addition to filling of the BV sulphide bottle. The sample chamber was nitrogen purged to prevent sample exposure to the atmosphere, as described in Appendix C.

Sample Interval 2 (GW028)

During core run CR26, from 61.15 to 63.06 mbgs (along hole), a volume loss of 400 L was encountered, along with poor quality rock and hematization. A broken quartzite dyke was also encountered at the base of the core run which caused the run to block and end before the full 3 meters was drilled. In consultation with the NWMO, the decision was made to finish the run and attempt to confirm the extent of the feature before groundwater sampling. Core run CR27, from 63.06 to 64.11 mbgs (along hole), encountered an additional volume loss of approximately 454 L and the purge rate assessment was initiated.

The drill string was pulled up, with the bit positioned at 58.15 mbgs (along hole), to position the single packer above the suspected water bearing fractures and isolate the interval from 59.30 to 64.11 mbgs (along hole).

With a system volume of approximately 199 litres, the minimum purge rate required to achieve 10 system volumes in 72 hours was 0.46 litres per minute (L/min). The interval was able to sustain this rate with an average rate of approximately 4.9 litres per minute during purging for 11.25 hours with over 16 system volumes removed. At this stage, water was poured into the annular space between the inner casing and the HQ drill rods, and a corresponding response was observed in the water level inside the HQ rods. This indicated that the packer was not completely sealed to the borehole wall or bypass from the isolated interval through the rock to the annulus of the borehole was occurring. The packers were deflated, removed from the borehole and the drill string moved up 0.3 m to attempt a new packer seat. After re-inflation, the same test was carried out by pouring water in the inner casing / drill string annulus with the same result, confirming bypass from the isolated interval through the rock to the annulus of the borehole.

The sample interval was abandoned as it was not possible to eliminate bypass through the rock to the borehole annulus. The final archived volume of purge water, taken at approximately 15 system volumes, was sampled as the primary groundwater sample (GW028). A full suite of in-field and laboratory analyses were carried out, recognizing that higher drill fluid contamination was likely. The field parameters EC, ORP and DO had stabilized within 10% variability between readings, temperature within 0.5 degrees C, and 0.1 pH, however turbidity was still above 10 NTU and fluorescein concentration was still over 10% of the starting drill fluid and slowly dropping when the purging was abandoned.

Drill fluid sample IG_BH02_DW004 was collected from the centrifuge tank upon WP07 initiation and was sampled for laboratory analyses and in-field analyses. Archive samples of the purge water were collected for system volumes 1 through 7, 9.4, and 15. The groundwater sample was collected with a suite of quality assurance / quality control (QA/QC) samples, including a field blank and a duplicate. Table A-1 in Appendix A contains the descriptions and full list of bottle sets and in-field parameters and analyses collected for Interval 2, with the results presented and discussed in Section 4.4.

Sample Interval 3 (GW031) – Failed Purge Rate Assessment

A volume loss of 149 L was measured using the totalizers during core run CR104 (280.14 to 283.12 mbgs along hole), but was not confirmed through manual tank readings, which indicated a volume loss of 41 L. A tonalite contact was observed in the core, with hematite, chlorite and calcite coated joint surfaces prevalent at the tonalite contact. The decision was confirmed by NWMO to attempt a purge rate assessment based on the core observations.

The drill string was pulled up, with the bit positioned at 277.13 mbgs (along hole), to position the single packer above the tonalite contact to isolate the interval from 278.33 to 283.12 mbgs (along hole).

With a system volume of approximately 1254 L, 2.90 L/min was required in order to remove 10 system volumes in 72 hours. The purge rate assessment indicated no measurable flow and the attempt was abandoned. The packers were removed from the borehole and drilling resumed.

Sample Interval 4 (GW032) – Failed Purge Rate Assessment

A volume loss of 127 L was measured using the totalizers during core run CR127 (346.15 to 349.16 mbgs along hole), but was not confirmed through manual tank readings, which indicated a volume loss of only 6 L. Some fractures with hematization and chloritization were observed. Coring continued to 358.16 mbgs along hole when NWMO confirmed the decision was made to attempt a purge rate assessment based on core observations.

The drill string was pulled up, with the bit positioned at 343.13 mbgs (along hole), to position the single packer above the noted fractures in core run CR127 to isolate the interval from 344.43 to 358.16 mbgs (along hole).

A purge rate of 3.99 L/min was required to remove 10 system volumes in 72 hours, considering the system volume of 1725 L. The purge rate assessment indicated no measurable flow and the attempt was abandoned. The packers were removed from the borehole and drilling resumed.

Sample Interval 5 (GW033)

A complete loss of drill fluid circulation was encountered during drilling of core run CR138, from 376.17 mbgs (along hole) to 377.05 mbgs (along hole), at which depth drilling was stopped. The core showed two features with chlorite and hematite gouge infilling, as well as hematization through the drill core. Refer to the WP03 Report – Geological and Geotechnical Core Logging, Photography and Sampling for IG_BH02 (Golder, 2020b) for further details of the drill core in this zone. A drop in the drill fluid injection pressure was also noted during coring of this run. To minimize drill fluid contamination into the zone, the decision was made to attempt a purge rate assessment and sample collection before attempting to finish coring through the feature.

The drill string was pulled up, with the bit positioned at 373.16 mbgs (along hole), to position the single packer above core run CR138 to isolate the interval from 374.46 to 377.05 mbgs (along hole).

During the initial purge rate assessment, after inflating the packers in the interval, the water level within the drill rods was observed not to recover after pumping with the Grundfos pump. The packers were pulled and checked for a blockage, and an open hole injection test and subsequent flushing was performed to attempt to clear any potential blockage in the interval. The packers were re-lowered to isolate the same interval, 374.46 – 377.05 mbgs (along hole), and the second attempt at the purge rate assessment indicated that the interval was able to sustain more than the required 3.7 L/min rate for 10 system volumes in 72 hours (considering a system volume of 1607 L).

Purging was carried out for 44 hours between October 25-26, 2019. Approximately 7.7 system volumes were removed at an average rate of 4.7 L/min. EC, ORP, DO and turbidity stabilized within 10% variability between readings (DO and turbidity were both 0), temperature within 0.5 degrees C, and 0.1 pH. Fluorescein concentration was approximately 3.4% of the source drill fluid and slowly dropping when the rest of the field parameters were within their targets. Sample collection was initiated at 3.4% fluorescein concentration with the decision confirmed by the NWMO, given the extended time it would take to get to the 1% specified in the Table 2.

Drill fluid sample IG_BH02_DW016 was collected from the centrifuge tank upon WP07 initiation and was sampled for laboratory analyses and in-field analyses. Five archive samples of the purge water were collected periodically during purging. The groundwater sample was collected with a full suite of quality assurance / quality control (QA/QC) samples, including a field blank, rinsate blank and a duplicate. Table A-1 in Appendix A contains the descriptions and full list of bottle sets and in-field parameters and analyses collected for Interval 1, with the results presented and discussed in Section 4.4.

Following collection of the OGW samples from the outlet of the flow-through cell, the Westbay in-situ sample probe was deployed three times to collect sufficient sample volume to perform the sulphide, DO, alkalinity and ferrous iron in-field analyses in addition to filling of the BV sulphide bottle. The sample chamber was nitrogen purged to prevent sample exposure to the atmosphere, as described in Appendix C.

4.2 Water Source Samples

Water source samples are generally of relatively consistent composition over the duration of WP07, which is expected given that the samples are taken from municipal water supply for drinking water. Ignace's municipal water is sourced from Michel Lake, with water supply for IG_BH02 collected from the municipal source from September 22, 2019 to November 22, 2019. The results are summarized as follows:

- Field pH ranged from 7.16 to 7.51;
- Total alkalinity ranged from 16 to 21 mg/L $CaCO_3$ in-field measured values, and ranged from 14 to 16 mg/L $CaCO_3$ in laboratory measured values;
- Sulphate ranged from 1.3 to 3.6 mg/L;
- Total dissolved sulphide was below the method detection limit in in-field measured samples, as well as below the method detection limit (<0.02 mg/L) in all laboratory measured samples;
- Dissolved oxygen concentration measured by Hach meter ranged from 8.70 to 10.8 mg/L, and ranged from 4.95 to 13.65 mg/L in samples measured by the Horiba probe;
- Oxygen-18 ($\delta^{18}O$) ranged from -8.56 to -8.13 ‰ VSMOW;
- Deuterium ($\delta^{2}H$) ranged from -71.5 to -68.8 ‰ VSMOW;
- $\delta^{13}C$-DIC ranged from -11.6 to -6.5 ‰ PDB;
- ^{14}C-DIC ranged from 97.4 to 97.8 percent Modern Carbon (pMC) or 177 to 209 years before present (BP) in the two samples that produced sufficient gas for analysis (IG_BH02_WS002, IG_BH02_WS005). Present is defined as the year 1950 and years BP is calculated by the analytical laboratory according to the formula:

$$Years\ BP = -8033 \times \ln \frac{pMC}{100}$$

- ^{3}H ranged from 7.4 to 12.5 TU; and
- $^{87}Sr/^{86}Sr$ ratio ranged from 0.723 to 0.769.

Relative results of key major ions are presented in piper plot in Figure 4. Water source samples are clustered and demonstrate that the major ion composition is generally consistent. The major ion chemistry of the water source samples is represented by similar proportions of calcium and sodium, with lesser concentrations of magnesium, and a higher proportion of bicarbonate relative to other anions.

Oxygen-18 and deuterium results are presented in Figure 5 and are compared to the Global Meteoric Water Line (GMWL) and Local Meteoric Water Line (LMWL). The LMWL presented is for Atikokan, Ontario (Fritz et al., 1987). This LMWL is considered a reasonable representation (based on distance) of the LMWL for Ignace, Ontario, for which a closer published LMWL has not been identified. All water source samples plot below and to the right of the LMWL and GMWL.

Water source samples are collected from the municipal water supply, which is sourced from a local lake, therefore it is known that the samples are primarily composed of modern precipitation. Tritium results are consistent with this origin.

4.3 Drill Water Samples

Drill water samples demonstrate a greater extent of variability in composition as compared to water source samples. Drill water samples are a mixture of source water, any drilling additives, inputs from rock flour (from the drilling process) and groundwater. High turbidity was observed in the drill water samples. Sample

IG_BH02_DW001 is associated with water sample IG_BH02_GW001 taken from the interval 14.36 – 19.16 m, sample IG_BH02_DW004 is associated with water sample IG_BH02_GW028 taken from the interval 59.30 – 64.11 m, and sample IG_BH02_DW016 is associated with water sample IG_BH02_GW033 taken from the interval 376.17 – 377.05 m. Drill water samples were also collected from three microbiology sample intervals: IG_BH02_DW009 (238.12 – 241.09 m), IG_BH02_DW018 (377.05 -379.14 m), and IG_BH02_DW024 (520.14 – 523.16 m). The results are summarized as follows:

- Field pH ranged from 7.77 to 10.48;
- Total alkalinity ranged from 53 to 195 mg/L $CaCO_3$ in field measured values (IG_BH02_DW004 and IG_BH02_DW016 only), and ranged from 34 to 240 mg/L $CaCO_3$ in laboratory measured values;
- Sulphate ranged from 2.7 to 14 mg/L;
- Total dissolved sulphide was below the method detection limit in field measured samples (IG_BH02_DW001, IG_BH02_DW004, IG_BH02_DW016), and was below the method detection limit (<0.02 mg/L) in all laboratory measured samples;
- Dissolved oxygen concentration measured by Hach meter ranged from 8.5 to 14.3 mg/L (IG_BH02_DW001, IG_BH02_DW004, and IG_BH02_DW016), and ranged from below the method detection limit to 11.81 mg/L in samples measured by the Horiba probe;
- Oxygen-18 ($\delta^{18}O$) ranged from -8.67 to -8.14 ‰ VSMOW;
- Deuterium ($\delta^{2}H$) ranged from -72.0 to -68.5 ‰ VSMOW;
- $\delta^{13}C$-DIC ranged from -21.3 to -14.8 ‰ PDB;
- ^{14}C-DIC ranged from 61.0 to 95.7 % modern carbon or 350 to 3967 years BP;
- ^{3}H ranged from 4.5 to 9.7 TU; and
- $^{87}Sr/^{86}Sr$ ratio ranged from 0.722 to 0.822.

Relative results of key major ions are presented in a piper plot in Figure 4. Total cation and anion concentrations in drill water are more than double those reported in water source samples. Four drill water samples are clustered and demonstrate that they are of generally consistent composition, while two samples (IG_BH02_DW001 and IG_BH02_DW018) plot in isolation from the other drill water samples. Sample IG_BH02_DW018 is more dominated by calcium and chloride with lower alkalinity, and sample IG_BH02_DW001 has no dominant anion type but is sodium/potassium dominant among cations, similar to water source samples. Samples IG_BH02_DW001 and IG_BH02_DW018 represent relatively fresh drill water with additive and minimal drilling exposure time. Sample IG_BH02_DW001 appears to have an ion composition with limited influence from additive relative to water source samples.

The ion composition of sample IG_BH02_DW018 indicates greater influence from groundwater, with elevated chloride relative to water source samples, while alkalinity remains low compared to most drill water samples. This difference is assumed to be due to influence from groundwater based on elevated chloride concentrations reported for sample IG_BH02_GW033 which was collected at similar depth (376 to 379 m).

The major ion compositions of the four clustered samples are more dominated by sodium, potassium, and bicarbonate. The four clustered samples represent drill water with longer drilling exposure time and their elevated sodium, potassium, and bicarbonate concentrations are assumed to be a result of the drilling process. Potential mechanisms for changes to drill water composition other than additive include influence from groundwater or dissolution of rock flour produced during the drilling process. Groundwater major ion compositions are incompatible as the source of influence, based on the calcium signature of groundwater samples (Figure 4). Dissolution of rock flour appears to be the most probable source of influence; however, as the composition of water influenced by dissolution of drill cuttings was not independently assessed, this mechanism cannot be confirmed.

Oxygen-18 and deuterium results are presented in Figure 5, and all drill water samples plot below and to the right of the LMWL.

Drill water samples are derived from the water source, which is collected from the municipal water supply. This water is sourced from Lake Michel, therefore it is known that the samples are primarily comprised of modern precipitation. Tritium results are consistent with this origin.

4.4 Groundwater Samples

Sample Interval 1 (14.36 – 19.16 m)

Sample IG_BH02_GW001 was collected at shallow depth within the borehole (14.36 – 19.16 mbgs along hole). Key analytical results are summarized as follows:

- Field pH of 6.04;
- Total alkalinity of 57 mg/L $CaCO_3$ in the field measured sample and 43 mg/L $CaCO_3$ in the laboratory measured sample;
- Sulphate concentration of 1.8 mg/L;
- Total dissolved sulphide was below the method detection limit in the field measured sample and below method detection limit (<0.02 mg/L) in the laboratory measured sample;
- Oxygen-18 ($\delta^{18}O$) of -13.99 ‰ VSMOW;
- Deuterium ($\delta^{2}H$) of -99.3 ‰ VSMOW;
- $\delta^{13}C$-DIC of -23.5 ‰ PDB;
- ^{14}C-DIC was not measured because the gas produced from the preparation work was not sufficient for analysis;
- ^{3}H of 10.4 TU; and
- $^{87}Sr/^{86}Sr$ ratio of 0.74825.

Results for key major ions are presented in a piper plot in Figure 4. Based on the major ion chemistry, the dominant major ions in IG_BH02_GW001 are bicarbonate and calcium.

Oxygen-18 and deuterium results are presented in Figure 5, and the sample plots in isolation from the water source, drill water and blank samples, in the lower left area of the plot above the LMWL and GMWL.

Analytical results of tritium indicate similar proportions of modern precipitation as compared to the water source and drill water values, indicating relatively recent recharge of the aquifer from surface precipitation. Tritium results are consistent with this origin, as tritium contents greater than 5 TU in natural waters are a consequence of anthropogenic nuclear activities.

Sample Interval 2 (59.30 – 64.11 m)

Sample IG_BH02_GW028 was collected at relatively shallow depth within the borehole (59.30 – 64.11 mbgs along hole). Key analytical results are summarized as follows:

- Field pH of 6.64;
- Total alkalinity of 76 mg/L $CaCO_3$ in the field measured sample and 70 mg/L $CaCO_3$ in the laboratory measured sample;
- Sulphate concentration of 3.0 mg/L;
- Total dissolved sulphide was below the method detection limit in the field measured sample and below method detection limit (<0.02 mg/L) in the laboratory measured sample;
- Oxygen-18 ($\delta^{18}O$) of -12.61 ‰ VSMOW;
- Deuterium ($\delta^{2}H$) of -91.0 ‰ VSMOW;
- $\delta^{13}C$-DIC of -18.6 ‰ PDB;
- ^{14}C-DIC of 80.6 % modern carbon or 1732 years BP;
- ^{3}H of 6.0 TU; and
- $^{87}Sr/^{86}Sr$ ratio of 0.74614.

Results for key major ions are presented in a piper plot in Figure 4. The major ion chemistry is generally similar to IG_BH02_GW001 and the dominant major ions in IG_BH02_GW028 are bicarbonate and to a lesser extent calcium.

Oxygen-18 and deuterium results are presented in Figure 5, and the sample plots in isolation from the water source, drill water and blank samples, in the lower left area of the plot on the LMWL and GMWL.

Analytical results of tritium indicate similar proportions of modern precipitation as compared to the water source and drill water values, indicating relatively recent recharge of the aquifer from surface precipitation. Tritium results are consistent with this origin.

Sample Interval 5 (374.46 – 377.05 m)

Sample IG_BH02_GW033 was collected at relatively greater depth within the borehole (374.46 – 377.05 mbgs along hole). Key analytical results are summarized as follows:

- Field pH of 7.98;
- Total alkalinity of 27 mg/L $CaCO_3$ in the field measured sample and 21 mg/L $CaCO_3$ in the laboratory measured sample;
- Sulphate concentration of 25 mg/L;
- Total dissolved sulphide was below the method detection limit in the field measured sample and below method detection limit (<0.02 mg/L) in the laboratory measured sample;

- Oxygen-18 ($\delta^{18}O$) of -12.76 ‰ VSMOW;
- Deuterium ($\delta^{2}H$) of -88.3 ‰ VSMOW;
- $\delta^{13}C$-DIC of -20.5 ‰ PDB;
- ^{14}C-DIC was not measured because gas produced from the preparation work was not sufficient for analysis;
- ^{3}H of 1.1 TU; and
- $^{87}Sr/^{86}Sr$ ratio of 0.71967.

Results for key major ions are presented in a piper plot in Figure 4. Based on the major ion chemistry, the dominant major ions in IG_BH02_GW033 are calcium and chloride. Concentrations of chloride and calcium were more than 3 orders of magnitude higher in IG_BH02_GW033 compared to the other groundwater samples. Concentrations of sulphate, magnesium and sodium were also approximately one order of magnitude higher in IG_BH02_GW033 compared to the other groundwater samples.

Oxygen-18 and deuterium results are presented in Figure 5 and the sample plots in isolation from the water source, drill water and blank samples, in the lower left area of the plot along the LMWL and GMWL. In contrast, water source and drill water samples indicate a more evaporative character by plotting below the LMWL and GMWL, which is consistent with the lake origin of these waters.

Analytical results of tritium indicate lower proportions of modern precipitation as compared to the water source and drill water values, as well as the shallower groundwater samples.

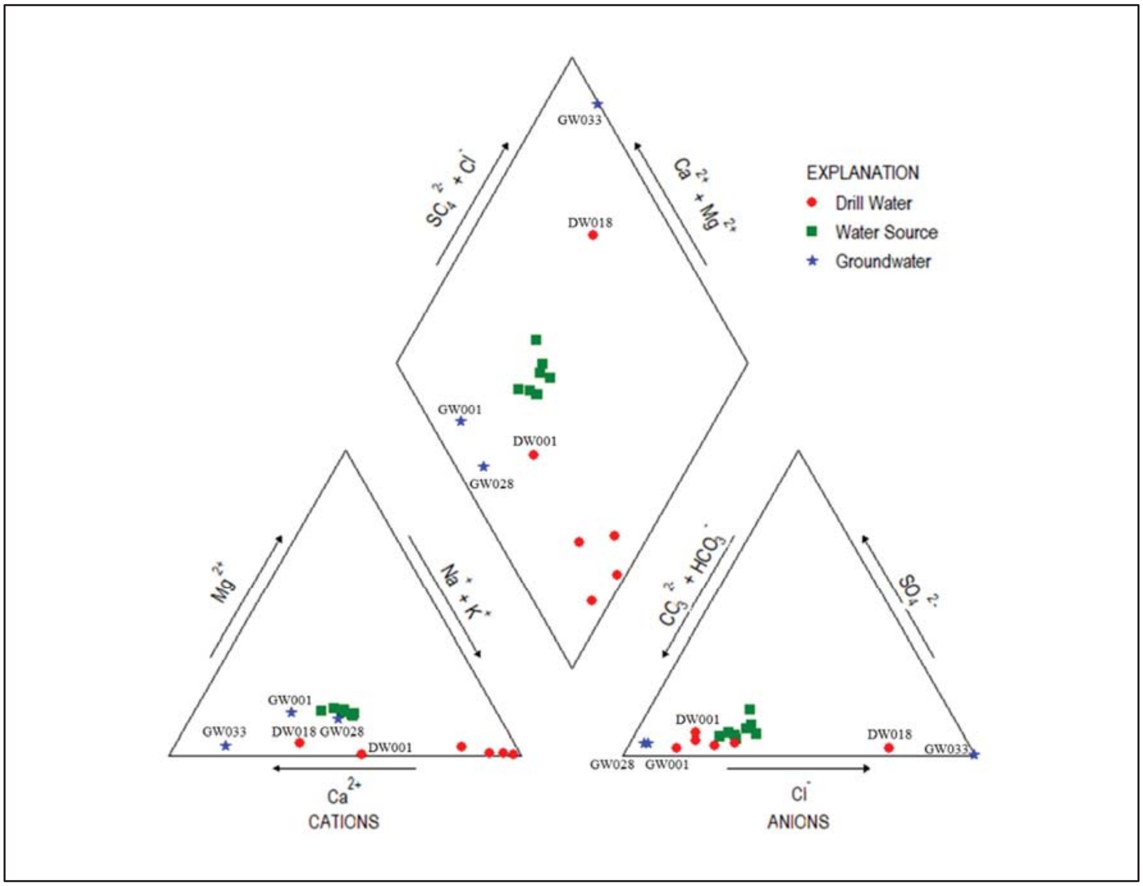

Figure 4: Piper plot of select WP07 water samples

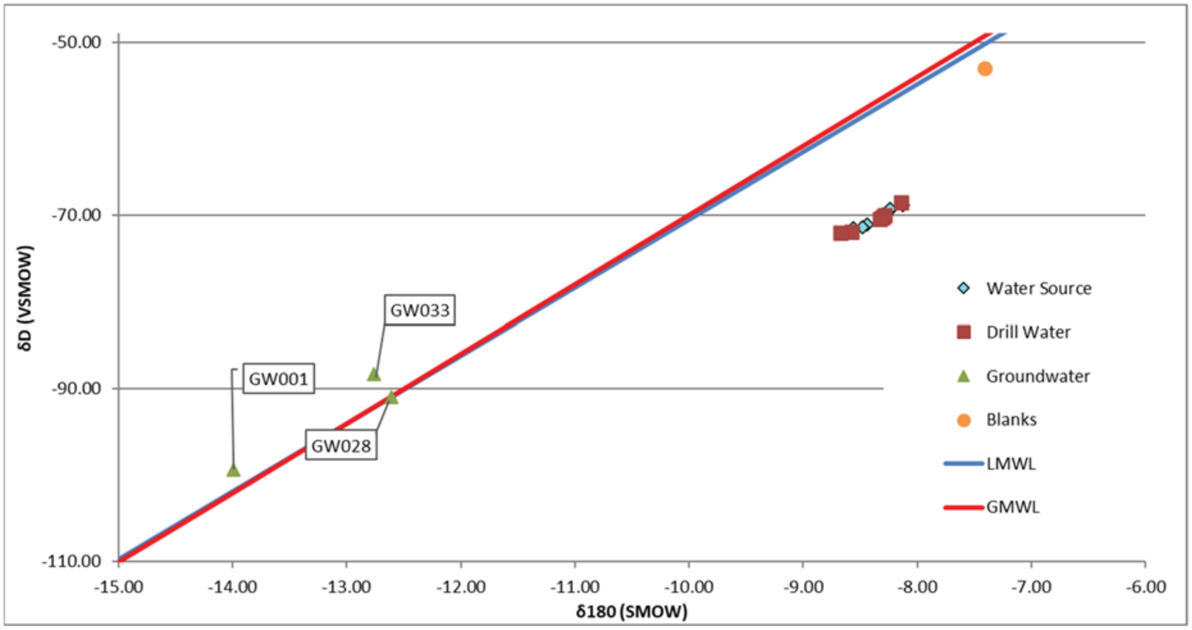

Figure 5: Oxygen (δ18O) - Deuterium (δ2H) plot of WP07 water samples. Local Meteoric Water Line for Atikokan, Ontario (Fritz et al., 1987).

4.5 QA/QC Samples

To evaluate the consistency of analytical results for IG_BH02_GW001 and duplicate sample IG_BH02_GW017, relative percent difference (RPD) was calculated for all laboratory reported parameters above detection limit as well as field measured alkalinity. A single set of field measurements was completed for all other field parameters. The majority of RPD values were below 10%, within the screening criteria of less than 20%, a typical limit for identifying variation in sample results outside normal ranges, however; the RPD for dissolved iron and ^{3}H were greater than the screening criteria, and both sets of results reported values greater than 5 times the detection limit.

No QA/QC concerns for the tritium analysis were identified by the laboratory; however, tritium results are reported with a 1 standard deviation range for each sample, and re-calculation of RPD using the lower bound value for IG_BH02_GW001 (9.2 TU) and the upper bound value for IG_BH02_GW017 (8.7 TU) results in an RPD within the screening criteria of less than 20%. Reliability of tritium results for the overall dataset is supported by the similarity of the results reported for shallow groundwater sample IG_BH02_GW001 to water source samples, and clear differences relative to the field blank sample (de-ionized water shipped from the laboratory in Mississauga, ON) reporting elevated tritium content, and the deep groundwater sample (IG_BH02_GW033) which reported lower tritium content as would be anticipated for groundwater which has not interacted with modern precipitation.

Laboratory reported QA/QC analyses for dissolved iron were completed the same day of the dissolved metals analysis was completed, and included matrix spike, spiked blank, and method blank samples, all of which were within acceptable ranges. The associated field blank (discussed further below) reported a dissolved iron concentration below detection limit. The source of difference in results for dissolved iron cannot be determined.

The total Kjeldahl nitrogen concentration for this sample was 0.17 mg/L and the reportable detection limit was 0.10 mg/L; at less than 5 times the detection limit, this is considered an acceptable result. Duplicate samples IG_BH02_GW029 (associated with OGW sample IG_BH028) and IG_BH02_GW039 (associated with OGW sample IG_BH02_GW033) were analyzed for sulphide only, and both returned below detection limit results; therefore, no RPD could be calculated; however, it is noted that both associated OGW samples also returned below detection limit results for sulphide.

One field blank (IG_BH02_GW018) associated with OGW sample IG_BH02_GW001 was submitted for comprehensive analysis and all parameters were reported at concentrations less than 5 times the method detection limit. An additional field blank (IG_BH02_GW040) associated with OGW sample IG_BH02_GW033 was submitted only for sulphide analysis and returned a below detection limit result for sulphide.

One equipment rinsate sample (IG_BH02_GW041) associated with OGW sample IG_BH02_GW033 was submitted for sulphide analysis only and returned a below detection limit result for sulphide.

The screening criteria exceedances for dissolved iron and tritium identified in the QA/QC program for WP07 water samples impact reliability of results for these constituents in sample IG_BH02_GW001; however, data from other samples and laboratory internal QA/QC suggests that these results are isolated and do not compromise the overall reliability of analytical results reported for IG_BH02.

4.6 Comparison of Water Source, Drill Water, and Groundwater Results

Water source samples (Section 4.2) generally contain lower concentrations of most constituents as compared to drill water and groundwater samples. This is consistent with the nature of the water as a treated potable supply. Comparing drill water results to OGW samples IG_BH02_GW001 and IG_BH02_GW028, the drill water samples contain higher concentrations of most parameters, while nitrate and sulphide are below the laboratory method detection limits in all drill water samples as well as IG_BH02_GW001 and IG_BH02_GW028. Comparing drill water results to OGW sample IG_BH02_GW033, the drill water samples generally contain lower concentrations of most parameters. Drill water samples were turbid, and samples IG_BH02_DW009 and IG_BH02_DW024 reported turbidity greater than 1000 NTU. Sulphide was below the method detection limit in all sample types, while pH, sulphate and alkalinity were generally higher in the drill water samples as compared to water source and groundwater samples.

Drill water samples collected after extended drilling intervals have a cation composition (Figure 4) that is sodium and potassium dominant as compared to water source and groundwater samples, while fresh drill water samples have a cation composition more similar to water source samples, indicating that drill water composition is influenced by the drilling process (potentially due to dissolution of rock flour produced during drilling). Groundwater samples IG_BH02_GW001 and IG_BH02_GW028 generally have a similar relative cation and anion characteristics to water source samples, with a stronger bicarbonate signature, while absolute cation concentrations are more than double water source samples. Groundwater sample IG_BH02_GW033 had an ion composition distinct from all other WP07 samples and the ion composition was dominated by calcium and chloride.

Drill water and water source samples plot in a cluster on Figure 5, indicating the oxygen-18 – deuterium composition of drill water is reflective of the original water source it was derived from. Groundwater samples IG_BH02_GW001, IG_BH02_GW028 and IG_BH02_GW033 plot well to the lower left of all other samples, with more strongly negative values for both $\delta^{18}O$ and $\delta^{2}H$.

The blank sample plots in the upper right of the figure and has a distinct composition as compared to all other samples, which is appropriate given that the de-ionized water was supplied by the laboratory, and therefore bears no relation to local waters.

4.7 Drill Water Contamination of Groundwater Samples

As described in Section 3.3.10, calculations can be completed to determine the proportion of drill water that comprises a groundwater sample, and subsequently this result can be used to determine corrected parameter concentrations for groundwater samples. The corrected analyte values applying the calculated fraction of drill water in each OGW sample are presented in Appendix B.

Prior to the start of purging for sample IG_BH02_GW001 (14.36 – 19.16 mbgs, along borehole), the borehole was circulated with clean drill water with a measured fluorescein concentration of 98.6 ppb. Sample IG_BH02_DW001 is the drill water sample associated with groundwater sample IG_BH02_GW001. Sample IG_BH02_GW001 contained 4.84 ppb fluorescein. The percentage of drill fluid in sample IG_BH02_GW001 can be calculated as 4.9% based on a fluorescein concentration in the drill fluid of 98.6 ppb.

Prior to the start of purging for groundwater sample IG_BH02_GW028 (59.30 – 64.11 mbgs, along borehole), the borehole was circulated with clean drill water with a measured fluorescein concentration of 82.8 ppb. Sample IG_BH02_DW004 is the drill water sample associated with groundwater sample IG_BH02_GW028. Sample IG_BH02_GW028 contained 10.19 ppb fluorescein. The percentage of drill fluid in sample IG_BH02_GW028 can be calculated as 12.3% based on a fluorescein concentration in the drill fluid of 82.8 ppb.

Prior to the start of purging for groundwater sample IG_BH02_GW033 (374.46 – 377.05 mbgs, along borehole), the borehole was circulated with clean drill water with a measured fluorescein concentration of 132.4 ppb. Sample IG_BH02_DW016 is the drill water sample associated with groundwater sample IG_BH02_GW033. Sample

IG_BH02_GW033 contained 4.70 ppb fluorescein. The percentage of drill fluid in sample IG_BH02_GW033 can be calculated as 3.6% based on a fluorescein concentration in the drill fluid of 132.4 ppb.

5.0 REFERENCES

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APPENDIX A

Table A-1: Sample Summary Description for IG_BH02 Fluid Samples

Table A-2: Laboratory Analytical Methodology

Table A-3: Water Source and Drill Water Sample Results

Table A-4: QA/QC Water Quality Results

Table A-1: Summary of Analyses for Groundwater, Drill Water and Water Source Samples Collected for IG_BH02

Sample ID	Date Collected	Time Collected	Depth		Bottle Sets for Laboratory Analysis											In-Field Geochemistry				In-Field Measurements[1]	Microbiology[4]			Purpose of Sample
					Major Elements & Metals[2]			Anions & Nutrients[2]			Stable Isotopes[3]			Radioisotopes[3]										
			From (mbgs)	To (mbgs)	Na, K, Ca, Mg, Sr, Li, Si, S_{Total}, Fe_{Total}	SiO_2	S^{2-}_{Total}	Br, F, Cl, I, SO_4, PO_4, NO_3, NO_2	Alkalinity	NH_4+NH_3, N_{total} P_{Total}	$\delta^{18}O$, δ^2H	$^{87}Sr/^{86}Sr$	$\delta^{13}C$ DIC	^{14}C-DIC	^3H	Sulphide	Dissolved Oxygen	Ferrous Iron	Alkalinity		PLFA	DNA	Cell Count	
IG_BH02_DW001	29-Sep-19	13:39	14.36	19.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	Drill fluid for OGW GW001, microbiology sample interval
IG_BH02_DW002	29-Sep-19	16:05	14.36	19.16																	✓	✓	✓	Microbiology QA/QC, duplicate of DW001
IG_BH02_DW003	04-Oct-19	8:25	52.13	55.16																✓				Archive @ 50m
IG_BH02_DW004	08-Oct-19	11:10	59.30	64.11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Drill fluid for OGW GW0028, microbiology sample interval
IG_BH02_DW005	08-Oct-19	22:30	59.30	64.11																	✓	✓	✓	Microbiology QA/QC, duplicate of DW004
IG_BH02_DW006	08-Oct-19	0:30	97.10	100.10																✓				Archive @ 100m
IG_BH02_DW007	14-Oct-19	2:47	148.13	150.73																✓				Archive @ 150m
IG_BH02_DW008	15-Oct-19	16:00	199.16	202.16																✓				Archive @ 200m
IG_BH02_DW009	17-Oct-19	0:30	238.12	241.09	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	Microbiology core sample interval
IG_BH02_DW010	17-Oct-19	0:30	238.12	241.09																	✓	✓	✓	Microbiology QA/QC, duplicate of DW009
IG_BH02_DW011	17-Oct-19	0:30	238.12	241.09																	✓	✓	✓	Microbiology QA/QC, blank of DW009
IG_BH02_DW012	17-Oct-19	5:34	247.12	250.11																✓				Archive @ 250m
IG_BH02_DW013	18-Oct-19	4:47	280.14	283.12																				Drill fluid for OGW attempt GW0031, sample not collected due to insufficient purge rate; null sample ID
IG_BH02_DW014	20-Oct-19	1:56	298.16	301.13																✓				Archive @ 300m
IG_BH02_DW015	22-Oct-19	2:00	349.71	352.15																✓				Archive @ 350m
IG_BH02_DW016	23-Oct-19	10:03	376.17	377.05	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Drill fluid for OGW GW0033, microbiology sample interval
IG_BH02_DW017	23-Oct-19	10:03	376.17	377.05																	✓	✓	✓	Microbiology QA/QC, duplicate of DW016
IG_BH02_DW018	27-Oct-19	15:36	377.05	379.14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	Microbiology core sample interval
IG_BH02_DW019	27-Oct-19	15:36	377.05	379.14																	✓	✓	✓	Microbiology QA/QC, duplicate of DW018
IG_BH02_DW020	27-Oct-19	15:36	377.05	379.14																	✓	✓	✓	Microbiology QA/QC, blank of DW018
IG_BH02_DW021	02-Nov-19	3:45	400.17	403.16																✓				Archive @ 400m
IG_BH02_DW022	04-Nov-19	1:45	448.15	451.15																✓				Archive @ 450m
IG_BH02_DW023	05-Nov-19	10:30	499.16	502.10																✓				Archive @ 500m
IG_BH02_DW024	06-Nov-19	1:15	520.14	523.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	Microbiology core sample interval
IG_BH02_DW025	06-Nov-19	1:15	520.14	523.16																	✓	✓	✓	Microbiology QA/QC, duplicate of DW024
IG_BH02_DW026	06-Nov-19	1:15	520.14	523.16																	✓	✓	✓	Microbiology QA/QC, blank of DW024
IG_BH02_DW027	06-Nov-19	5:40	547.15	550.17																✓				Archive @ 550m
IG_BH02_DW028	09-Nov-19	13:56	598.02	601.10																✓				Archive @ 600m
IG_BH02_DW029	11-Nov-19	9:05	649.13	652.10																✓				Archive @ 650m
IG_BH02_DW030	14-Nov-19	11:40	697.13	700.12																✓				Archive @ 700m
IG_BH02_DW031	16-Nov-19	3:20	748.09	751.12																✓				Archive @ 750m
IG_BH02_DW032	18-Nov-19	3:20	799.13	802.13																✓				Archive @ 800m
IG_BH02_DW033	20-Nov-19	5:25	847.13	850.12																✓				Archive @ 850m
IG_BH02_DW034	22-Nov-19	0:20	898.12	901.13																✓				Archive @ 900m
IG_BH02_DW035	24-Nov-19	12:00	949.13	952.11																✓				Archive @ 950m
IG_BH02_DW036	26-Nov-19	5:22	997.13	1000.12																✓				Archive @ 1000m
IG_BH02_GW001	01-Oct-19	21:08	14.36	19.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Opportunistic GW sample
IG_BH02_GW002	29-Sep-19	8:09	14.36	19.16																✓				GW001 purge archive @ 1 system volume
IG_BH02_GW003	29-Sep-19	14:39	14.36	19.16																✓				GW001 purge archive @ 2 system volume
IG_BH02_GW004	29-Sep-19	19:01	14.36	19.16																✓				GW001 purge archive @ 3 system volume
IG_BH02_GW005	30-Sep-19	1:30	14.36	19.16																✓				GW001 purge archive @ 4 system volume
IG_BH02_GW006	30-Sep-19	6:00	14.36	19.16																✓				GW001 purge archive @ 5 system volume
IG_BH02_GW007	30-Sep-19	10:02	14.36	19.16																✓				GW001 purge archive @ 6 system volume
IG_BH02_GW008	30-Sep-19	13:34	14.36	19.16																✓				GW001 purge archive @ 7 system volume
IG_BH02_GW009	30-Sep-19	17:10	14.36	19.16																✓				GW001 purge archive @ 8 system volume
IG_BH02_GW010	30-Sep-19	21:10	14.36	19.16																✓				GW001 purge archive @ 9 system volume
IG_BH02_GW011	01-Oct-19	1:00	14.36	19.16																✓				GW001 purge archive @ 10 system volume
IG_BH02_GW012	01-Oct-19	5:00	14.36	19.16																✓				GW001 purge archive @ 11 system volume
IG_BH02_GW013	01-Oct-19	8:21	14.36	19.16																✓				GW001 purge archive @ 12 system volume
IG_BH02_GW014	01-Oct-19	11:34	14.36	19.16																✓				GW001 purge archive @ 13 system volume
IG_BH02_GW015	01-Oct-19	15:37	14.36	19.16																✓				GW001 purge archive @ 14 system volume
IG_BH02_GW016	01-Oct-19	19:04	14.36	19.16																✓				GW001 purge archive @ 15 system volume
IG_BH02_GW017	01-Oct-19	23:07	14.36	19.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	Duplicate of OGW GW001
IG_BH02_GW018	03-Oct-19	2:20	14.36	19.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						✓	✓	✓	Blank with OGW GW001
IG_BH02_GW019	-	-	-	-																				Null Sample ID; failed sample attempt
IG_BH02_GW020	05-Oct-19	15:25	59.30	64.11																✓				GW028 purge archive @ 1 system volume
IG_BH02_GW021	05-Oct-19	15:49	59.30	64.11																✓				GW028 purge archive @ 2 system volume
IG_BH02_GW022	05-Oct-19	16:22	59.30	64.11																✓				GW028 purge archive @ 3 system volume
IG_BH02_GW023	05-Oct-19	16:50	59.30	64.11																✓				GW028 purge archive @ 4 system volume
IG_BH02_GW024	05-Oct-19	17:12	59.30	64.11																✓				GW028 purge archive @ 5 system volume
IG_BH02_GW025	05-Oct-19	17:55	59.30	64.11																✓				GW028 purge archive @ 6 system volume
IG_BH02_GW026	05-Oct-19	18:07	59.30	64.11																✓				GW028 purge archive @ 7 system volume
IG_BH02_GW027	05-Oct-19	19:50	59.30	64.11																✓				GW028 purge archive @ 8 system volume
IG_BH02_GW028	08-Oct-19	10:35	59.30	64.11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Opportunistic GW sample (final purge sample from interval; originally intended to be GW019, but purging terminated due to bypass)
IG_BH02_GW029	08-Oct-19	11:00	59.30	64.11			✓													✓	✓	✓	✓	Duplicate of GW028 for sulphide & microbiology
IG_BH02_GW030	08-Oct-19	22:10	59.30	64.11																	✓	✓	✓	Blank with OGW GW028 for microbiology
IG_BH02_GW031	18-Oct-19	-	278.33	283.12																				Abandoned sample attempt due to insufficient purge rate
IG_BH02_GW032	22-Oct-19	-	344.43	358.16																				Abandoned sample attempt due to insufficient purge rate
IG_BH02_GW033	26-Oct-19	22:00	374.46	377.05	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Opportunistic GW sample
IG_BH02_GW034	25-Oct-19	5:20	374.46	377.05																✓				GW033 purge archive @ 1 system volume
IG_BH02_GW035	25-Oct-19	8:20	374.46	377.05																✓				GW033 purge archive @ 1.6 system volumes
IG_BH02_GW036	25-Oct-19	11:58	374.46	377.05																✓				GW033 purge archive @ 2.2 system volumes
IG_BH02_GW037	25-Oct-19	17:30	374.46	377.05																✓				GW033 purge archive @ 3.2 system volumes
IG_BH02_GW038	26-Oct-19	1:55	374.46	377.05																✓				GW033 purge archive @ 4.7 system volumes
IG_BH02_GW039	26-Oct-19	22:00	374.46	377.05			✓													✓	✓	✓	✓	Duplicate of GW033 for sulphide & microbiology
IG_BH02_GW040	26-Oct-19	22:00	374.46	377.05			✓														✓	✓	✓	Blank with OGW GW033 for sulphide & microbiology
IG_BH02_GW041	26-Oct-19	22:00	374.46	377.05			✓																	Rinsate blank for OGW GW033 for sulphide
IG_BH02_WS001	22-Sep-19	11:00	0.00	0.01	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS002	01-Oct-19	16:10	19.15	19.16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS003	08-Oct-19	16:27	100.09	100.10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS004	10-Oct-19	15:55	100.10	100.11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS005	17-Oct-19	18:30	259.16	259.17	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS006	31-Oct-19	13:00	397.17	397.18	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS007	13-Nov-19	11:26	688.14	688.15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling
IG_BH02_WS008	22-Nov-19	10:20	910.15	913.09	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Water source sample for drilling

Notes

IG_BH02_GWxxx indicates a groundwater sample

IG_BH02_DWxxx indicates a drill water sample

IG_BH02_WSxxx indicates a water source (fresh water supply) sample

[1] In-field measurements include the fluorescein concentration measured with an Aqualuor Fluorometer, and the following parameters measured with a Horiba U52-2 Multiprobe: temperature, pH, electrical conductivity, ORP, turbidity and dissolved oxygen. Density measurements were also collected for archive drill water samples using a hydrometer and included as part of WP02 Data Delivery. In-field measurements for archive drill water samples are reported under WP02 Data Delivery.

[2] Laboratory analyses completed by Bureau Veritas (BV)

[3] Laboratory analyses completed by Isotope Tracer Technologies (IT2)

[4] IG_BH02_DW001 sampled for microbiology on 29-Sep-19 at 15:21; IG_BH02_DW004 sampled for microbiology on 08-Oct-19 at 22:30; IG_BH02_DW009 sampled for microbiology on 17-Oct-19 at 11:30; IG_BH02_DW016 sampled for microbiology on 23-Oct-19 at 10:03; IG_BH02_DW018 sampled for microbiology on 27-Oct-19 at 15:36; IG_BH02_DW024 sampled for microbiology on 06-Nov-19 at 01:15; IG_BH02_GW028 sampled for microbiology on 08-Oct-19 at 21:30; IG_BH02_GW018 sampled for microbiology on 02-Oct-19 at 01:30; IG_BH02_GW029 sampled for microbiology on 08-Oct-19 at 21:45

Prepared By: NS
Checked By: ML
Reviewed By: KDV

Table A-2: WP07 Laboratory Analytical Methodology

Parameter	Units	Method	Method Detection Limit (conventional parameters) Standard Deviation (isotopes)
ANIONS & NUTRIENTS			
Bromide	mg/L	Ion Chromatography (CAM SOP-00435)	1.0
Chloride	mg/L	Ion Chromatography (CAM SOP-00435)	1.0
Iodide	mg/L	Ion Chromatography (CAL SOP-00057)	0.1
Fluoride	mg/L	Potentiometry - ISE (CAM SOP-00449)	0.1
Nitrite	as N mg/L	Colourimetry (CAM SOP-00440)	0.01
Nitrate	as N mg/L	Colourimetry (CAM SOP-00440)	0.1
Total Ammonia	as N mg/L	Colourimetry (CAM SOP-00441)	0.05
Total Kjeldahl Nitrogen	as N mg/L	SKAL (CAM SOP-00938)	0.1
Orthophosphate	mg/L	KONE (CAM SOP-00461)	0.01
Total Phosphorus	mg/L	Colourimetry (CAM SOP-00407)	0.02
Sulphate	mg/L	Automated Colourimetry	1.0
Sulphide	mg/L	ISE (CAM SOP-00455)	0.02
TOTAL AND DISSOLVED METALS			
Calcium	mg/L	ICP/MS (CAM SOP-00447)	0.2
Iron	mg/L	ICP/MS (CAM SOP-00447)	0.1
Lithium	mg/L	ICP/MS (CAM SOP-00447)	0.005
Magnesium	mg/L	ICP/MS (CAM SOP-00447)	0.05
Potassium	mg/L	ICP/MS (CAM SOP-00447)	0.2
Silicon	mg/L	ICP/MS (CAM SOP-00447)	0.05
Sodium	mg/L	ICP/MS (CAM SOP-00447)	0.1
Strontium	mg/L	ICP/MS (CAM SOP-00447)	0.001
Silica	mg/L	KONE (AB SOP-00011)	0.05
Sulphur	mg/L	ICP/MS (CAM SOP-00447)	0.05
STABLE ISOTOPES			
$\delta^{18}O$	VSMOW	Cavity Ring Down Spectroscopy	±0.1‰
$\delta^{2}H$	VSMOW	Cavity Ring Down Spectroscopy	±1‰
$^{87}Sr/^{86}Sr$	ratio	Thermal Ionization Mass Spectrometry	±0.0001
$\delta^{13}C$ DIC	PDB	Finnigan MAT, DeltaPlus XL IRMS	±0.2‰
RADIOISOTOPES			
^{14}C-DIC	years BP	Accelerator Mass Spectrometry	25-111
^{3}H	TU	Liquid Scintillation Counting	±1

Notes:

1) Detection limits are not applicable to isotopes as measurement is relative to a standard rather than absolute.

2) When a sample required dilution, the detection limit is adjusted accordingly. Adjusted detection limits are specified in the Laboratory Certificates of Analyses (COAs) for BV included in the data deliverable.

Prepared By: NS
Checked By: BT
Reviewed By: ML

Table A-3: Water Supply and Drill Water Sample Results

Sample Type		Source Water								Drill Water					
Sample Date		2019-09-22	2019-10-01	2019-10-08	2019-10-10	2019-10-17	2019-10-31	2019-11-13	2019-11-22	2019-09-29	2019-10-08	2019-10-17	2019-10-23	2019-10-27	2019-11-06
Sample ID		IG_BH02 _WS001	IG_BH02_ WS002	IG_BH02 _WS003	IG_BH0 _WS004	IG_BH02 _WS005	IG_BH02 _WS006	IG_BH02 _WS007	IG_BH02 _WS008	IG_BH02_DW 001	IG_BH02_DW 004	IG_BH02_DW 009	IG_BH02_DW 016	IG_BH02_DW 018	IG_BH02_DW 024
Associated OGW Sample										IG_BH02_GW 001	IG_BH02_GW 028		IG_BH02_GW 033		
GENERAL PARAMETERS															
pH (field)	-	7.21	7.51	7.41	7.22	7.28	7.5	7.48	7.16	10.48	9.23	9.70	8.72	7.77	10.37
Temperature (field)	°C	18.12	12.2	15.17	15.33	12.72	7.12	17.71	5.65	19.56	11.23	14.49	10.94	10.61	10.41
ORP (field)	mV	530	624	570	659	590	657	621	650	90	263	86	207	341	10
EC (field)	mS/cm	0.051	0.06	0.056	0.060	0.039	0.043	0.042	0.041	0.267	0.120	0.519	0.565	0.299	0.829
Turbidity (field)	NTU	BDL	5.1	BDL	BDL	BDL	BDL	BDL	BDL	>1000	>1000	>1000	>1000	>1000	>1000
Fluorescein (field)	ppb	NA	NA	NA	NA	NA	NA	NA	NA	98.6	82.8	80.6	132.4	63.7	103.5
Dissolved Oxygen (field-Horiba)	mg/L	6.91	8.97	6.40	6.31	4.95	8.46	10.49	13.65	7.50	6.78	11.81	4.84	7.10	BDL
[1]Dissolved Oxygen (field-Hach)	mg/L	8.7	10.8	10.5	9.8	10.3	-[8]	9	9.3	10.2	8.5	-	14.3	-	-
Total Alkalinity (lab)	mg/L $CaCO_3$	14	16	14	14	14	16	15	-	86	45	170	240	34	240
[2]Total Alkalinity (field)	mg/L $CaCO_3$	16	21	18	18	19	18	20	17	-	53	-	195	-	-
[6]Total Alkalinity	mg/L HCO_3^-	17	20	17	17	17	20	18	20	105	55	207	293	41	293
Hydroxide Alkalinity (speciated)	mg/L $CaCO_3$	0	0	0	0	0	0	0	0	10	1	2	0	0	8
Hydroxide Alkalinity (speciated)	mg/L OH^-	0	0	0	0	0	0	0	0	3	0	1	0	0	3
Carbonate Alkalinity (speciated)	mg/L $CaCO_3$	0	0	0	0	0	0	0	0	57	6	56	12	0	163
Carbonate Alkalinity (speciated)	mg/L CO_3^{2-}	0	0	0	0	0	0	0	0	34	4	34	7	0	98
Bicarbonate Alkalinity (speciated)	mg/L $CaCO_3$	14	16	14	14	14	16	15	17	19	38	112	228	34	69
Bicarbonate Alkalinity (speciated)	mg/L HCO_3^-	17	19	17	17	17	19	18	20	23	46	137	278	41	84
Charge Balance	-	0.5%	-2.7%	-1.0%	2.1%	5.5%	-4.1%	2.9%	-3.6%	2.3%	-0.4%	8.7%	12.1%	1.4%	6.6%
ANIONS & NUTRIENTS															
Bromide	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.2	<1.0	1.5	1.3
Chloride	mg/L	5.9	6.1	5.0	5.1	4.4	5.1	4.2	4.2	12	7.5	41	29	78	74
Iodide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	1.1	<0.10	2.6
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.20	0.21	1.1	1.3	0.12	1.0
Nitrite	as N mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.123	0.047	<0.010	<0.010
Nitrate	as N mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrite + Nitrate	as N mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Ammonium	mg/L	0.099	<0.05	<0.05	<0.05	0.11	0.07	<0.05	<0.05	<0.05	<0.05	0.13	0.24	<0.00069	0.21
Total Ammonia	as N mg/L	0.077	<0.050	<0.050	<0.050	0.082	0.055	<0.050	<0.050	0.27	<0.050	0.24	0.20	<0.050	0.90
Total Kjeldahl Nitrogen	as N mg/L	0.20	0.23	0.33	0.32	0.22	0.22	0.29	0.23	1.4	0.46	13	27	0.84	27
Orthophosphate	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.017	0.02	0.25	0.21	<0.20	0.11
Total Phosphorus	mg/L	<0.020	0.072	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.042	0.028	0.66	0.26	0.069	0.48
Sulphate	mg/L	1.6	2.6	1.9	3.6	1.4	1.3	1.6	1.4	7.1	2.7	7.7	6.5	3.3	14
Sulphide (lab)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
[1]Sulphide (field)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-	BDL	-	-
Hydrogen Sulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Bisulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Reactive Silica (SiO2)	mg/L	3.7	3.5	3.3	3	2.7	2.6	2.9	2.9	20	10	21	17	3.6	36
METALS															
Dissolved Calcium	mg/L	4.3	4.3	3.9	5.2	4	3.8	4.2	4.1	21	3.6	2.3	6.6	37	14
Dissolved Iron	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	0.29	4	<0.1	4.1
[1]Ferrous Iron (field-Hach)	mg/L	BDL	0.01[7]	0.10	0.01	0.03	BDL	BDL	BDL	0.21[7]	0.19	-	1.74[7]	-	-
Dissolved Lithium	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.046	0.049	0.27	0.41	0.017	0.25
Dissolved Magnesium	mg/L	0.84	0.82	0.82	0.93	0.8	0.74	0.83	0.85	0.13	0.42	0.24	0.71	1.5	0.89
Dissolved Potassium	mg/L	0.42	0.55	0.44	0.45	0.41	0.4	0.43	0.48	12	6.7	30	37	2.6	37
Dissolved Silicon	mg/L	1.7	1.6	1.5	1.4	1.2	1.2	1.3	1.3	9.9	5.7	5.9	13	1.8	40
Dissolved Sodium	mg/L	4.5	5.2	4.2	4.1	4.9	4.5	4.5	3.8	22	18	110	140	23	150
Dissolved Strontium	mg/L	0.012	0.013	0.012	0.013	0.011	0.0099	0.011	0.011	0.055	0.0092	0.008	0.026	0.38	0.064
Total Sulphur	mg/L	0.56	0.61	0.48	1.1	0.5	0.5	0.53	0.48	2.5	0.79	3.3	2.9	1.3	7
STABLE ISOTOPES															
$\delta^{18}O$	VSMOW	-8.27	-8.25	-8.24	-8.44	-8.30	-8.48	-8.13	-8.56	-8.30	-8.29	-8.14	-8.33	-8.58	-8.67
$\delta^{2}H$	VSMOW	-69.9	-69.5	-69.3	-71.1	-69.9	-71.4	-68.8	-71.5	-70.2	-70.0	-68.5	-70.4	-71.9	-72.0
$^{87}Sr/^{86}Sr$	ratio	0.76868	0.73455	0.73047	0.72904	0.73023	0.72698	0.73087	0.72337	0.74857	0.78313	0.81588	0.82238	0.72218	0.80307
$\delta^{13}C$ DIC	PDB	-8.5	-10.3	-11.6	-11.0	-7.9	-9.4	-10.8	-6.5	-17.8	-14.9	-21.3	-21.0	-14.8	-18.7
RADIOISOTOPES															
^{14}C-DIC	years BP	-[5]	177	-[5]	-[5]	209	-[5]	-[5]	-[5]	350	1652	3729	3967	1939	970
^{3}H	TU	11.5	9.2	9.6	9.4	10.6	7.4	12.5	12.2	9.6	9.2	9.7	4.5	9.1	8.9

Notes:

[1] Hach model DR2800 Spectrophotometer used for field readings.

[2] Alkalinity kit model 10-400 mg/L Model AL-DT used for field titration.

[3] Calculation not possible due to at least one input either below detection limit or not reported.

[4] Reading masked by high turbidity.

[5] Produced gas from preparation work not sufficient for analysis

[6] Total Alkalinity as HCO3- calculated based on laboratory reported alkalinity result. Where only a field reported alkalinity result was available, the field value was used.

[7] The test plan and manufacturer's procedure specified a reagent blank was to be prepared and used to zero the spectrophotometer prior to sample readings. These samples were associated with a blank reading recorded as a calibration check only and the instrument not zeroed. Following the Hach recommendation for non-zero blank readings where the instrument is not zeroed, the blank value has been subtracted from the sample reading. This corrected value is the reported value.

[8] Measurement not reported due to field error during high range analysis of DO

For Charge Balance, Total Alkalinity and speciated value calculations, see Calculations spreadsheet as part of the Data Deliverable
"NA": Parameter not applicable to this sample type.
"-": Analyses not performed. No value reported.
"BDL": Result below method detection limit.

Prepared By:	SR
Checked By:	BT
Reviewed By:	ML

Sample Type		Opportunistic Groundwater Samples			Blank		Rinsate	Duplicate					
Sample Date		2019-10-01	2019-10-08	2019-10-26	2019-10-03	2019-10-26	2019-10-26	2019-10-01		2019-10-08		2019-10-26	
Sample ID		IG_BH02_GW001	IG_BH02_GW028	IG_BH02_GW033	IG_BH02_GW018	IG_BH02_GW040	IG_BH02_GW041	IG_BH02_GW017	Relative Percent Difference (%)	IG_BH02_GW029	Relative Percent Difference (%)	IG_BH02_GW039	Relative Percent Difference (%)
Associated OGW Sample					IG_BH02_GW001	IG_BH02_GW033	IG_BH02_GW033	IG_BH02_GW001		IG_BH02_GW028		IG_BH02_GW033	
GENERAL PARAMETERS													
pH (field)	-	6.04	6.64	7.98	-	-	-	6.04	-[3]	6.64	-[3]	7.98	-[3]
Temperature (field)	°C	7.91	8.99	9.37	-	-	-	7.91	-[3]	8.99	-[3]	9.37	-[3]
ORP (field)	mV	74	23	-492	-	-	-	74	-[3]	23	-[3]	-492	-[3]
EC (field)	mS/cm	0.098	0.171	21.8	-	-	-	0.098	-[3]	0.171	-[3]	21.8	-[3]
Turbidity (field)	NTU	BDL	15.5	BDL	-	-	-	BDL	-[3]	15.5	-[3]	BDL	-[3]
Fluorescein (field)	ppb	4.84	10.19	4.70	-	-	-	4.84	-[3]	10.19	-[3]	4.70	-[3]
Dissolved Oxygen (field-Horiba)	mg/L	BDL	0.36	BDL	-	-	-	BDL	-[3]	0.36	-[3]	BDL	-[3]
[1]Dissolved Oxygen (field-Hach)	mg/L	2.2	9.2	12.3	-	-	-	-	-[3]	-	-[3]	-	-[3]
Total Alkalinity (lab)	mg/L CaCO$_3$	43	70	21	<1.0	-	-	44	-2.3	-	-[3]	-	-[3]
[2]Total Alkalinity (field)	mg/L CaCO$_3$	57	76	27	-	-	-	-	-[3]	-	-[3]	-	-[3]
[6]Total Alkalinity	mg/L HCO$_3^-$	52	85	26	-	-	-	54	-2.3	-	-[3]	-	-[3]
Hydroxide Alkalinity (speciated)	mg/L CaCO$_3$	0	0	0	-	-	-	0	0.0	-	-[3]	-	-[3]
Hydroxide Alkalinity (speciated)	mg/L OH$^-$	0	0	0	-	-	-	0	0.0	-	-[3]	-	-[3]
Carbonate Alkalinity (speciated)	mg/L CaCO$_3$	0	0	0	-	-	-	0	-2.3	-	-[3]	-	-[3]
Carbonate Alkalinity (speciated)	mg/L CO$_3^{2-}$	0	0	0	-	-	-	0	-2.3	-	-[3]	-	-[3]
Bicarbonate Alkalinity (speciated)	mg/L CaCO$_3$	43	70	21	-	-	-	44	-2.3	-	-[3]	-	-[3]
Bicarbonate Alkalinity (speciated)	mg/L HCO$_3^-$	52	85	25	-	-	-	54	-2.3	-	-[3]	-	-[3]
Charge Balance	-	-0.5%	-0.5%	1.5%	-	-	-	-2.0%	-	-	-[3]	-	-[3]
ANIONS & NUTRIENTS													
Bromide	mg/L	<1.0	<1.0	150	<1.0	-	-	<1.0	-[3]	-	-[3]	-	-[3]
Chloride	mg/L	1.8	2.2	7100	<1.0	-	-	1.8	0	-	-[3]	-	-[3]
Iodide	mg/L	<0.10	<0.10	0.33	<0.10	-	-	<0.10	-[3]	-	-[3]	-	-[3]
Fluoride	mg/L	<0.10	0.17	0.75	<0.10	-	-	<0.10	-[3]	-	-[3]	-	-[3]
Nitrite	as N mg/L	<0.010	<0.010	<0.010	<0.010	-	-	<0.010	-[3]	-	-[3]	-	-[3]
Nitrate	as N mg/L	<0.10	<0.10	<0.10	<0.10	-	-	<0.10	-[3]	-	-[3]	-	-[3]
Nitrite + Nitrate	as N mg/L	<0.10	<0.10	<0.10	<0.10	-	-	<0.10	-[3]	-	-[3]	-	-[3]
Ammonium	mg/L	<0.05	<0.05	0.74	<0.05	-	-	<0.05	-[3]	-	-[3]	-	-[3]
Total Ammonia	as N mg/L	<0.050	<0.050	0.59	<0.050	-	-	<0.050	-[3]	-	-[3]	-	-[3]
Total Kjeldahl Nitrogen	as N mg/L	0.12	<0.10	0.85	<0.10	-	-	0.17	-[8]	-	-[3]	-	-[3]
Orthophosphate	mg/L	<0.010	<0.010	<0.010	<0.010	-	-	<0.010	-[3]	-	-[3]	-	-[3]
Total Phosphorus	mg/L	<0.020	<0.020	0.027	<0.020	-	-	<0.020	-[3]	-	-[3]	-	-[3]
Sulphate	mg/L	1.8	3.0	25	<1.0	-	-	2.0	-10.5	-	-[3]	-	-[3]
Sulphide (lab)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	-[3]	<0.020	-[3]	<0.020	-[3]
[1]Sulphide (field)	mg/L	BDL	BDL	BDL	-	-	-	-	-[3]	-	-[3]	-	-[3]
Hydrogen Sulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-	-	-[3]	-[3]	-	-[3]	-	-[3]
Bisulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-	-	-[3]	-[3]	-	-[3]	-	-[3]
Reactive Silica (SiO2)	mg/L	18	16	14	<0.050	-	-	18	0	-	-[3]	-	-[3]
METALS													
Dissolved Calcium	mg/L	11.0	14.0	3400	<0.2	-	-	11.0	0	-	-[3]	-	-[3]
Dissolved Iron	mg/L	1.4	<0.1	2.4	<0.1	-	-	0.84	50	-	-[3]	-	-[3]
[1]Ferrous Iron (field-Hach)	mg/L	5.52[7]	0.03	1.29	-	-	-	-	-[3]	-	-[3]	-	-[3]
Dissolved Lithium	mg/L	0.028	0.052	0.33	<0.005	-	-	0.028	0	-	-[3]	-	-[3]
Dissolved Magnesium	mg/L	1.60	2.20	85.0	<0.05	-	-	1.60	0	-	-[3]	-	-[3]
Dissolved Potassium	mg/L	2.50	4.60	15.0	<0.2	-	-	2.50	0	-	-[3]	-	-[3]
Dissolved Silicon	mg/L	8.9	8.9	4.3	<0.05	-	-	9.2	-3.3	-	-[3]	-	-[3]
Dissolved Sodium	mg/L	4.60	12.0	690	0.37	-	-	4.50	2.2	-	-[3]	-	-[3]
Dissolved Strontium	mg/L	0.04	0.049	51.0	<0.001	-	-	0.039	2.5	-	-[3]	-	-[3]
Total Sulphur	mg/L	0.70	0.86	9.2	<0.05	-	-	0.70	0	-	-[3]	-	-[3]
STABLE ISOTOPES													
δ^{18}O	VSMOW	-13.99	-12.61	-12.76	-7.41	-	-	-14.04	-0.4	-	-[3]	-	-[3]
δ^{2}H	VSMOW	-99.3	-91.0	-88.3	-53.0	-	-	-100.3	-1.0	-	-[3]	-	-[3]
^{87}Sr/^{86}Sr	ratio	0.74825	0.74614	0.71968	0.71139	-	-	0.74829	0.0	-	-[3]	-	-[3]
δ^{13}C DIC	PDB	-23.5	-18.6	-20.5	-16.2	-	-	-22.3	5.2	-	-[3]	-	-[3]
RADIOISOTOPES													
^{14}C-DIC	years BP	-[5]	1732	-[5]	-[5]	-	-	>Modern(1950)	-	-	-[3]	-	-[3]
^{3}H	TU	10.4	6.0	1.1	35.8	-	-	7.7	29.8	-	-[3]	-	-[3]

Notes:

[1] Hach model DR2800 Spectrophotometer used for field readings.

[2] Alkalinity kit model 10-400 mg/L Model AL-DT used for field titration.

[3] Calculation not possible due to at least one input either below detection limit or not reported.

[4] Reading masked by high turbidity.

[5] Produced gas from preparation work not sufficient for analysis

[6] Total Alkalinity as HCO3- calculated based on laboratory reported alkalinity result. Where only a field reported alkalinity result was available, the field value was used.

[7] The test plan and manufacturer's procedure specified a reagent blank was to be prepared and used to zero the spectrophotometer prior to sample readings. These samples were associated with a blank reading recorded as a calibration check only and the instrument not zeroed. Following the Hach recommendation for non-zero blank readings where the instrument is not zeroed, the blank value has been subtracted from the sample reading. This corrected value is the reported value.

[8] RPD calculation not valid at concentrations within five times the detection limit.

Relative Percent Difference calculated per method described in APHA (American Public Health Association). 2017. Standard Methods for the Examination of Water and Wastewater, 23rd Edition. Washington, DC, USA.
NA: Parameter not applicable to this sample type.
BDL: Result below method detection limit.

Prepared By:	SR
Checked By:	BT
Reviewed By:	ML

APPENDIX B

Table B-1: Drill Water Contamination Correction Values

Sample Type		OGW Sample	Drill Water Sample	Corrected Result	OGW Sample	Drill Water Sample	Corrected Result	OGW Sample	Drill Water Sample	Corrected Result
Sample Date		**2019-10-01**	**2019-09-29**	**2019-10-01**	**2019-10-08**	**2019-10-08**	**2019-10-08**	**2019-10-26**	**2019-10-23**	**2019-10-26**
Sample ID		**IG_BH02_GW001**	**IG_BH02_DW001**	**IG_BH02_GW001**	**IG_BH02_GW028**	**IG_BH02_DW004**	**IG_BH02_GW028**	**IG_BH02_GW033**	**IG_BH02_DW016**	**IG_BH02_GW033**
GENERAL PARAMETERS										
pH (field)	-	6.04	10.48	5.81	6.64	9.23	6.28	7.98	8.72	7.95
Temperature (field)	°C	7.91	19.56	-	8.99	11.23	-	9.37	10.94	-
ORP (field)	mV	74	90	-	23	263	-	-492	207	-
EC (field)	mS/cm	0.098	0.267	-	0.171	0.120	-	21.8	0.565	-
Turbidity (field)	NTU	BDL	>1000	-	15.5	>1000	-	BDL	>1000	-
Fluorescein (field)	ppb	4.84	98.6	-	10.19	82.8	-	4.70	132.4	-
Dissolved Oxygen (field-Horiba)	mg/L	BDL	7.50	-	0.36	6.78	-	BDL	4.84	-
[1]Dissolved Oxygen (field-Hach)	mg/L	2.2	10.2	-	9.2	8.5	-	12.3	14.3	-
Total Alkalinity (lab)	mg/L $CaCO_3$	43	86	41	70	45	74	21	240	13
[2]Total Alkalinity (field)	mg/L $CaCO_3$	57	-	-[3]	76	53	79	27	195	21
[4]Total Alkalinity	mg/L HCO_3^-	52	105	49	85	55	89	26	293	16
Hydroxide Alkalinity (speciated)	mg/L $CaCO_3$	0	10	0	0	1	0	0	0	0
Hydroxide Alkalinity (speciated)	mg/L OH^-	0	3	0	0	0	0	0	0	0
Carbonate Alkalinity (speciated)	mg/L $CaCO_3$	0	57	0	0	6	0	0	12	0
Carbonate Alkalinity (speciated)	mg/L CO_3^{2-}	0	34	0	0	4	0	0	7	0
Bicarbonate Alkalinity (speciated)	mg/L $CaCO_3$	43	19	44	70	38	75	21	228	13
Bicarbonate Alkalinity (speciated)	mg/L HCO_3^-	52	23	54	85	46	91	25	278	16
Charge Balance	-	-0.5%	2.3%	-	-0.5%	-0.4%	-	1.5%	12.1%	-
ANIONS & NUTRIENTS										
Bromide	mg/L	<1.0	<1.0	-[3]	<1.0	<1.0	-[3]	150	<1.0	-[3]
Chloride	mg/L	1.8	12	1.3	2.2	7.5	1.5	7100	29	7360
Iodide	mg/L	<0.10	<0.10	-[3]	<0.10	<0.10	-[3]	0.33	1.1	0.30
Fluoride	mg/L	<0.10	0.20	-[3]	0.17	0.21	0.16	0.75	1.3	0.73
Nitrite	as N mg/L	<0.010	<0.010	-[3]	<0.010	<0.010	-[3]	<0.010	0.047	-[3]
Nitrate	as N mg/L	<0.10	<0.10	-[3]	<0.10	<0.10	-[3]	<0.10	<0.10	-[3]
Nitrite + Nitrate	as N mg/L	<0.10	<0.10	-[3]	<0.10	<0.10	-[3]	<0.10	<0.10	-[3]
Ammonium	mg/L	<0.05	<0.05	-[3]	<0.05	<0.05	-[3]	0.74	0.24	0.76
Total Ammonia	as N mg/L	<0.050	0.27	-[3]	<0.050	<0.050	-[3]	0.59	0.20	0.60
Total Kjeldahl Nitrogen	as N mg/L	0.12	1.4	0.1	<0.10	0.46	-[3]	0.85	27	0
Orthophosphate	mg/L	<0.010	0.017	-[3]	<0.010	0.02	-[3]	<0.010	0.21	-[3]
Total Phosphorus	mg/L	<0.020	0.042	-[3]	<0.020	0.028	-[3]	0.027	0.26	0.018
Sulphate	mg/L	1.8	7.1	1.5	3.0	2.7	3.0	25	6.5	26
Sulphide (lab)	mg/L	<0.020	<0.020	-[3]	<0.020	<0.020	-[3]	<0.020	<0.020	-[3]
[1]Sulphide (field)	mg/L	BDL	BDL	-[3]	BDL	BDL	-[3]	BDL	BDL	-[3]
Hydrogen Sulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Bisulphide (field)	mg/L	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Reactive Silica (SiO2)	mg/L	18	20	17.9	16	10	17	14	17	14
METALS										
Dissolved Calcium	mg/L	11.0	21	10.5	14.0	3.6	15.5	3400	6.6	3525
Dissolved Iron	mg/L	1.4	<0.1	-[3]	<0.1	<0.1	-[3]	2.4	4	2.3
[1]Ferrous Iron (field-Hach)	mg/L	5.52[5]	0.21[5]	5.80	0.03	0.19	0.01	1.29	1.74[5]	1.27
Dissolved Lithium	mg/L	0.028	0.046	0.027	0.052	0.049	0.052	0.33	0.41	0.33
Dissolved Magnesium	mg/L	1.60	0.13	1.68	2.20	0.42	2.45	85	0.71	88
Dissolved Potassium	mg/L	2.50	12	2.01	4.60	6.7	4.3	15	37	14
Dissolved Silicon	mg/L	8.9	9.9	8.8	8.9	5.7	9.3	4.3	13	4.0
Dissolved Sodium	mg/L	4.60	22	3.7	12.0	18	11.2	690	140	710
Dissolved Strontium	mg/L	0.04	0.055	0.04	0.049	0.0092	0.055	51	0.026	52.9
Total Sulphur	mg/L	0.70	2.5	0.61	0.86	0.79	0.87	9.2	2.9	9.4
STABLE ISOTOPES										
$\delta^{18}O$	VSMOW	-13.99	-8.30	-14.28	-12.61	-8.29	-13.22	-12.76	-8.33	-12.92
$\delta^{2}H$	VSMOW	-99.3	-70.2	-100.8	-91.0	-70.0	-93.9	-88.3	-70.4	-89.0
$^{87}Sr/^{86}Sr$	ratio	0.74825	0.74857	0.74823	0.74614	0.78313	0.74095	0.71968	0.82238	0.71590
$\delta^{13}C$ DIC	PDB	-23.5	-17.8	-23.8	-18.6	-14.9	-19.1	-20.5	-21.0	-20.5
RADIOISOTOPES										
^{14}C-DIC	% Modern Carbon	-[3]	0.9574	-[3]	0.8060	0.8141	0.8049	-[3]	0.6103	-[3]
^{3}H	TU	10.4	9.6	10.4	6.0	9.2	5.6	1.1	4.5	1.0

Notes:

[1] Hach model DR2800 Spectrophotometer used for field readings

[2] Alkalinity kit model 10-400 mg/L Model AL-DT used for field titration

[3] Calculation not possible due to at least one input either below detection limit or not reported

[4] Total Alkalinity as HCO3- calculated based on laboratory reported alkalinity result. Where only a field reported alkalinity result was available, the field value was used.

[5] The test plan and manufacturer's procedure specified a reagent blank was to be prepared and used to zero the spectrophotometer prior to sample readings. These samples were associated with a blank reading recorded as a calibration check only and the instrument not zeroed. Following the Hach recommendation for non-zero blank readings where the instrument is not zeroed, the blank value has been subtracted from the sample reading. This corrected value is the reported value.

For Charge Balance, Total Alkalinity and speciated value calculations, see Calculations spreadsheet as part of the Data Deliverable
"-": Analyses not performed. No value reported.
"BDL": Result below method detection limit.

Prepared By: BT
Checked By: ML
Reviewed By: KD

APPENDIX C

Analytical In-field Analysis Procedures

1.0 ANALYTICAL IN-FIELD PARAMETER MEASUREMENTS

The sample analyses for alkalinity, total sulfide, dissolved oxygen and ferrous iron can be impacted by contact with the atmosphere. In order to collect, prepare and analyze samples while preventing contact to the atmosphere, the samples were collected using a MOSDAX Sampler Probe Model 2532 designed by Westbay Instruments and outfitted with four 250 mL stainless steel sampling canisters. Prior to lowering the sampling assembly downhole, sample valves at each end of the sampling assembly were opened, and the sampling assembly was flushed with 99.999% nitrogen gas. Following flushing, the valve at one end of the assembly was closed, and a handpump was then placed on the other end of the sample chambers. The hand pump was used to evacuate the high purity nitrogen gas from within the sampling assembly, and pumping continued until a nominal vacuum pressure of -20 inches of mercury (in/Hg) was reached inside the sampling assembly. After the pressure reached -20 in/Hg inside the assembly, the sampling valve was closed, and the sampling assembly was lowered downhole on a wireline winch.

The sampling assembly was lowered downhole until the sampling valve of the probe was positioned approximately 3 meters above the inflated packers. The probe was left in this position until pressure readings from the MAGI interface indicated that pressures had stabilized. At this time, the sampling valve was opened, allowing the vacuum canisters to be filled. Pressure readings were monitored while the vacuum canisters filled until the pressures stabilized. At this point the sampling valve was closed, and the sampling assembly was brought back to surface.

Once the sampling assembly was at surface, the four sealed vacuum canisters were disconnected from the sampling probe. A valve at one end of the four vacuum canisters was pressurized with 99.999% nitrogen gas, and the valve on the opposite end of the assembly was opened under a shroud of 99.999% nitrogen gas. The nitrogen pressure caused the sampled water to be evacuated into the laboratory sample bottles, and the sample bottles were then closed before the nitrogen shroud was removed.

Whenever additional sample volume was required for analyses, the process for decontaminating and placing a vacuum on the sampling assembly was repeated, and the assembly was lowered downhole for additional sample collection. The sampling process was repeated until sufficient volumes were collected.

Alkalinity

Alkalinity of the OGW sample was measured in the field using a titration method that determines the phenolphthalein and total alkalinities. The titration method consists of incremental addition of sulphuric acid (H_2SO_4), while using phenolphthalein and bromcresol green-methyl red indicators to visually identify key endpoints in the titration. Once the phenolphthalein and total alkalinities were determined, the proportion of the phenolphthalein alkalinity relative to the total alkalinity was used to estimate the hydroxide, carbonate and bicarbonate alkalinities.

The OGW sample for alkalinity analysis was first collected by passing the sample through a 0.45 µm groundwater filter and into a clean flask (rinsed with nanopure deionized water). Next, a Hach kit and digital titrator was used to complete alkalinity measurements.

Sulphide

Total sulphide (S^{2-}_{Total}) was measured in the field immediately after sample collection using the Methylene Blue Method. Hach sulphide reagents and spectrophotometer was used to carry out the analysis in the field. First, two standard Hach reagents, referred to as Sulphide 1 Reagent and Sulphide 2 Reagent, were readied by loading two separate 1 mL syringes (fitted with a hypodermic needle) with each reagent with no headspace. A blank was prepared with 25 mL deionized water in a Hach spectrophotometer sample cell; the blank was used to zero the Hach spectrophotometer before reading the OGW sample. The Hach spectrophotometer was turned on and readied, as it needs time to warm-up prior to use. These steps were completed first to minimize the time between the OGW sample collection and the analysis.

Next, a glass syringe was connected to the sample tubing and an OGW sample was extruded into the glass syringe with compressed nitrogen. A glass syringe is needed (rather than plastic) to mitigate the ingress or egress of gases through the syringe wall. About 10 mL of sample was extruded into the glass syringe and then the syringe was disconnected to bleed out any air and some of the sample; this was to ensure there is no headspace. The syringe was then reconnected to the sample tubing and the full OGW sample volume (25 mL) was collected with no air bubbles. A steady flow from the sample tube was maintained at a slow rate upon reconnection of the syringe to assist with mitigating the entry of air bubbles. Once the 25 mL sample was attained, the syringe was disconnected and the tip capped with a rubber septum. If there are air bubbles present after attaching the rubber septum, the OGW sample was discarded and the sample collection steps repeated until an OGW sample was attained with no air bubbles. The syringe with 1 mL of Sulphide 1 Reagent was then immediately inserted through the rubber septum into the glass syringe and the first reagent was then injected into the OGW sample. The syringe with 1 mL of Sulphide 2 Reagent was then immediately inserted through the rubber septum into the glass syringe and the second reagent was then injected into the OGW sample. The reagents also need to be added to the blank in the same sequence immediately after adding to the OGW sample: 1 mL of Sulphide 1 Reagent, then 1 mL of Sulphide 2 Reagent. The timer on the Hach spectrophotometer was then started for a 5 minimum reaction time. Once the 5-minute reaction time was complete, the blank was inserted into the Hach spectrophotometer to zero the instrument. The sample in the glass syringe was then injected into a sample cell and inserted into the Hach spectrophotometer for an immediate sample reading; the reading value was recorded directly into the AcQuire groundwater sampling data entry object. If there is dissolved sulphide in the OGW sample, the sample will turn a blue colour during the reaction time; therefore, the colour of the OGW sample was recorded in field notes as a qualitative indicator of presence/absence of sulphide. Given the importance of the potential presence of dissolved sulphide on the long-term chemical stability of some of the barrier components associated with the deep geological repository, this procedure was repeated twice to attain a duplicate in-field measurement of total sulphide ($S^{2-}{}_{\text{Total}}$).

Prior to collecting the OGW sample, a series of five sulphide standards was prepared using a sulphide stock standard solution (Radiello™ Methylene Blue Calibration Standard). Using the stock standard solution, five standards were prepared at different concentrations that are expected to encompass the range of sulphide concentrations in the OGW sample (0.01 mg/L to 1 mg/L). The known concentrations of the standards can be compared to the values measured using the Hach spectrophotometer to determine a sample-specific correction factor. Preparation and analysis of standards were completed prior to the start of, and during, field work as a QA check on the operation of the Hach spectrophotometer and recorded in the Data Quality Confirmation Workbook.

The concentrations of hydrogen sulphide (H_2S) and unionized hydrogen sulphide (or bisulphide ion, HS^-) were calculated using the total sulphide ($S^{2-}{}_{\text{total}}$) concentration and pH. Concentration of S^{2-} ions will not be measured or calculated, given that the concentrations of S^{2-} ions under natural conditions are negligible.

Dissolved Oxygen

Dissolved oxygen (DO) was measured in the field immediately after sample collection using the Indigo Carmine Method. Hach AccuVac Ampuls and spectrophotometer were used to carry out the analysis in the field. The Hach AccuVac Ampuls are glass cells pre-loaded with reagent and under a vacuum so that the sample is sucked into the ampul without exposure to atmospheric conditions. The DO results were compared to the DO measured using the multiprobe; all values were recorded in the Data Quality Confirmation Workbook.

Ferrous Iron

Ferrous iron (Fe^{2+}) was measured in the field after sample collection using the 1-10 Phenanthroline Method. Hach AccuVac Ampuls and spectrophotometer was used to carry out the analysis in the field. As with the Hach DO

AccuVac Ampuls, the Hach Ferrous Iron AccuVac Ampuls are glass cells that are pre-loaded with regent and under a vacuum so that the sample is sucked into the ampul without exposure to atmospheric conditions. This method is only applicable for concentrations up to 3 mg/L; in the case when samples contain concentrations of ferrous iron greater than 3 mg/L, the sample would need to be diluted with nanopure water (attained from a laboratory) to bring the concentration within the detection range of the method. The concentration would then be corrected by the dilution factor.

Ferrous iron oxidizes very rapidly at neutral pH conditions but oxidizes at a much slower rate under acidic conditions. As such, an alternative to completing the analysis immediately in the field during the collection of the OGW samples is to preserve a filtered OGW sample with trace grade nitric acid (HNO_3). The Hach method can then be completed later in the day or within a 24-hour period. This would provide some additional time to complete the analysis, which is particularly useful if the concentrations in the OGW sample are greater than 3 mg/L and sample dilution is necessary to complete the analysis.

Similar to the hydrogen sulphide analysis, a series of five ferrous iron standards were prepared using ferrous ammonium sulfate, hexahydrate ($Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$). These standards were prepared at different concentrations, which are expected to encompass the range of ferrous iron concentrations in the OGW sample; in this case, it is expected that the concentrations will be relatively low (<1 mg/L). The standards will be analysed using the 1-10 Phenanthroline Method and the known concentrations of the standards were compared to the values measured using the Hach spectrophotometer to determine a sample-specific correction factor. Preparation and analysis of standards were completed prior to the start of, and during, field work as a QA check on the operation of the Hach spectrophotometer and recorded in the Data Quality Confirmation Workbook.

2.0 SAMPLE COLLECTION FOR MICROBIOLOGY RESEARCH AND DEVELOPMENT

The University of Waterloo ordered and shipped the required sampling equipment to the Ignace office for Golder to use during sampling. This section provides the field instructions that were followed for collection of samples for microbiology research and development. For each opportunistic sampling event, water samples were taken for deoxyribonucleic acid (DNA), phospholipid fatty acid (PLFA) and cell count analysis, as described in this section.

It is recognized that the microbiology samples are lower priority than the geochemical analyses described in previous sections. The overall goal was to prepare for future site characterization activities by assessing detection limits and contamination sources. The water volumes requested were best case scenario. If less water was available, the volume of the sample was noted. Duplicate samples for DNA, PLFA, and cell count were taken if water was available. One replicate for DNA, PLFA, and cell count were first collected before collecting the duplicate samples. This way, it was ensured that at least one replicate was collected for each analysis.

The item number of the Sterivex filters was verified as SVGV010RS for all samples, noting that the procedures and equipment for DNA and PLFA sampling were identical.

Note: A field blank for DNA and PLFA (one each) were collected for each groundwater sample. Field blanks were not taken for DNA and PLFA when taking the drill water return associated with the groundwater sample. Field blanks for DNA and PLFA (one each) were taken when sampling the drill water return associated with core sampling.

Opportunistic water samples for DNA analysis

- For DNA samples, opportunistic water was filtered via syringe filtration as described below. Although a specific syringe filter is noted, any syringe filter rated for DNA extraction with at least a 0.45-micron pore size and ideally a 0.22 pore size to capture smaller organisms can be used.

- For DNA analysis, water volumes were the minimum required to clog the filter such that no further water could pass to a maximum of 1200 mL.
- DNA filtering was carried out by filling a syringe (Fisher, BD 60 mL Luer Lok syringe, catalogue number B309653) with ground water (by removing the plunger) and after replacing the plunger passing the water through Sterivex filters (Fisher Scientific, Millipore SVGV010RS, Sterivex-GV 0.22 µm, PVDF).
- Water was passed through the filter until the filter clogged. When the filter clogged, the volume of water passed through the filter was recorded. If clogging did not occur, filtering was stopped at 1200 ml. The easiest way to refill the syringe was to unscrew the Sterivex filter, withdraw the plunger from the syringe (being sure to keep it clean and handle only with clean sterile surgical gloves; the plunger was stored in the clean wrapper from the syringe), then reattach the filter, pour more sample into the syringe. The syringe was filled all the way until the water bulges before placing the plunger back in. This way, no air was introduced into the syringe (once wetted, the membrane is not air permeable and any air would reduce the filtration area in the filter unit). The sample was then pushed through and repeated. If the syringe is filled all the way, it holds 72 ml liquid (16.5 syringe volumes = 1,200 ml). Once the filter plugged, it was followed-up with a final slug of air to force the water on the upstream side of the filter through and out (e.g. this dewatering step ensures freezing occurs without a lot of water to prevent expansion and casing cracking).
- Once the DNA filter clogged and dewatering was complete, the DNA filter was placed in a 50 cc plastic centrifuge tube (Fisher, Tube screw cap grad 50 mL, catalogue number C352070), and the tube placed in a Ziploc bag and stored in a freezer. The sample remained frozen and was shipped on dry ice.
- Along with each sample, a field blank was collected by setting up the filter and syringe in preparation to sample and then the filter was placed in the 50-cc tube and treating as a sample.

Opportunistic water samples for PLFA analysis

- For PLFA samples, opportunistic water was filtered via syringe filtration as described below. In the case of PLFA sampling, only solvent extractable filter material was used, therefore making sure to use SVGV010RS, Sterivex-GV 0.22 µm, PVDF.
- For PLFA analysis water, volumes were the minimum required to clog the filter such that no further water could pass through, to a maximum of 1200 mL.
- PLFA filtering was carried out by filling a syringe (Fisher, BD 60 mL Luer Lok syringe, catalogue number B309653) with groundwater (by removing the plunger) and after replacing the plunger passing the water through Sterivex filters (Fisher Scientific, Millipore SVGV010RS, Sterivex-GV 0.22 µm, PVDF).
- Water was passed through the filter until the filter clogged. When the filter clogged, the volume of water passed through the filter was recorded. If clogging did not occur, filtering was stopped at 1200 ml. The easiest way to refill the syringe was to unscrew the Sterivex filter, withdraw the plunger from the syringe (being sure to keep it clean and handle only with clean sterile surgical gloves; the plunger was stored in the clean wrapper from the syringe), then reattach the filter, pour more sample into the syringe. The syringe was filled all the way until the water bulged before placing the plunger back in. This way, no air was introduced into the syringe (once wetted, the membrane is not air permeable and any air would reduce the filtration area in the filter unit). The sample was then pushed through and repeated. If the syringe is filled all the way, it holds 72 ml liquid (16.5 syringe volumes = 1,200 ml). Once the filter plugged, it was followed-up with a final slug of air to force the water on the upstream side of the filter through and out (e.g. this dewatering step ensures freezing occurs without a lot of water to prevent expansion and casing cracking).

- Once the PLFA filter was clogged and dewatering was complete, the PLFA filter was placed in a 50-cc plastic centrifuge tube (Fisher, Tube screw cap grad 50 mL, catalogue number C352070), and the tube placed in a Ziploc bag and stored in a freezer. The sample remained frozen and was shipped on dry ice.
- Along with each sample, a field blank was collected by preparing the syringe and filter as for collection of a sample, then without filtering water, collecting the filter and treating as a sample.

Cell count sample

- The cell count samples were collected by adding opportunistic water to the 50 cc tubes preloaded with 2% glutaraldehyde. They were stored ***refrigerated but not frozen*** before they were picked up by NWMO.
- A field blank was collected by opening a 50-cc tube, reclosing and treating as a sample.

2.1 Drill water samples for assessing contamination

A grab sample of the drill water return (DW) was collected immediately **following both opportunistic groundwater and core sampling**. The grab sample was obtained by collecting a bucket sample of the drill water return.

Sampling was coordinated with the core sampler to make sure that drill water samples are taken at the same time.

Core samples were taken at the following approximate intervals (summarized in WP03):

- Approximately 100m depth
- Following the first opportunistic water sampling below 200m
- Approximately 534m depth

When core or opportunistic groundwater samples were collected, the drill water return was sampled by the following method:

- Wear disposable surgical gloves while sampling drill water return.
- Collect drill water return in a bucket.
- pH, Eh (redox), electrical conductivity, temperature, and alkalinity were measured, as per above.
- Samples of drill water were taken for commercial laboratory analysis, as per above.
- Sampling for DNA analysis, PLFA analysis and total cell counts as described below.

The on-site geochemical measurements were logged in the Data Quality Confirmation workbook and identified by DW-XXXX-YYY, where XXXX is the borehole identifier and YYY is the consecutive index number of the sample unique to the borehole. The core run number, date and depth associated with the sample were noted in the Data Quality Confirmation workbook. The sample identifier was used to label the filters and water samples described below.

Drill fluid samples for DNA analysis

- For DNA samples, drill water return was filtered via syringe filtration as described below. Although a specific syringe filter is noted, any syringe filter rated for DNA extraction with at least a 0.45-micron pore size.
- For DNA analysis water, the minimum volume was required to clog the filter such that no further water could pass to a maximum of 1200 mL.

- DNA filtering was carried out by filling a syringe (Fisher, BD 60 mL Luer Lok syringe, catalogue number B309653) with drill water return (by removing the plunger) and after replacing the plunger, passing the water through Sterivex filters (Fisher Scientific, Millipore SVGV010RS, Sterivex-GV 0.22 µm, PVDF).
- Water was passed through the filter until the filter clogged. When the filter clogged, the volume of water passed through the filter was recorded. If clogging did not occur, filtering was stopped at 1200 ml. The easiest way to refill the syringe was to unscrew the Sterivex filter, withdraw the plunger from the syringe (being sure to keep it clean and handle only with clean sterile surgical gloves; the plunger was stored in the clean wrapper from the syringe), then reattach the filter, pour more sample into the syringe. The syringe was filled all the way until the water bulged before placing the plunger back in. This way, no air was introduced into the syringe (once wetted, the membrane is not air permeable and any air would reduce the filtration area in the filter unit). The sample was then pushed through and repeated. If the syringe is filled all the way, it holds 72 ml liquid (16.5 syringe volumes = 1,200 ml). Once the filter plugged, it was followed-up with a final slug of air to force the water on the upstream side of the filter through and out (e.g., this dewatering step ensures freezing occurs without a lot of water to prevent expansion and casing cracking).
- Once the DNA filter was clogged and dewatering complete, the DNA filter was placed in a 50-cc plastic centrifuge tube (Fisher, Tube screw cap grad 50 mL, catalogue number C352070), the tube placed in a Ziploc bag and stored in a freezer. The sample remained frozen and was shipped on dry ice.

Drill fluid samples for PLFA analysis

- For PLFA samples, drill return water was filtered via syringe filtration as described below. In the case of PLFA sampling, only solvent extractable filter material was used, therefore making sure to use SVGV010RS, Sterivex-GV 0.22 µm, PVDF.
- For PLFA analysis, water volumes were the minimum required to clog the filter such that no further water could pass through, to a maximum of 1200 mL.
- PLFA filtering was carried out by filling a syringe (Fisher, BD 60 mL Luer Lok syringe, catalogue number B309653) with drill water (by removing the plunger) and after replacing the plunger, passing the water through Sterivex filters (Fisher Scientific, Millipore SVGV010RS, Sterivex-GV 0.22 µm, PVDF).
- Water was passed through the filter until the filter was clogged. Once the filter clogged, the volume of water passed through the filter was recorded. If clogging did not occur, filtering was stopped at 1200 ml. The easiest way to refill the syringe was to unscrew the Sterivex filter, withdraw the plunger from the syringe (being sure to keep it clean and handle only with clean sterile surgical gloves; you can store the plunger in the clean wrapper from the syringe), then reattach the filter, pour more sample into the syringe. Fill the syringe all the way until the water bulged before placing the plunger back in. This way, no air was introduced into the syringe (once wetted, the membrane is not air permeable and any air would reduce the filtration area in the filter unit). The sample was then pushed through and repeated. If the syringe is filled all the way, it holds 72 ml liquid (16.5 syringe volumes = 1,200 ml). Once the filter plugs, it was followed-up with a final slug of air to force the water on the upstream side of the filter through and out (e.g., this dewatering step ensures freezing occurs without a lot of water to prevent expansion and casing cracking).
- Once the PLFA filter was clogged and dewatering was complete, the PLFA filter was placed in a 50 cc plastic centrifuge tube (Fisher, Tube screw cap grad 50 mL, catalogue number C352070), the tube was placed in a Ziploc bag and stored in a freezer. The sample remained frozen and was shipped on dry ice.
- Along with each sample, a field blank was collected by preparing the syringe and filter as for collection of a sample, then without filtering water, collecting the filter and treating as a sample.

- Once filtering was complete, the filter was removed and placed into its own Ziploc bag stored in a freezer.. The sample remained frozen and was shipped on dry ice. Dewatering was not necessary in this case.

Cell count sample

- The cell count samples were collected by adding drill water return to the 50 cc tubes preloaded with 2% glutaraldehyde. The samples were stored ***refrigerated but not frozen*** before they were picked up by NWMO.

2.2 Summary of sampling equipment for microbiology samples

Sampling equipment was gathered and shipped by University of Waterloo. The following table summarizes the equipment.

Table 1: Microbiology sampling equipment

Quantity	Part number	Item description	Purpose
4 boxes	19-188-587 fishersci.com	Kimberly-Clark™ KC500 Purple Nitrile Sterile Exam Gloves (2x medium and 2x large)	Sampling
2 each	----	Red and black Sharpie markers	Labelling
60	82028-488 vwr.com	2000 mL Nalgene bottle, polypropylene	Container to hold water before filtering/ sampling
80	B309653 Fishersci.com	60 mL Luer Lok syringe	Microbiology (DNA and PLFA)
150	SVGV010RS Fishersci.com	Millipore SVGV010RS, Sterivex-GV 0.22 µm, PVDF	Microbiology (DNA and PLFA)
150	C352070 Fishersci.com	Centrifuge tube screw cap graduated 50 mL	Microbiology
60	O2957-1 fishersci.com	25% glutaraldehyde solution, certified	Microbiology (cell counts)
2 boxes		Ziploc heavy duty freezer bags (2x 28 Gallon size)	Microbiology (core samples)
1 box		Ziploc bags small (x40)	To hold collected DNA / PLFA filters for storage

2.3 Microbiology sample preservation summary and shipping

Microbiology samples were stored frozen or refrigerated, as outlined in Table 2. At the end of sampling, all samples were transported on ice packs in coolers to the Ignace office and placed into refrigerator/freezer. The NWMO coordinated shipping all samples to McMaster/Waterloo University. Frozen samples were shipped on dry ice. Refrigerated samples were shipped with ice packs.

Table 2: Samples for microbiology research and development for opportunistic water and core sampling events

Sample Type	Analysis type	Sample storage	Sample type	Total number of samples
Opportunistic groundwater	DNA	Frozen	Filter	3 (6 total with replicates) = one from each OGW sample interval
Opportunistic groundwater	PLFA	Frozen	Filter	3 (6 total with replicates) = one from each OGW sample interval
Opportunistic groundwater	Cell count	Refrigerate	Water in tube with glutaraldehyde	3 (6 total with replicates) = one from each OGW sample interval
Field blank	DNA	Frozen	Filter	6 total = one from each OGW sample interval (3) + and one from each core sample interval (3)
Field blank	PLFA	Frozen	Filter	6 total = one from each OGW sample interval (3) + and one from each core sample interval (3)
Field blank	Cell count	Refrigerate	Water in tube with glutaraldehyde	6 total = one from each OGW sample interval (3) + and one from each core sample interval (3)
Drill water	DNA	Frozen	Filter	6 (12 total with replicates) = one from each OGW sample interval (3) + and one from each core sample interval (3)
Drill water	PLFA	Frozen	Filter	6 (12 total with replicates) = one from each OGW sample interval (3) + and one from each core sample interval (3)
Drill water	Cell count	Refrigerate	Water in tube with glutaraldehyde	6 (12 total with replicates) = one from each OGW sample interval (3) + and one from each core sample interval (3)
Core	DNA, PLFA	Frozen	Core	3 total (6 total with replicates)

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