GROUNDWATER MONITORING OF SHALLOW WELL NETWORKS

Ignace Chemistry Data Annual Report 2022

APM-REP-01332-0448 **December 2024**

KGS Group

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

This report has been prepared under contract to NWMO. The report has been reviewed by NWMO, but the views and conclusions are those of the authors and do not necessarily represent those of the NWMO.

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Groundwater Monitoring of Shallow Well Networks – Ignace Chemistry Data Annual Report 2022

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Appendix C1: 2022 General Chemistry Results for High Confidence Samples

Appendix C2: 2022 General Chemistry Results for Low Confidence Samples

STATEMENT OF LIMITATIONS AND CONDITIONS

Limitations

This report has been prepared for Nuclear Waste Management Organization (NWMO) in accordance with the agreement between KGS Group and NWMO (the “Agreement”). This report represents KGS Group’s professional judgment and exercising due care consistent with the preparation of similar reports. The information and recommendations in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

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1.0 INTRODUCTION

1.1 Overview

The Groundwater Monitoring of Shallow Well Networks project is part of the Phase 2 Geoscientific Preliminary Field Investigations of the NWMO's Adaptive Phased Management (APM) Site Selection Phase. As part of the Phase 2 Preliminary Field Investigations, NWMO has established a shallow groundwater monitoring network at the Wabigoon Lake Ojibway Nation (WLON)-Ignace Area in Northwestern Ontario. The objective of this project is to retrieve, on a quarterly basis, measurements of groundwater pressures and temperatures that are collected on installed dataloggers, and to collect groundwater samples for chemical analyses.

The field work at the site started in the beginning of the third quarter (Q3) of year 2022, i.e., in the month of July, followed by another field event in September 2022. The final field work event for the year 2022 was conducted in its fourth quarter (Q4), in the month of December.

Each groundwater monitoring and sampling program involved the collection of groundwater pressure measurements and baseline groundwater samples from a selection of the 27 permanently installed monitoring well intervals for each of the 2022 field sampling events. The groundwater pressure and temperature measurements were recorded with 27 permanently installed vibrating wire piezometers connected to dedicated four-channel dataloggers (one datalogger connected to three vibrating wire transducers per multilevel monitoring well) taking measurements at 6-hour intervals.

The quarterly groundwater chemistry testing included the analysis of parameters including dissolved metals, routine parameters (see Table 2 for the complete list of parameters), nutrients, iodide, stable isotopes of oxygen and hydrogen ($\delta^{18}O$ and $\delta^{2}H$). Other specialized radioactive isotopes were sampled and analyzed only once in 2022.

This annual report presents the work completed and the data findings/analysis for the groundwater chemistry data and results collected in 2022 from the shallow well network at the WLON/Ignace Area, also referred to as the Revell Site.

1.2 Scope of Work

The overall objective of the groundwater monitoring and sampling program is to collect groundwater pressure measurements and baseline groundwater samples. This annual report focuses on the findings and analysis for the groundwater chemistry data collected in the year 2022, which includes three field events occurring in the months of July, September, and December. A separate report will present the groundwater pressure results for 2022.

This data report presents results of the field and laboratory measurements and groundwater physicochemical characteristics. The laboratory results of the groundwater samples collected in 2022 were assessed and analysed to characterize groundwater chemistry at the Revell Site. The characterization of groundwater was done based on the chemical composition of major ions using the software tool AquaChem, by Waterloo

Hydrogeologic, to visualize and assess water chemistry. A total of 45 groundwater samples were collected in 2022 and analyzed for dissolved metals, routine parameters (such as Br, F, Cl, SiO_2, electrical conductivity, alkalinity, see Table 2 for complete list), nutrients, iodide, stable isotopes of oxygen and hydrogen ($\delta^{18}O$ and $\delta^{2}H$), gross alpha, gross beta, Strontium 87/86 ratio ($^{87}Sr/^{86}Sr$), Carbon-13 ($\delta^{13}C$ DIC), Chlorine-37 ($\delta^{37}Cl$) and Carbon-14 (^{14}C) and Tritium (^{3}H). Of these 45 groundwater samples, 11 had sufficient volume of water to be deemed high confidence samples of groundwater at the site.

The groundwater laboratory results were plotted on Durov and Stiff diagrams to visualize physicochemical characteristics of groundwater and analyze trends. In addition to concentration of major ions in water, a discussion of trends in concentrations and ratios of stable and radio isotopes was completed.

2.0 PROJECT LOCATION

2.1 Land Acknowledgment

It is important to acknowledge that this project was completed on the traditional territory of the Anishinaabe people of Treaty Three. KGS Group and its subcontractors are grateful for being given the opportunity to complete work within the area and are thankful for the generations of people who have taken care of the land for thousands of years.

2.2 Study Area

The Revell site is located on the Canadian Shield, at approximately 43 km northwest of the Town of Ignace, 21 km southeast of the Wabigoon Lake Ojibway Nation, and 260 km northwest of Lake Superior (NWMO, 2023), Figure 1.

The ground surface elevation at the western boundary of the Revell site where the Wabigoon River lies, is at 368 metres above sea level (masl), while it increases to 554 masl at the southeastern boundary of the site (NWMO, 2023). The site area is comprised of rolling surfaces of Canadian Shield bedrock that is either covered with shallow glacial deposits or is exposed to the ground surface. This reflects an interplay between glacial action and rock resistance, with weaker rocks having been eroded to lower elevations while more resistant rocks forming the topographic highs (Renwick, 2009). The two major surface soils in the Ignace area are clay and sand of morainal, glaciofluvial or glaciolcustrial origin (Golder, 2013).

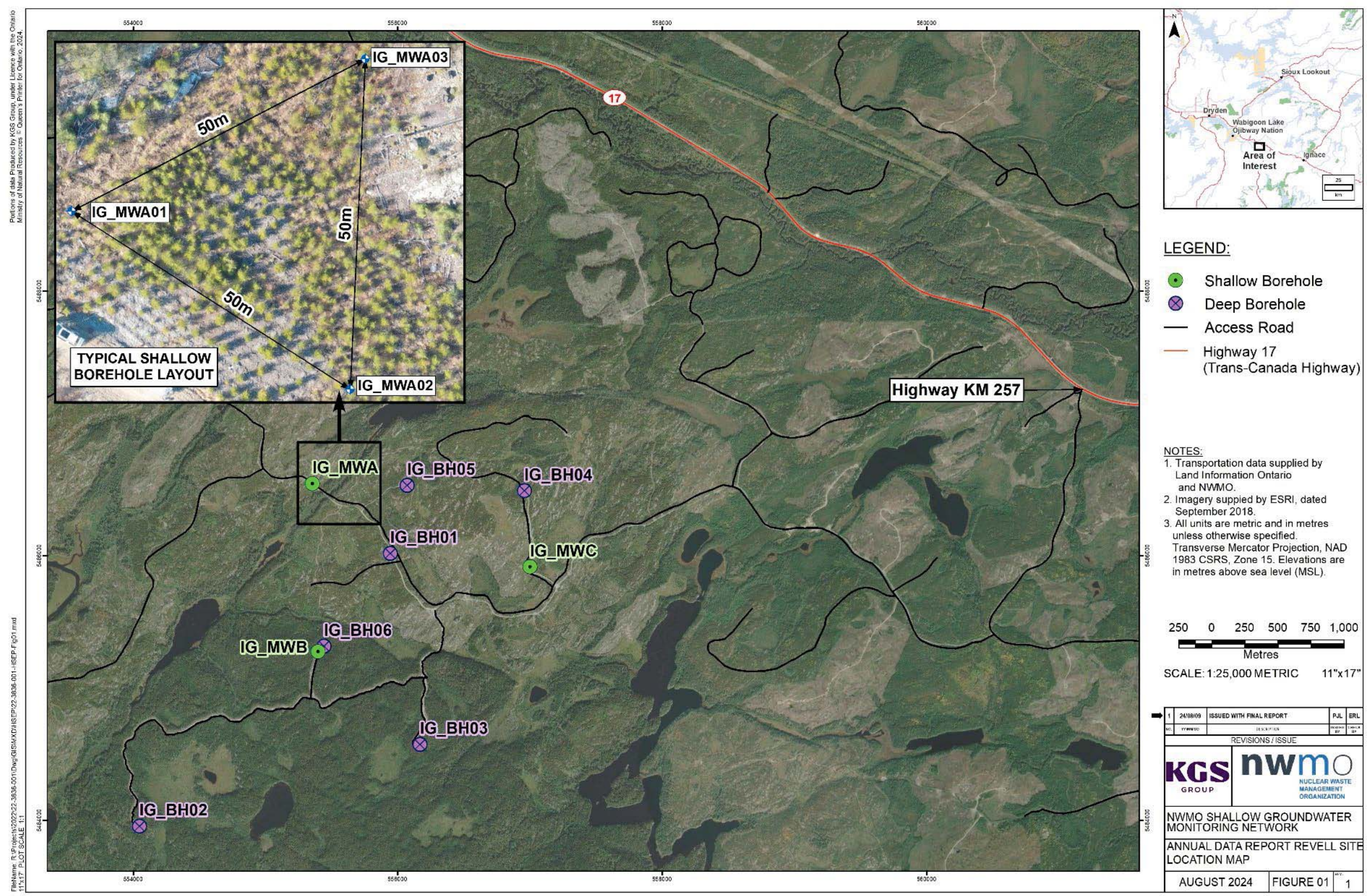
The Ignace area lies within the Superior Province of Canadian Shield and is underlain by Archean bedrock created from several ancient and tectonically stable plates, and gradually accumulated juvenile arc terranes (Card and Ciesielski, 1986). Within the Superior Province, the area is situated in the central portion of Wabigoon Subprovince which is comprised of thin greenstone belts that are separated by large felsic plutonic rock masses (Stone, 2010a). A number of granite and granodioritic batholiths dominate the bedrock geology of the Ignace area (Stone, 2010a). The geological setting of the Ignace area is discussed in detail by Golder, 2013.

There are numerous lakes in the Ignace area which are interconnected by a network of rivers such as English, Wabigoon, and Turtle rivers. These rivers drain into the Nelson River which further flows into the Hudson Bay as its largest contributor of fresh water (JDMA, 2013). Details about the three tertiary-scale watersheds and several quaternary-scale watersheds in the Ignace area are provided in the Phase 1 Geoscientific Desktop Study by JDMA, 2013.

A total of nine (9) 100 m deep multilevel monitoring wells were drilled and installed in 2021 (KGS Group, 2023). Three multilevel monitoring wells were drilled and installed at three separate sites. Each multilevel monitoring well is comprised of three discrete depths/zones that have dedicated pressure monitoring instrumentation, to measure and record groundwater pressures and temperatures, thus, leading to a total of 27 separate monitoring well points. The three pressure monitoring instruments are connected to a datalogger on surface. Each multilevel well also has equipment for collecting groundwater samples. The three multilevel monitoring well sites include (Figure 1):

- IG_MWA
- IG_MWB
- IG_MWC

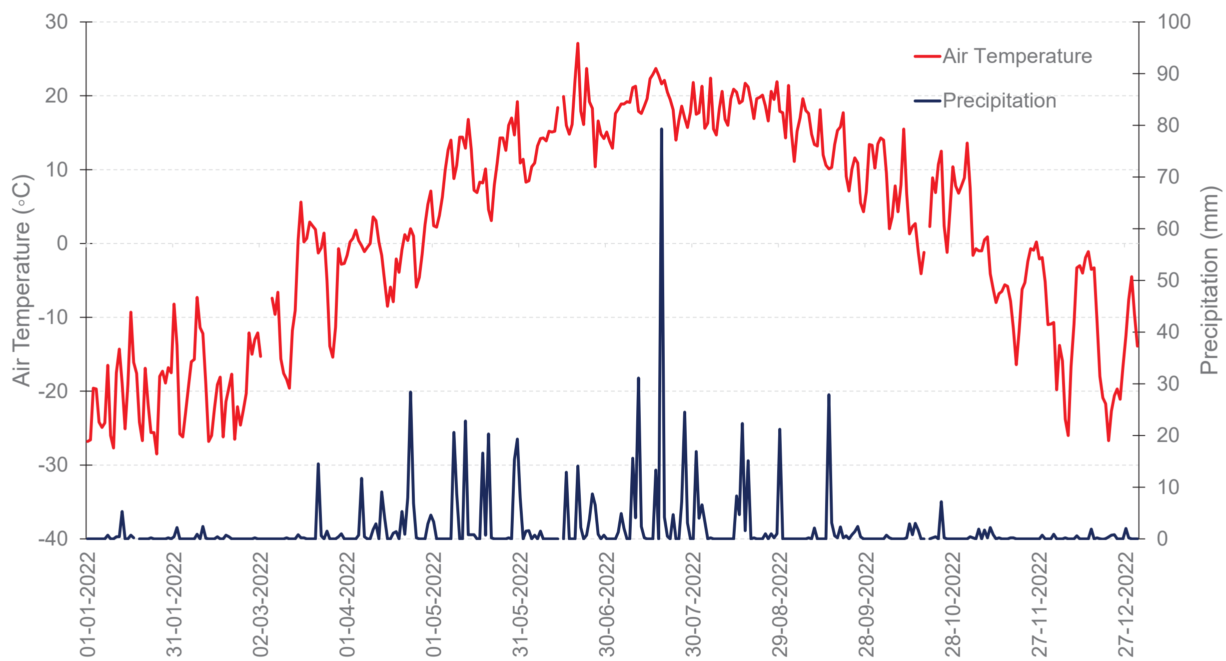
FIGURE 1 SITE LOCATION



2.3 Climate

The study area is subject to a humid continental climate of the warm summer subtype (Dfb under the Köppen climate classification defined by Kottek et al., (2006)). The closest weather station that exhibits the 1981-2010 Climate Normal Data is located in Dryden, ON, and is located approximately 49 kms Northwest of the Site (Environment and Climate Change Canada, 2017). The monthly average temperature varies from -16.8 ^{o}C in January to 18.9 ^{o}C in July as per the 1981 – 2010 Canadian Climate Normal. The area receives an average annual rainfall precipitation of 555.8 mm and 174.7 mm of snowfall precipitation, with a total annual precipitation of 719.7 mm. The wettest months are June and July (Environment and Climate Change Canada, 2017). The daily temperature and precipitation data for the year 2022 was available from the Dryden (Regional) weather station that is located at about 50 kms Northwest of the Ignace Site and is presented below on Figure 2:

FIGURE 2 SITE CLIMATE



2.4 Bedrock Geology

The site is located in the Revell batholith within the Wabigoon Subprovince of Canadian Shield. The Ignace area comprises of a number of granitic to granodioritic batholiths as described by Stone, 2010a. A number of geological units identified by Golder, 2011 in their initial screening report of the Ignace area include: Indian Lake Batholith, Revell Batholith, and the White Otter Lake Batholith. The Revell Batholith was formed about 2.7 billion years (Percival & Easton, 2007) and is located in the western portion of the Wabigoon Sub-Province of the Superior Province. It is also surrounded by the greenstone belts that are composed of old volcanic and sedimentary rocks (Golder, 2013).

The lithology of the shallow bedrock (<101 m below ground surface) at the Revell Site was interpreted from the borehole drilling and geophysical logging of the shallow monitoring well drilling sites (IG_MWA, IG_MWB, and IG_MWC)(KGS Group, 2023).

There is minimal overburden material in the Revell Site area leading to high bedrock exposure at the surface. The three main suites of plutonic rock in the Revell Batholith, include (oldest to youngest): a Biotite Tonalite to Granodiorite suite, Hornblende Tonalite to Granodiorite suite, and a Biotite Granite to Granodiorite suite. A detailed description of the bedrock geology of Ignace area has been provided by WSP, 2023.

3.0 METHODOLOGY

3.1 Overview

Monitoring and sampling activities were scheduled to be completed by KGS Group on a quarterly basis. Each quarterly event consisted of checking and downloading pressure data from all 27 vibrating wire transducers, followed by purging select intervals, measuring water chemistry parameters and collecting groundwater samples and submitting them for laboratory analysis. A detailed Test Plan for the Ignace site was prepared in advance of the first field event. The Test Plan outlines all the equipment, methodologies, criteria, and steps needed to achieve the desired outcomes of the project within the confines of the approved scope of work.

Wells to be sampled were pre-determined together with the NWMO project team in advance of each event. For each quarterly event, technical work followed the same general procedures as outline below, but were not limited to:

- Pre-mobilization equipment and material checks.
- Mobilization of all personnel.
- Checked and downloaded the data from all nine dataloggers (27 transducers), verified that the 4-channel dataloggers were functioning and were in good working order, perform maintenance on the datalogger(s) if required, field checked the data, and saved the data following the DMP (Data Management Plan) on the field laptop.
- Purged selected monitoring zones until purging criteria was met, collected and contained all purged water and disposed at the local wastewater treatment plant.
- Measured and recorded water quality parameters while purging.
- Collected one groundwater sample for the quarterly sample analysis package from each selected zone after purging criteria was met and after the well recovered to a minimum of 80% of the static pressure.
- Collected additional QA/QC samples (matrix blank and spike and a trip blank) as part of the 10% QA/QC requirements during each quarterly event.
- Submitted the samples for analysis to approved laboratories.
- Stored, processed, and prepared the analytical data for analysis and submission to NWMO.
- Prepared separate pressure data and chemistry data quarterly reports.

The steps outlined above are detailed further as pre-mobilization and mobilization activities, fluid pressure and temperature monitoring, purging and field parameters, groundwater sampling, data assessment and reporting activities.

3.2 Health, Safety and Environment Activities

As per the Health, Safety and Environment Management Plan (HSEP) developed for the project, the KGS Group project team held a pre-job meeting via MS Teams to review the HSEP and the Test Plan to ensure all team members understood their roles and the expectations given the planned scope of work.

While the field team was working on site, the Field Lead/Supervisor held daily tailgate meetings with the field crew at the beginning of their workday to review the planned work activities, the related health, safety and environmental issues related to the planned work and specific hazards associated with each task and mitigation and control measures related to the hazards. All Job Safety Analysis (JSA) forms were updated as needed and signed off by the field team. Completed JSAs have been provided with the data package. An example of some of the specific hazards identified during the field event included:

- Heavy lifting
- Compressed gas
- Water containment
- Slips, trips, and falls
- Hand Tool Safety
- Use/handling of cleaning detergents, sample preservatives
- Highway driving
- Tire punctures from driving on gravel roads, narrow forest road access, and farm field access, etc
- Wildlife crossings/encounters
- Handling of preservatives when collecting samples
- Weather (e.g., heavy rain, thunderstorms, lightning protocols)

No health and safety or environmental incidents occurred during any of the field events in 2022. The field lead conducted a daily environmental inspection at each of the sites using a prescribed checklist. The completed checklist was included with each data package.

3.3 Fluid Pressure and Temperature Monitoring

Fluid pressure and temperature monitoring was also completed during each monitoring event in 2022. The annual pressure data for 2022 is addressed in a separate report.

3.4 Groundwater Sampling

The collection of groundwater samples comprised a significant portion of the scope of work of this project. The methodology for conducting the field work is described in the following sections.

3.4.1 SAMPLE LOCATION SELECTION

Monitoring well sample location selection was made in collaboration between the KGS Group project team and the NWMO project team several weeks prior to mobilizing to the field for each quarterly event. The rationale for selecting the monitoring wells to be sampled was documented on *DQCF01-Sample Location Rationale*, which provides the criteria and rationale for the sample location selection process. Completed DQCF01s were included with the Data Deliverable package for each of the quarterly events.

Well selection was done collaboratively and applied selection criteria such as: (i) even sample distribution over time, (ii) sufficient volume of water to be purged and sampled. It was already determined that many intervals did not have sufficient yield of water to reliably be purged and sampled based on previous work done on the wells in 2021 under a separate contract, however efforts were made during the sampling events in 2022 to attempt to collect water from intervals even with low water yields.

3.4.2 GROUNDWATER FIELD CHEMISTRY EQUIPMENT CALIBRATION AND DECONTAMINATION

As per the Ignace Test Plan, KGS Group field staff did a field verification of each piece of equipment at the beginning of each day. If the instrument was not within manufacturer tolerance ranges when reading the calibration standards, then the instrument was re-calibrated in the field using valid National Institute of Standards and Technology (NIST) certified calibration standards and following the manufacturer's instructions. All field verifications and calibrations were recorded on *DQCF03-Equipment Calibration Log*. Completed DQCF03s have been provided with each of the 2022 Quarterly Data Delivery packages.

Certificates of calibration for each instrument used to measure a groundwater parameter in the field and Certificate of Analysis for all calibration standards have been provided with the Quarterly Data Deliverable packages.

Decontamination and cleaning of each piece of equipment used to measure groundwater parameters was completed before purging was started as per the test plan. The decontamination process was recorded on *DQCF04-Equipment Decontamination Log* every time an interval was purged/pumped. Completed DQCF04s have been provided with each Quarterly Data Deliverable package.

3.4.3 MONITORING WELL PURGING CRITERIA

The defined criteria agreed to by NWMO for when a groundwater sample can be collected is described in the Ignace Test Plan, which describes how purging activities would be completed and the criteria that should be used to determine when a groundwater sample can be collected. Due to the generally low hydraulic conductivities measured in the multilevel monitoring wells during the 2021 Shallow Groundwater Installation by KGS Group, well purging criteria was developed to guide the field purging activity and to try and ensure that a sample could be collected with high confidence in terms of sample integrity and more likely be representative of the groundwater at the Revell Site. The criteria used for determining when a sample would attempt to be collected must be one of three possible scenarios:

I. **Stabilization of field parameters:** Three consecutive readings that do not deviate more than the defined ranges as shown on Table 1 below for all field parameters (e.g., pH, electrical conductivity, temperature, total dissolved solids, turbidity, oxygen reduction potential, fluorescein, dissolved oxygen, density).
II. **Three well volumes purged:** Calculated total volume of water in each monitoring interval is purged three times before Criteria I is observed.
III. **Well purged dry three times after 80% recovery each time:** Neither Criteria I nor II as described above is achieved. Interval is not able to be purged at steady-flow rates.

The groundwater field parameters stabilization criteria are given on Table 1 below and are also shown on *DQCF05-Field Parameter Data Sheet* provided with the Quarterly Data Deliverable packages.

TABLE 1: FIELD PARAMETER STABILIZATION TARGETS

Field Parameters	Measurement Instrument	Units	Stabilization targets
Fluoresceine Dye	Pyxis Handheld Fluorometer, SP-380	ppb	<1 ppb Change
Hydraulic Density	Polycarbonate Buoyant Hydraulic Densometer	g/cm^3	N/A
Total Dissolved Solids (TDS)	Hanna DiST1 Total Dissolved Solids Meter	mg/L	± 10% Change
Turbidity	YSI Pro Series Water Chemistry Kit	NTU	± 10% or ± 5 NTU, if initial NTU measurement is >50 NTU
Dissolved Oxygen (DO)		mg/L	± 10% Change
Electrical Conductivity (EC)		mS/cm	± 10% Change
Temperature		Degrees Celsius	± 0.5 ºC Change
pH		pH unit	± 0.1 standard pH units Change
Oxidation-Reduction Potential (ORP)		mV	± 10% Change

3.4.4 PURGING METHODOLOGY

The Ignace Test Plan describes how purging of the monitoring well intervals at the Revell site was completed using the dedicated double valve pump installed as part of the Solinst Waterloo multilevel system with each pump having a dedicated drive and vent tube that extends to surface and is connected to the wellhead manifold. The pump was driven by compressed nitrogen gas controlled by a Solinst electronic control unit (ECU) that regulates and controls the pressure applied and duration of drive and vent cycles. Each monitoring interval required application of specific pressures with the main goal being to optimize the drive and vent times so that a low-flow steady flow rate was achieved. Steady flow stabilization allowed for collecting water quality field parameter measurements to track stabilization progress in each interval, and to ensure a high confidence groundwater sample was collected. The range of flow rates ranged between 20 and 300 mL/min.

KGS Group attempted to optimize the drive/vent cycles for each of the depth intervals to try and establish drive/vent timing that produced a steady low-flow rate. All purge water was diverted into pails and sealed with lids. Pails of purged water were disposed of at the City of Dryden Wastewater Plant.

A summary of the pump settings used in the field and the actual purge volumes is included in the *DQCF05-Field Parameter Data Sheets* provided with each Quarterly Data Deliverable packages.

3.4.5 GROUNDWATER PARAMETER MONITORING

As per the Ignace Test Plan, a flow-thru cell was used with the field verified YSI Pro multi-probe testing unit that allowed the measurement of water quality parameters every 5 minutes. Water quality parameters that were not measured using the YSI Pro multi-probe unit were measured with field verified/calibrated instruments from water collected from the discharge tubing of the flow-thru cell in a clean/decontaminated plastic cup or instrument-specific sample containers. Field measurements were recorded directly onto DQCF05. All completed DQCF05s and excel files were included with the Quarterly Data Deliverable packages and reported on in the Quarterly Chemistry Data Reports.

3.4.6 QA/QC OF FIELD DATA

KGS Group completed the QA/QC of the field data that was captured on Data Quality Confirmation Forms used to capture datalogger readings at the time of downloading (DQCF02-*Transducer Download*), equipment calibration log (DQCF03), verify decontamination of field equipment (DQCF04), collect groundwater chemistry field measurements (DQCF05) and sample collection logs (DQCF06-*Sample Collection Log*).

This was completed as part of preparation for each of the quarterly data delivery packages. Each DQCF was reviewed by a senior reviewer for formatting, consistency of information being recorded, errors in the values and identification of values that were outside of the expected ranges. Where an error was found that error was highlighted, and a note was made of the correction. When a reading or value was outside of the expected range, that value was highlighted either by bolding or the cell was highlighted on the DQCF.

After the review was completed, the DQCF was signed off on by both the person who prepared the DQCF and the person who verified it.

3.5 Groundwater Analysis

During the field program, KGS Group field staff presented the field parameter measurements recorded on DQCF05 to the KGS Group technical lead for verification that the purge criteria had been met and documented correctly before each sample was collected. Then groundwater sampling was completed by KGS Group field staff as described in Section 3.5.1 in the Ignace Test Plan.

The specifics and details for sample collection for all the field events are included on DQCF06 provided with the Quarterly Data Deliverable packages.

QA/QC blanks were prepared as described in the Ignace Test Plan by ALS Laboratories LTD. All samples (including QA/QC samples) were analyzed for the Quarterly and Annual analytical packages as detailed on Table 2 below.

TABLE 2: SUMMARY OF LABORATORY PARAMETERS

Analysis Group	Parameters	Analysis Frequency
Dissolved Metals	Aluminum (Al), Antinomy (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Bismuth (Bi), Boron (B), Cadmium (Cd), Calcium (Ca), Cesium (Cs), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Lithium (Li), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Phosphorous (P), Potassium (K), Rubidium (Rb), Ruthenium (Ru), Selenium (Se), Silicon (Si), Silver (Ag), Sodium (Na), Strontium (Sr), Sulfur (S), Tellurium (Te), Thallium (Tl), Thorium (Th), Tin (Sn), Titanium (Ti), Tungsten (W), Uranium (U), Vanadium (V), Zinc (Zn), Zirconium (Zr)	Quarterly
Routine and Nutrients	Conductivity, pH, Alkalinity (Total, as CaCO3), Ammonia (Total, as N), Bicarbonate (HCO3), Bromide (Br), Carbonate (CO3), Chloride (Cl), Fluoride (F), Hydroxide (OH), Nitrate and Nitrite as N, Nitrate (as N), Nitrite (as N), Orthophosphate-Dissolved (as P), Phosphorus (P)-Total, Phosphorus (P)-Total Reactive, Silica (SiO2)-Reactive, Sulfate (SO4), Total Kjeldahl Nitrogen, Total Nitrogen	Quarterly
Dissolved Inorganic Carbon	Dissolved Inorganic Carbon (DIC)	Quarterly
Iodide	Iodide	Quarterly
$\delta^{18}O$, $\delta^{2}H$	Oxygen-18 ($\delta^{18}O$), Deuterium ($\delta^{2}H$)	Quarterly
Ruthenium – dissolved	Ruthenium – dissolved	Annually
$^{87}Sr/^{86}Sr$, $\delta^{13}C$ DIC, $\delta^{37}Cl$	Strontium 87/86 ratio ($^{87}Sr/^{86}Sr$), Carbon-13 ($\delta^{13}C$ DIC), Chlorine-37 ($\delta^{37}Cl$)	Annually
Gross Alpha/ Beta	Gross Alpha/ Beta	Annually
^{14}C and ^{3}H	Carbon-14 (^{14}C) and Tritium (^{3}H)	Annually

For all quarterly events, all the collected samples were submitted to ALS Laboratories located in Winnipeg, Manitoba by KGS Group.

All Certificates of Analysis (COA) (in both PDF and excel file formats), Sample Reception Confirmation (SRC) forms, Chain of Custody (CoC) forms, and electronic data deliverable (EDD) files have been provided with the Data Deliverable packages for each quarterly event.

3.5.1 QA/QC OF LABORATORY RESULTS

KGS Group completed a verification of the laboratory reports and data sets. Each set of reports and data have been identified and detailed on *DQCF07-Laboratory Data Quality Confirmation* forms and recorded per ALS work order #. These have been provided with each Quarterly Data Deliverable package. The verification of the laboratory reports and data sets included the following checklist items:

- All results and data were received from the laboratory
- All submitted samples requiring analysis were tested
- Laboratory QA/QC procedures are outlined in the report
- Laboratory results are in the proper format/unit
- Laboratory results are in expected/reasonable ranges
- Laboratory detection limits are correct
- Chain-of-Custody contains the required information (dates, signatures, etc.)
- Hold time issues are identified
- Additional notes (such as any other pertinent observations made by the reviewer of the lab reports)

Details regarding the results of the Quality Assurance/Quality Control checks and verifications done for the 2022 analytical data are described below.

Results and Data Received from the Laboratory

There was one sample (IG_MWC02_A_GW0001) in the Q3 (September) period that was not analyzed by the laboratory for total nitrogen, while ‘anion sum’ and ‘cation sum’ were also not calculated by the laboratory for several samples during the same event. This was addressed within the framework of the project non-conformance procedures.

Laboratory Results are Reported in the Proper Format/Unit

The 2022 annual isotopes were analyzed and reported in units and detection limits that did not meet the NWMO project objectives. The two isotopes that did not meet these objectives were 14C-DIC, which was to be analyzed by Accelerator Mass Spectrometry (AMS) and Tritium (3H), which was to be reported in Tritium Units (TU) with a minimum detection limit of 0.8 TU. These specifications were added to the project laboratory analysis in late 2022 and will be reflected in the 2023 annual report.

Hold Time Exceedances

Table 3 below summarizes the total number of samples and which parameters exceeded the laboratory recommended hold times for each of the quarterly sample events. Important to note that the hold time for pH is 15 minutes and was exceeded for all samples submitted to the lab. This is an unavoidable exceedance but is mitigated by collecting field measurements with a calibrated pH meter during purging. The field measured pH results are provided in Table 6.

Possible reasons for a sample to exceed a hold time can be due to travel time to deliver the samples from the site to the lab, time of travel of a sample between laboratories for specific analysis (i.e. nitrate (as N), nitrite (as N), Total alkalinity (as $CaCO_3$) or some other issue at the lab, which is detailed on each of the quarterly DQCF07 and on Table 3.

TABLE 3 2022 SAMPLE HOLD TIME EXCEEEDANCES

Analysis Group	Recommended Hold Times	Hold Time Exceedances		
		Q3-July 2022	Q3-September 2022	Q4 2022
Dissolved Metals	180 days	7 samples for total aluminum	None	None
Routine and Nutrients	Br, F, Cl, SiO_2, EC – 28 days ALK – 14 days ortho-PO_4^{3-}, NO_2^-, NO_3^- – 3 days All other nutrients – 28 days	3 samples for nitrate and nitrite (as N) – samples received less than 24 hours prior to expiry. 8 samples for total phosphorous. 14 samples for total reactive phosphorus. (1)	15 samples for total alkalinity. 18 samples for dissolved orthophosphate and total reactive phosphorus. 2 samples for dissolved inorganic carbon.	12 samples for dissolved orthophosphate and total reactive phosphorus.
Dissolved Inorganic Carbon	14 days	None	None	None
Iodide	28 days	.	None	None
$\delta^{18}O$, $\delta^{2}H$	Unlimited if no headspace and chilled	None	None	None
Ruthenium – dissolved	180 days	None	None	None
$^{87}Sr/^{86}Sr$, $\delta^{13}C$ DIC, $\delta^{37}Cl$	Unlimited if no headspace and chilled	None	None	None
Gross Alpha/ Beta	Unlimited	None	None	None
^{14}C and ^{3}H	Unlimited	None	None	None

Note: 1. Freezing of the reactive phosphorus samples by the laboratory was done in accordance with ISO-5667-3 (2012) and does not affect the validity of the analysis.

3.5.2 ASSESSMENT OF LABORATORY RESULTS

Assessment of the laboratory data for this 2022 annual report by KGS Group was principally done by preparation of two distinct geochemistry plots, Durov and Stiff Diagrams. These plots were generated using AquaChem 11. 0.

AquaChem 11.0 is a commercially available off the shelf software developed by Waterloo Hydrogeologic. The version 11.0 and build 19.22.0516.1 of AquaChem was used to generate the Durov and Stiff Diagrams for the 2022 shallow groundwater quality data for each quarterly sampling event. The Durov and Stiff plots were used for making interpretations of the groundwater types and trend analysis.

Data Processing: KGS Group received the laboratory data from ALS Laboratories LTD as an Electronic Data Deliverable file format (.EDD) which was imported into an environmental database management system called ESdat. The file generated by the lab reporting system consists of three files (a header file in a .xml format, a sample file in a .csv format, and a chemistry file in a .csv format) compressed in a zip folder. Within ESdat, the chemistry data was then arranged to be exported into the excel based acQuire import templates and as the primary data input into AquaChem to generate the geochemical plots.

Durov Plots: Multiple water types can be compared using a Durov plot. AquaChem 11.0 calculates the milliequivalents per litre (meq/L) of each cation and anion from the laboratory water quality data. The total cations and the total anions are expected to balance each other, however, there were inequalities in the sum totals of cations and anions as measured by the laboratory within the accepted margin of error of +/= 10% difference for the majority of samples. A total of four of the forty-two total samples analyzed by the lab had charge balance error greater than +/- 10%.

On the Durov plots, the cations and anions are plotted on adjacent ternary plots. The ternary diagram on the left (Y-Axis) represents the cations: Magnesium, Calcium, and Sodium + Potassium, while the ternary diagram on the top (X-Axis) represents the anions: Sulfate, Chloride, and Carbonate + Bicarbonate. The intersection of the data is shown on a central rectangular plot which is a projection of anions (X axis, SO4, HCO3+CO3 and Cl) and cations (Y axis, Na+K, Mg and Ca) ternary plots. Side plots show the actual pH and conductivity values for each point. Durov plots can be used to differentiate between different water types, which plot in different sections of the graph. Similar water types tend to cluster within the same region of the central rectangular plot. The plot can also be used to infer the origin of the water or mixing processes between water types. Durov plots can also be used to plot changes in water quality data with time, which could be applied at this site in the future. Specific Durov Plots grouped by water type (Figures 3 and 4) and then by sampling events (Figures 6, 7 and 8) are provided below. The Durov plots for high confidence and low confidence samples are provided in Appendix A1 and A2, respectively.

Stiff Diagrams: Individual water types can be compared using Stiff diagrams that display the relative concentrations of major ions expressed in milliequivalents per litre (meq/L). The lengths of the polygon sides illustrate the major ion concentrations, and plots of different shapes indicate different “fingerprints” of water qualities. Waters of similar type have a similar plot shape and would be generally expected to originate from the same source. Water can be named using the major cations and anions found on a percentage basis in the laboratory water analysis, see Table 7.

Stiff diagrams for high and low confidence samples collected in 2022 are provided separately in Appendix B1 and B2, respectively.

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4.0 RESULTS

4.1 Sample Selection

4.1.1 SAMPLE LOCATION SELECTION

As indicated previously, the team selected all intervals from multilevel monitoring wells IG_MWA03, IG_MWB03 and IG_MWC01 to be sampled in the Q3-July event, whereas all multilevel monitoring wells except IG_MWA01, IG_MWA02, IG_MWB01 and IG_MWB02 were sampled in the Q3-September event. The multilevel monitoring wells IG_MWA01, IG_MWB01 and IG_MWC02 (nine monitoring well intervals total) were sampled during the Q4-December field event. Table 4 below shows which samples were collected during each quarterly event.

TABLE 4: 2022 LOCATIONS SAMPLED

Field Event	Q3-July 2022	Q3-September 2022	Q4 2022
Dates of Event	July 18 to 20, 2022	September 27 to October 3, 2022	November 29 to December 6, 2022
Multilevel Monitoring Well Sampled	IG_MWA03, IG_MWB03 and IG_MWC01	IG_MWA03, IG_MWB03, IG_MWC01, IG_MWC02 and IG_MWC03	IG_MWA01, IG_MWB01 and IG_MWC02
Multilevel Monitoring Well Not Sampled	IG_MWA01, IG_MWB01, IG_MWC02 and IG_MWC03	IG_MWA01 and IG_MWB01	IG_MWA03, IG_MWB03, IG_MWC01 and IG_MWC03
Total Samples Collected	9 groundwater samples + 3 QA/QC samples	15 groundwater samples + 3 QA/QC samples	9 groundwater samples + 3 QA/QC samples

Each multilevel monitoring well comprised three depth intervals (e.g. IG_MWA01_A, IG_MWA01_B, IG_MWA01_C), where “A” represents the deep interval, “B” represents the intermediate depth interval, and “C” is the shallowest within the multilevel). Purging of the nine monitoring well intervals during the Q3-July field event, fifteen monitoring well intervals during the Q3-September field event, and nine monitoring well intervals during the Q4-December field event were completed as per the Ignace Test Plan.

4.2 Purging and Field Chemistry

In the 2022 Q3-July quarterly event, three multilevel monitoring wells, IG_MWA03, IG_MWB03 and IG_MWC01 were purged for field chemistry parameters and groundwater samples, whereas in Q3-September, all multilevel monitoring wells except IG_MWA01, IG_MWA02, IG_MWB01 and IG_MWB02 were purged for field chemistry parameters and groundwater samples. In Q4-December quarterly event, the multilevel monitoring wells IG_MWA01, IG_MWB01 and IG_MWC02 were purged for groundwater samples and field chemistry.

KGS Group has reviewed the laboratory results from the field events of 2022 and included a detailed assessment of the hydrogeochemical characteristics of groundwater at the Ignace Site. The results are presented and discussed in the sections below.

4.2.1 FIELD PURGING RESULTS

4.2.1.1 Purge Volumes

A summary of purge volumes corresponding to each quarterly event is shown on Tables 5 and 6 below separated into High and Low Confidence Samples, these measurements are also included on DQCF05 provided with the Data Deliverable package of each quarterly event.

TABLE 5: PURGING RESULTS HIGH CONFIDENCE SAMPLES

Monitoring Well ID	Purging Results			Field Event
	Total Purge Volume (mL)	Purge Method	Purge Criteria Achieved (I, II, III)	
IG_MWA03_B	14,620	Double Valve Pump	I-GW parameters stabilized	Q3-July 2022
IG_MWB03_B	4,450	Double Valve Pump	III-Purged dry 3x	Q3-July 2022
IG_MWC01_A	13,646	Double Valve Pump	I-GW parameters stabilized	Q3-July 2022
IG_MWA03_B	34,669	Double Valve Pump	I-GW parameters stabilized	Q3-September 2022
IG_MWC01_C	11,281	Double Valve Pump	I-GW parameters stabilized	Q3-September 2022
IG_MWC01_A	21,046	Double Valve Pump	I-GW parameters stabilized	Q3-September 2022
IG_MWC02_A	33,679	Double Valve Pump	II-Three well volumes purged	Q3-September 2022
IG_MWC03_C	19,402	Double Valve Pump	I-GW parameters stabilized	Q3-September 2022
IG_MWA01_C	17,220	Double Valve Pump	I-GW parameters stabilized	Q4-2022
IG_MWB01_C	20,510	Double Valve Pump	I-GW parameters stabilized	Q4-2022
IG_MWC02_A	23,250	Double Valve Pump	I-GW parameters stabilized	Q4-2022

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TABLE 6: PURGING RESULTS LOW CONFIDENCE SAMPLES

Monitoring Well ID	Purging Results			Field Event
	Total Purge Volume (mL)	Purge Method	Purge Criteria Achieved (I, II, III)	
IG_MWA03_C	3,880	Double Valve Pump	III-Purged dry 3x	Q3-July 2022
IG_MWA03_A	6,471	Double Valve Pump	III-Purged dry 3x	
IG_MWB03_C	1,465	Double Valve Pump	III-Purged dry 3x	
IG_MWB03_A	11,820	Double Valve Pump	III-Purged dry 3x	
IG_MWC01_C	4,318	Double Valve Pump	III-Purged dry 3x	
IG_MWC01_B	7,125	Double Valve Pump	III-Purged dry 3x	
IG_MWA03_C	2,624	Double Valve Pump	III-Purged dry 3x	Q3-September 2022
IG_MWA03_A	6,551	Double Valve Pump	III-Purged dry 3x	
IG_MWB03_C	1,883	Double Valve Pump	III-Purged dry 3x	
IG_MWB03_B	4,951	Double Valve Pump	III-Purged dry 3x	
IG_MWB03_A	9,296	Double Valve Pump	III-Purged dry 3x	
IG_MWC01_B	2,537	Double Valve Pump	III-Purged dry 3x	
IG_MWC02_C	752	Double Valve Pump	III-Purged dry 3x	
IG_MWC02_B	5,302	Double Valve Pump	III-Purged dry 3x	
IG_MWC03_B	784	Double Valve Pump	III-Purged dry 3x	
IG_MWC03_A	6,303	Double Valve Pump	III-Purged dry 3x	
IG_MWA01_A	3,515	Double Valve Pump	III-Purged dry 3x	Q4 2022
IG_MWA01_B	5,360	Double Valve Pump	III-Purged dry 3x	
IG_MWB01_A	5,065	Double Valve Pump	III-Purged dry 3x	
IG_MWB01_B	1,625	Double Valve Pump	III-Purged dry 3x	
IG_MWC02_B	4,033	Double Valve Pump	III-Purged dry 3x	
IG_MWC02_C	175	Double Valve Pump	III-Purged dry 3x	

It should be noted that twenty-two of the monitoring intervals purged and sampled in 2022 were not able to be purged at a constant low-flow sampling rate. This is due to the low permeabilities of the rock formation and very slow rates of recharge which ultimately resulted samples that were low confidence of being represenative of crystalline bedrock formation groundwater. Also, intervals that were purged dry three times (purging criteria III) generally resulted in field parameters (TDS, EC, DO) and analytical results that are notably different than the results from intervals that were able to reach groundwater field parameter stabilization, and these samples were also deemed as low confidence of being representative of the groundwater at the site.

4.2.2 FIELD CHEMISTRY RESULTS

KGS Group has reviewed the laboratory results from all the field events of 2022 and included a detailed assessment of the hydrogeochemical characteristics of groundwater at the Ignace Site. The results for both high confidence and low confidence samples are provided in the following sections, however, the

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interpretations of groundwater characteristics at the site were only made for the high confidence sample results.

The groundwater temperature values during the field work generally ranged between 6.8 and 19.7 °C. Generally, the groundwater temperature at the Site is expected to be below 10 °C, however, higher than expected temperatures were observed for some samples, most likely due to the time it takes to fill the flow-through cell of the field probe and taking a field measurement at 5-minute intervals. The values of pH in groundwater of the area of study vary from 5.68 to 8.09, revealing the slightly acidic to slightly alkaline nature of the groundwater.

The values of field EC in samples varied between 49 and 6696 µS/cm at field groundwater temperatures, whereas the field TDS values ranged between 30 mg/L and 1156 mg/L. To understand the accuracy of field EC and field TDS measurements, the field EC values were compared against the EC values reported by the laboratory, whereas the field TDS measurements were compared with the calculated TDS values using the expression:

$TDS = k.EC_{field}$

Where, TDS is represented in mg/L, “k” is a unitless conversion factor, and EC is represented in µS/cm (Rusydi, 2018). The value of “k” is derived from the literature to be in the range 0.55 – 0.75 (Hem & Survey, 1985). There were instances where field dissolved oxygen (DO), electrical conductivity, turbidity, fluorescein, and field TDS of the samples were higher than expected or remained elevated during purging. The elevated readings of the above-mentioned field parameters are noted on Table 7 below.

4.2.2.1 Field Parameters Data Review

The internal review of the DQCFs identified values that were outside of the expected ranges for typical groundwater conditions after the purging process was complete. The review of the field data was done on the DQCF05 as well as on the acQuire importer IG_IMP-29_SH_FieldParameters included with each quarterly data deliverable.

The results of the field chemistry parameter monitoring for high confidence and low confidence samples are presented on Table 7 and 8 below, respectively. These field measurements were recorded during the purging of each of the well intervals in preparation for collecting a high confidence groundwater sample for laboratory analysis.

TABLE 7: FIELD CHEMISTRY PARAMETER SUMMARY FOR HIGH CONFIDENCE SAMPLES

Monitoring Interval	Sample Event	Field DO (Multimeter) [mg/L]	Field EC [mS/cm]	Field ORP [mV]	Field Turbidity (NTU)	Field Fluorescein [ppb]	Field pH	Field TDS [mg/L]	Field Temp [°C]	Field Density (g/cm3)	Purging Criteria	Comments
IG_MWA01_C	Q4	**3.2**	0.05	195.6	**455**	0	**5.68**	301	7.5	0.996	GW parameters stabilized	Field DO and turbidity were higher than expected. Even though pH stabilized during purging, it was lower than expected.
IG_MWA03_B	Q3-July	1.62	1.55	-106	**1500**	0.36	7.72	**1156**	8.2	1	GW parameters stabilized	Field TDS was higher than expected
	Q3-September	2.15	0.88	-110.9	**2345.2**	0	7.58	428	6.8	0.997	GW parameters stabilized	Field turbidity is higher than expected.
IG_MWB01_C	Q4	**3.18**	0.09	110.2	0.69	0	6.03	501	7.5	0.996	GW parameters stabilized	Field DO was higher than expected.
IG_MWB03_B	Q3-July	0.81	**6.7**	-166	**809**	0.66	7.68	**>2000**	**19.7**	0.992	GW parameters stabilized	Field TDS was higher than expected
IG_MWC01_A	Q3-July	0.94	1.43	-122.2	**365**	0.67	7.03	**1019**	8.1	1	GW parameters stabilized	Field TDS was higher than expected
	Q3-September	0.95	0.86	-106.9	**710.3**	0	7.01	429	7.1	0.995	GW parameters stabilized	Field turbidity is higher than expected.
IG_MWC01_C	Q3-September	1.12	0.75	-70.4	37.82	0	6.85	358	**10.5**	0.995	GW parameters stabilized	Field temperature was higher than expected.
IG_MWC02_A	Q3-September	0.96	0.24	-162.6	24.21	0	8.09	118	6.9	0.994	Three well volumes purged	-
	Q4	0.3	0.24	-133.2	0.59	0	8.01	1301	7.2	0.998	GW parameters stabilized	-
IG_MWC03_C	Q3-September	1.04	0.33	-88.5	**882**	0	7.36	169	7.9	0.996	GW parameters stabilized	Field Turbidity was higher than expected.

1. TDS was measured in ppt units in field during the Q4 2022 monitoring event. These values are manually converted to mg/L and reported in mg/L in Table 7.

TABLE 8: FIELD CHEMISTRY PARAMETER SUMMARY FOR LOW CONFIDENCE SAMPLES

Monitoring Interval	Sample Event	Field DO (Multimeter) [mg/L]	Field EC [mS/cm]	Field ORP [mV]	Field Turbidity (NTU)	Field Fluorescein [ppb]	Field pH	Field TDS [mg/L]	Field Temp [°C]	Field Density (g/cm3)	Purging Criteria	Comments
IG_MWA01_A	Q4	**5.9**	**4**	-59.6	**122**	**5.8**	7.49	**2100**[1]	8.5	0.995	Purged dry 3x	Field DO, EC, turbidity, TDS, and fluorescein values were higher than expected.
IG_MWA01_B	Q4	1.05	**8.4**	-85.9	11.5	0	7.39	**4200**[1]	8	0.999	Purged dry 3x	Field EC and TDS were higher than expected.
IG_MWA03_A	Q3-July	0.89	**9.5**	-118	**683**	2.5	7.58	**>2000**	11	1.02	Purged dry 3x	Field TDS was higher than expected
	Q3-September	0.81	**12.72**	-175	2.1	**10.9**	7.47	**>2000**	**14.7**	0.999	Purged dry 3x	Field EC, fluorescein, TDS, and temperature were higher than expected.
IG_MWA03_C	Q3-July	1.21	2.78	-150.9	8	0.46	7.73	**1553**	**17.9**	1	Purged dry 3x	Field TDS was higher than expected
	Q3-September	1.26	2.84	-140.7	8.09	0	7.74	**1327**	**11.3**	1	Purged dry 3x	Field TDS and temperature measurements were higher than expected.
IG_MWB01_A	Q4	**6.46**	**7.85**	-82.4	6.28	**3.1**	7.36	**3940**[1]	8.7	0.996	Purged dry 3x	Field DO, EC, TDS, and fluorescein values were higher than expected.
IG_MWB01_B	Q4	**3.06**	**10.99**	90.7	57.2	**3.1**	8.22	**5010**[1]	**10.4**	-	Purged dry 3x	Field DO, EC, TDS, fluorescein and temperature values were higher than expected. Insufficient volume of water at the end of the last purge to measure density.
IG_MWB03_A	Q3-July	0.77	0.32	-36.8	439	**9.3**	8.15	204	10.9	0.996	Purged dry 3x	-
	Q3-September	**9.2**	0.44	-107.2	**714.83**	**5.5**	8.23	227	8.3	0.992	Purged dry 3x	Field DO, turbidity and fluorescein values were higher than expected.
IG_MWB03_B	Q3-September	0.8	**8.05**	-172	143.33	**10.7**	7.49	**>2000**	**10.2**	1	Purged dry 3x	Field EC, fluorescein, TDS and temperature values were higher than expected.
IG_MWB03_C	Q3-July	0.8	**9.99**	-140	**2500**	3.9	7.47	**>2000**	**13.3**	1	Purged dry 3x	Field TDS was higher than expected
	Q3-September	1.21	**12.35**	-146.4	67.19	**13.8**	7.53	**>2000**	9.6	1.002	Purged dry 3x	Field EC, fluorescein, and TDS values were higher than expected.
IG_MWC01_B	Q3-July	0.83	**11.7**	-151	885	0.98	7.49	**>2000**	**18**	1	Purged dry 3x	Field TDS was higher than expected

Monitoring Interval	Sample Event	Field DO (Multimeter) [mg/L]	Field EC [mS/cm]	Field ORP [mV]	Field Turbidity (NTU)	Field Fluorescein [ppb]	Field pH	Field TDS [mg/L]	Field Temp [°C]	Field Density (g/cm3)	Purging Criteria	Comments
	Q3-September	1.21	**13.22**	-145.7	**490.2**	2.5	7.4	**>2000**	**12.2**	0.995	Purged dry 3x	Field EC, turbidity, TDS, and temperature values were higher than expected.
IG_MWC01_C	Q3-July	1.62	0.57	-74.8	0	0	7.24	384	**17.5**	0.994	Purged dry 3x	-
IG_MWC02_B	Q3-September	**9.8**	**15.45**	-93.5	**466.63**	0	7.25	**>2000**	9.7	1.008	Purged dry 3x	Field DO, EC, turbidity and TDS values were higher than expected.
	Q4	0.34	**14.92**	-70.3	13.1	**12.9**	7.12	**7560**[1]	8.1	0.999	Purged dry 3x	Field EC, TDS, and fluorescein values were higher than expected.
IG_MWC02_C	Q3-September	**10.1**	0.66	-159.1	**1504**	0	7.81	431	-	0.996	Purged dry 3x	Field DO and turbidity values were higher than expected.
	Q4	1.2	1.65	-100.6	45.8	**3.1**	7.66	**930**[1]	9.4	-	Purged dry 3x	Field TDS and Fluorescein values were elevated. There was not enough water volume available to measure the field density.
IG_MWC03_A	Q3-September	1.05	0.49	-133.4	**443.95**	0	7.57	234	9.6	0.998	Purged dry 3x	Field Turbidity was higher than expected.
IG_MWC03_B	Q3-September	1.22	**5.76**	-120.3	**2528.7**	**6.1**	7.55	**>2000**	**10.2**	1	Purged dry 3x	Field EC, turbidity, fluorescein, TDS, and temperature values were higher than expected.

1. TDS was measured in ppt units in field during the Q4 2022 monitoring event. These values are manually converted to mg/L and reported in mg/L in Table 8.

4.3 Groundwater Sampling Results

The 2022 Q3-July event comprised of collecting nine groundwater samples, one field duplicate, one trip blank, and one field blank, for a total of twelve samples, whereas fifteen groundwater samples, one field duplicate, one trip blank and one field blank sample, for a total of eighteen samples were collected during the 2022 Q3-September event. The 2022 Q3-December event comprised of collecting nine groundwater samples, one field duplicate, one trip blank, and one field blank sample for a total of twelve samples, all submitted for analysis at ALS Laboratories LTD. All sample IDs were provided by the NWMO Geoscientific Data Management (GDMS) Administrator prior to mobilizing to the field. Table 4 provides a summary of the total number of samples collected each quarterly sample event and from where the samples were collected.

Due to the very low hydraulic conductivity of many of the monitored intervals and the challenge associated with collecting a high confidence sample (i.e., not able to purge at a steady flow rate until field chemistry stabilization criteria or “purge criteria I” was met), the samples for which “purge criteria I” was achieved are considered of high confidence in terms of sample integrity and are discussed in further detail. As shown above on Tables 5 and 6, ten out of thirty-three groundwater samples (excluding the QA/QC samples) were collected upon satisfying “purge criteria I” while twenty-two samples were collected after purging the well dry thrice (purge criteria II). One sample was collected upon removal of three well volumes of groundwater (purge criteria II). Alternately, a total of eleven samples collected were considered as a high confidence sample (Table 5) and twenty-two samples collected are considered as a low confidence sample (Table 6). A summary of laboratory results for high confidence samples (Appendix C1) and low confidence samples (Appendix C2) are included in appendices to this report. As purging criteria II and III did not allow for collection of high confidence samples, any sample collected meeting those two criteria are not addressed further in the discussion of the results and the remainder of this report focusses on the results and analysis of the 11 high confidence samples as they are more likely to be representative of the groundwater chemistry.

4.3.1 LABORATORY RESULTS

KGS Group has reviewed the laboratory results from all the field events of 2022 and included an assessment of the hydrogeochemical characteristics of groundwater at the Revell Site, focused on the high confidence samples.

4.3.1.1 Concentrations of major ions

There are many natural factors that can affect the groundwater quality of an area. The primary factors include the chemical composition and the source of recharge water, the lithological as well as hydrological properties of the water-bearing geological unit and the groundwater residence time in a geological unit.

Major ions, both positively (cations) and negatively (anions) charged, are the most abundant dissolved constituents in the groundwater, and are found at equal concentrations for electroneutrality. The most abundant cations present in water are calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). The most abundant anions are bicarbonate (HCO_3), chloride (Cl), and sulfate (SO_4). Durov plots were prepared for samples based on the concentration of these ions and are provided in Appendix A. Durov plots were also prepared for each quarterly sample event seen on Figures 5 to 7 below. The concentration of major ions listed above are also shown for reference on all stiff diagrams presented in Appendix B1 for High Confidence Samples and B2 for Low Confidence Samples.

The groundwater water type is based on the dominant dissolved cation and anion, expressed in milliequivalents per liter (meq/L). The dominant dissolved ion must be greater than 50% of the total. For example, the sodium-sulphate (Na-SO_4) type water contains greater than 50% of total cation milliequivalents as sodium and more than 50% of total anion milliequivalents in water as sulphate. If no cation or anion is dominant, the water is classified as mixed, and the two most common anions (or anions in decreasing order of their composition) are used to describe the water type.

The water type of every sample is provided below grouped by water type and then sample location and excludes the trip blank, field blank and field duplicate samples:

TABLE 9: WATER TYPES AT THE REVELL SITE (HIGH CONFIDENCE SAMPLES)

Sample ID	Sample Event	Sample Date (dd-mm-yyyy)	Water Type
IG_MWA01_C_GW0001	Q4 - December	01-12-2022	Na-Ca-HCO_3
IG_MWA03_B_GW0001	Q3 - July	18-07-2022	Na-SO_4
IG_MWA03_B_GW0002	Q3 - September	02-10-2022	Na-Ca- SO_4-HCO_3
IG_MWB01_C_GW0001	Q4 - December	01-12-2022	Ca- HCO_3
IG_MWB03_B_GW0001	Q3 - July	20-07-2022	Na- SO_4
IG_MWC01_A_GW0001	Q3 - July	19-07-2022	Na- SO_4
IG_MWC01_A_GW0003	Q3 - September	30-09-2022	Na- SO_4- HCO_3
IG_MWC01_C_GW0002	Q3 - September	30-09-2022	Na-Ca- SO_4-HCO_3
IG_MWC02_A_GW0001	Q3 - September	27-09-2022	Na-Ca- HCO_3
IG_MWC02_A_GW0002	Q4 - December	01-12-2022	Na-Ca- HCO_3
IG_MWC03_C_GW0001	Q3 - September	29-09-2022	Na-Ca- HCO_3

Table 9 shows the list of high confidence samples along with their date of collection and water type.

Of the eleven high confidence samples, the predominant groundwater type of the shallow bedrock at the Revell Site is Na-Ca-HCO_3 (four samples) shown at monitoring intervals IG_MWA01_C, IG_MWC03_C, and IG_MWC02_A. The samples with this water type are all installed in Biotite Granodiorite-Tonalite (BGT) and have been plotted on Durov plot shown on Figure 6. The other water types that were measured include Na-SO_4 (three samples), Na-Ca-HCO_3-SO_4 (two samples), Na-HCO_3-SO_4 (one sample), and Ca-HCO_3 (one sample).

Overall, it is evident that Na^+ and Ca^{2+} are the most prevalent cations whereas, the SO_4^{2-} and HCO_3^- are the most abundant anions in the shallow bedrock at the Revell Site. The samples with these water types are plotted together on a Durov plot shown on Figure 4. All the high confidence samples collected from the Revell Site had sodium as the most abundant cation, however, a higher percentage of calcium was found in the well IG_MWB01_C than the percentage proportion of sodium. Bicarbonate was the predominant anion found in the groundwater, however, the second most abundant anion at the Site was sulphate. Also of note is the change to the water type of samples IG_MWC01_A and IG_MWA03_B between the first and second samples, both showing an increase of HCO_3 and a decrease in SO_4.

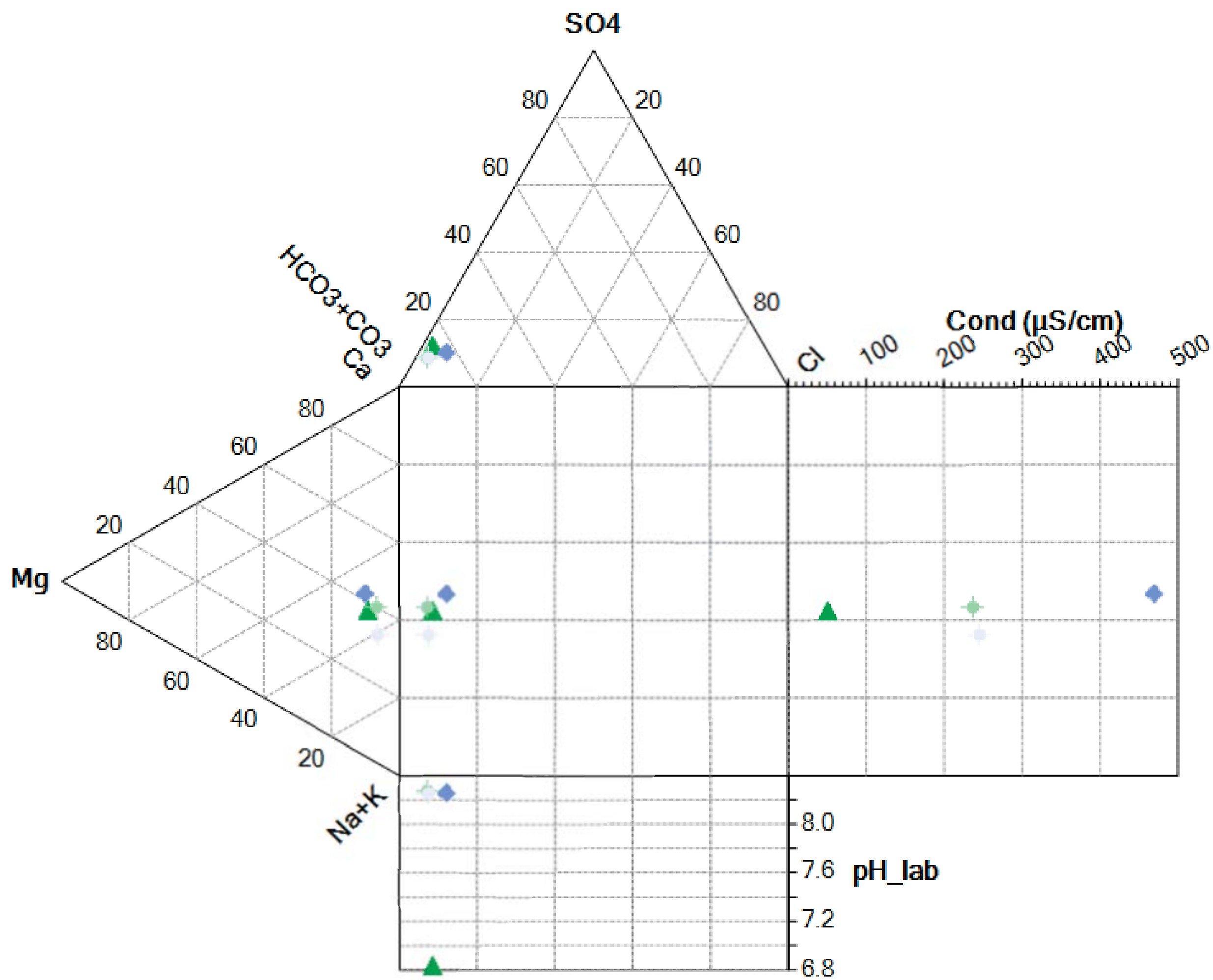
Generally, the chemistry of groundwater in crystalline rocks of the Canadian Shield is found to show a strong relationship to depths primarily in terms of bicarbonate, sulfate, and chloride concentrations (Drever, 2005). The bicarbonate concentrations are typically higher in shallow groundwaters (<300 m depth) but tend to decrease with depth (>300 m depth). An opposite trend is seen for chloride and sulfate concentrations that have been found to increase with depth (Drever, 2005).

The groundwater collected from the Revell Site is from shallow depths (less than 100 m below ground surface) and would be expected to have low concentrations of chloride in the groundwater and not be a dominant anion in the water type at these shallow depths (<300 m). This correlates with the calculation of water types for high confidence samples as none of the samples in Table 9 has chloride as a major anion. The predominant water type found at the Revell site does correlate with the typical shallow groundwater types (Na-Ca-HCO_3) found in the crystalline rocks in the Canadian Shield (Fritz et al, 1994).

The Durov plots were used to characterize the high confidence samples collected from the Revell Site according to their water types (Figures 3 and 4). Then on Figures 5, 6, and 7, all samples collected in 2022 are shown by sample event (i.e., Q3-July, Q3-September and Q4), for high confidence samples. All other Durov plots are included in Appendix A1 and A2.

Figures 8, 9 and 10 show the concentrations of chloride, sodium and sulphate respectively with depth and are discussed in the sections below.

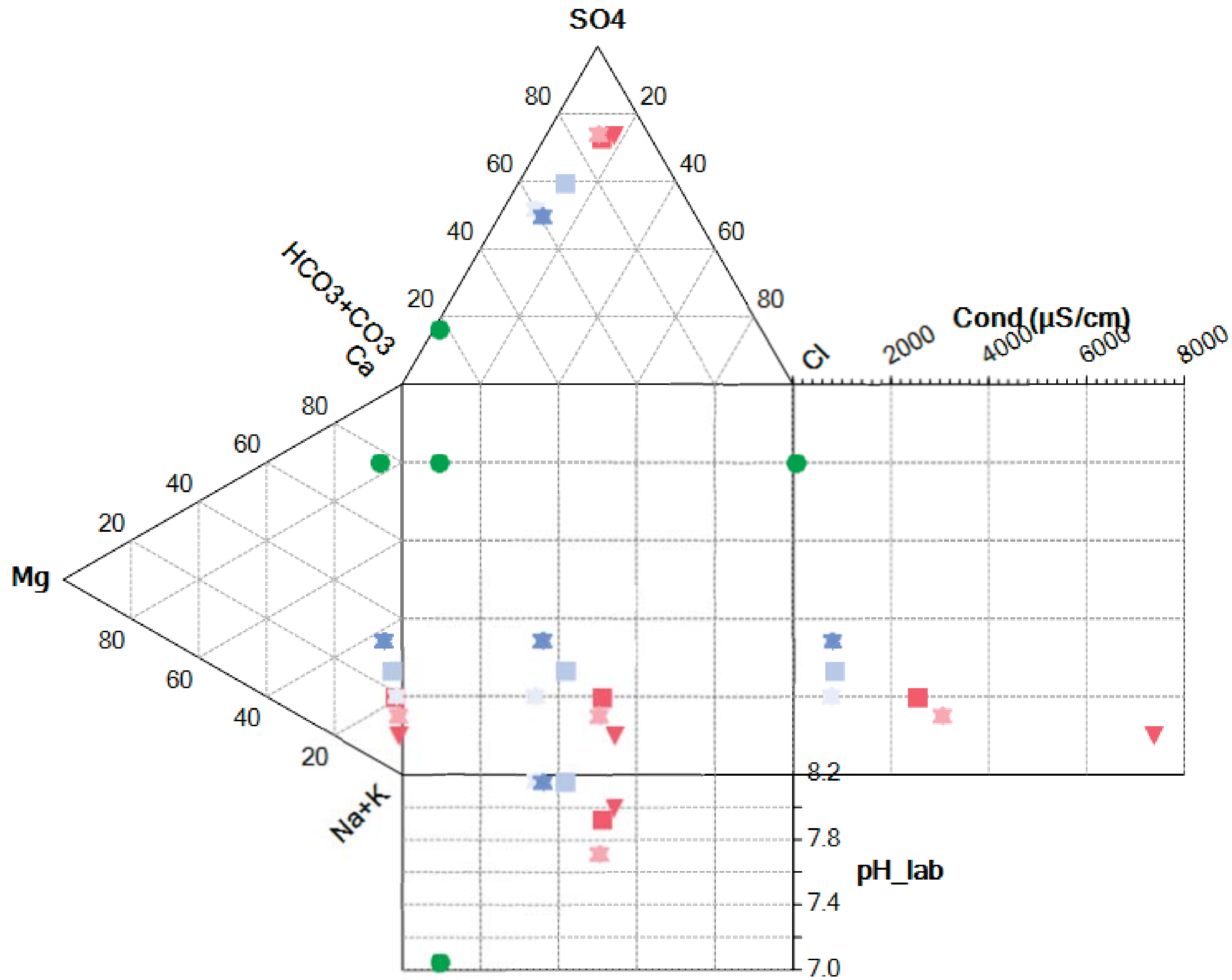
FIGURE 3: DUROV PLOT OF NA-CA-HCO₃ WATER TYPE (HIGH CONFIDENCE SAMPLES)



Water Type
Na-Ca-HCO_3

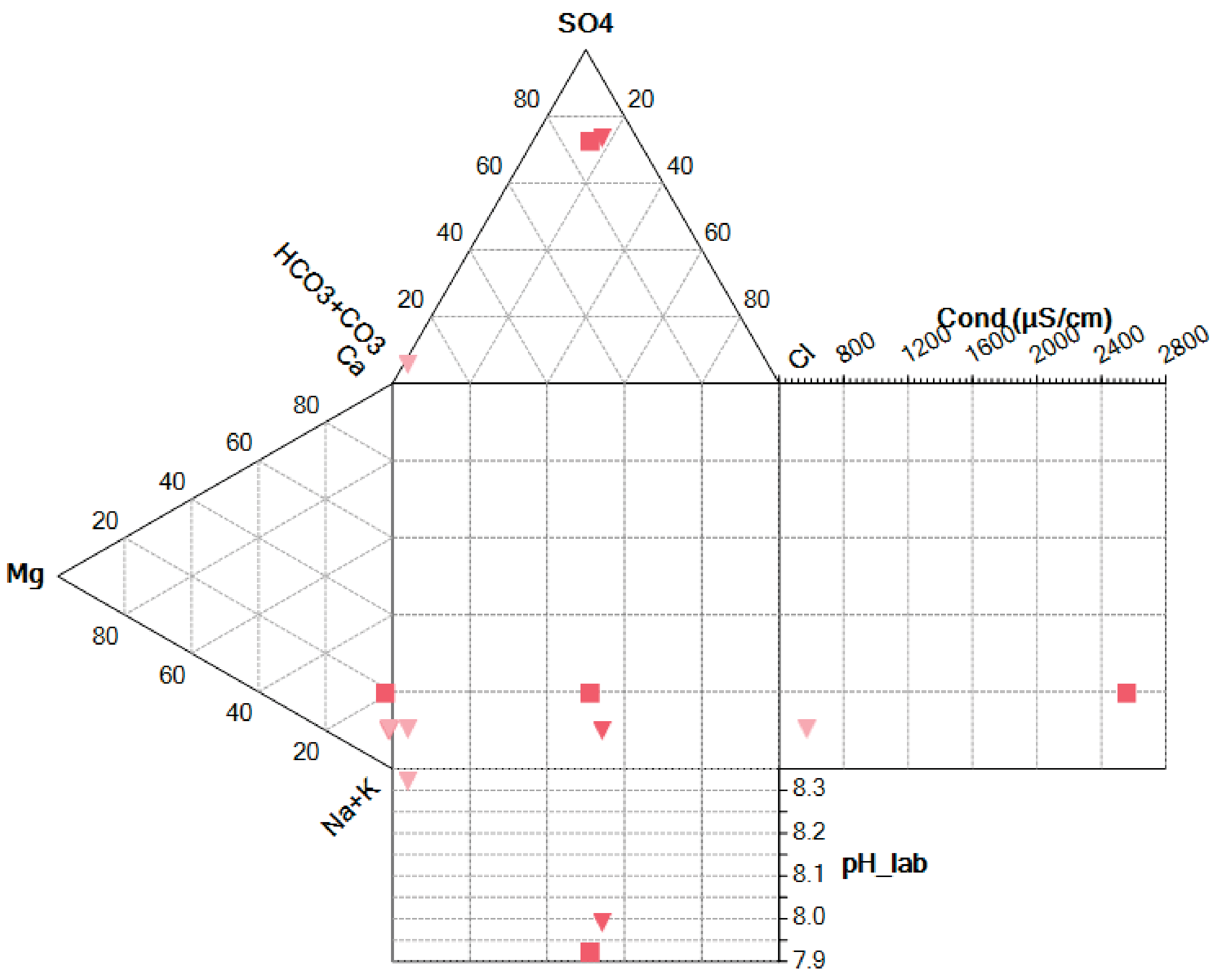
Sample ID	Water Type
IG_MWA01_C_GW0001	Na-Ca-HCO_3
IG_MWC02_A_GW0002	Na-Ca-HCO_3
IG_MWC02_A_GW0001	Na-Ca-HCO_3
IG_MWC03_C_GW0001	Na-Ca-HCO_3

FIGURE 4: DUROV PLOT OF ALL OTHER WATER TYPES (HIGH CONFIDENCE SAMPLES)



Sample ID	Water Type
IG_MWA03_B_GW0001	Na-SO4
IG_MWB01_C_GW0001	Ca-HCO3
IG_MWB03_B_GW0001	Na-SO4
IG_MWA03_B_GW0002	Na-Ca-SO4-HCO3
IG_MWC01_A_GW0001	Na-SO4
IG_MWC01_A_GW0003	Na-SO4-HCO3
IG_MWC01_C_GW0002	Na-Ca-SO4-HCO3

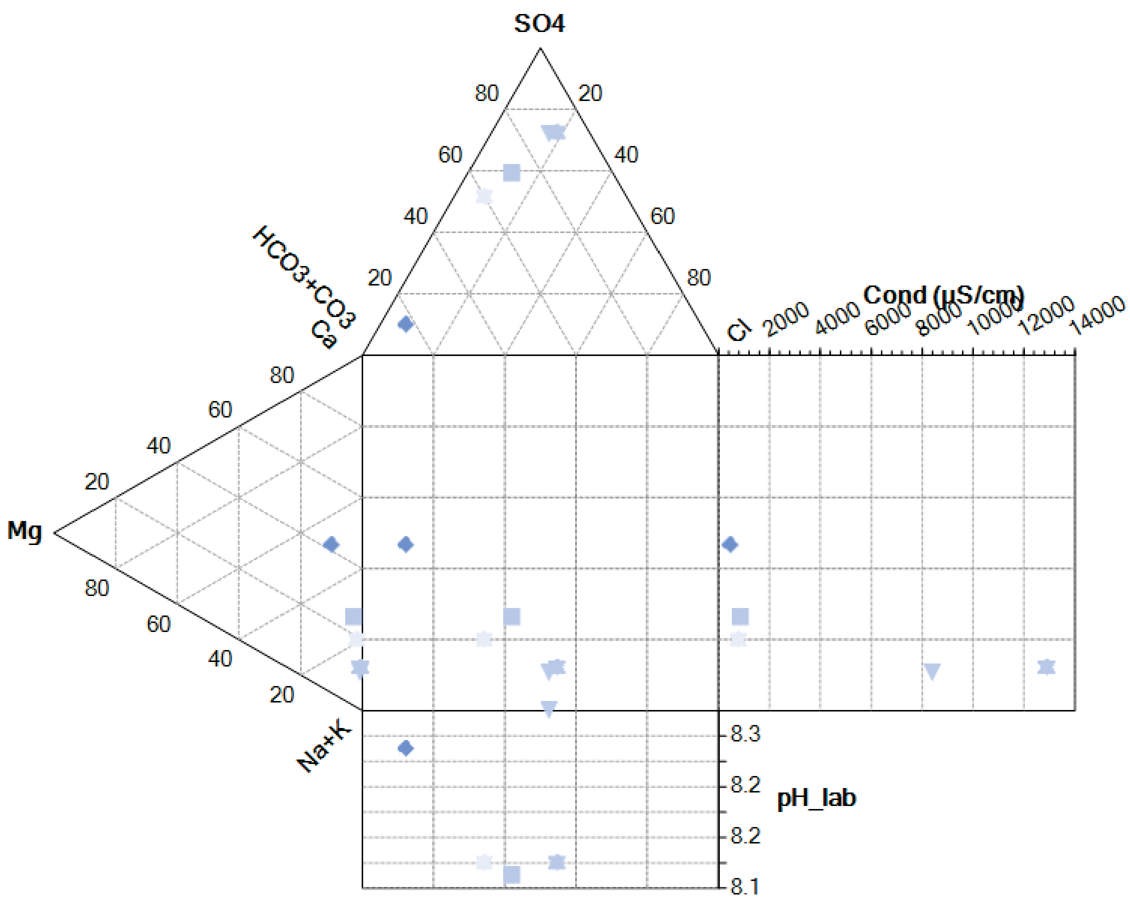
FIGURE 5: DUROV PLOT FOR Q3-JULY 2022 SAMPLES (HIGH CONFIDENCE SAMPLES)



Monitoring Event:
Q3 July 2022

Sample ID	Water Type
IG_MWA03_B_GW0001	Na-SO_4
IG_MWB03_B_GW0001	Na-SO_4
IG_MWB03_A_GW0001	Na-HCO_3

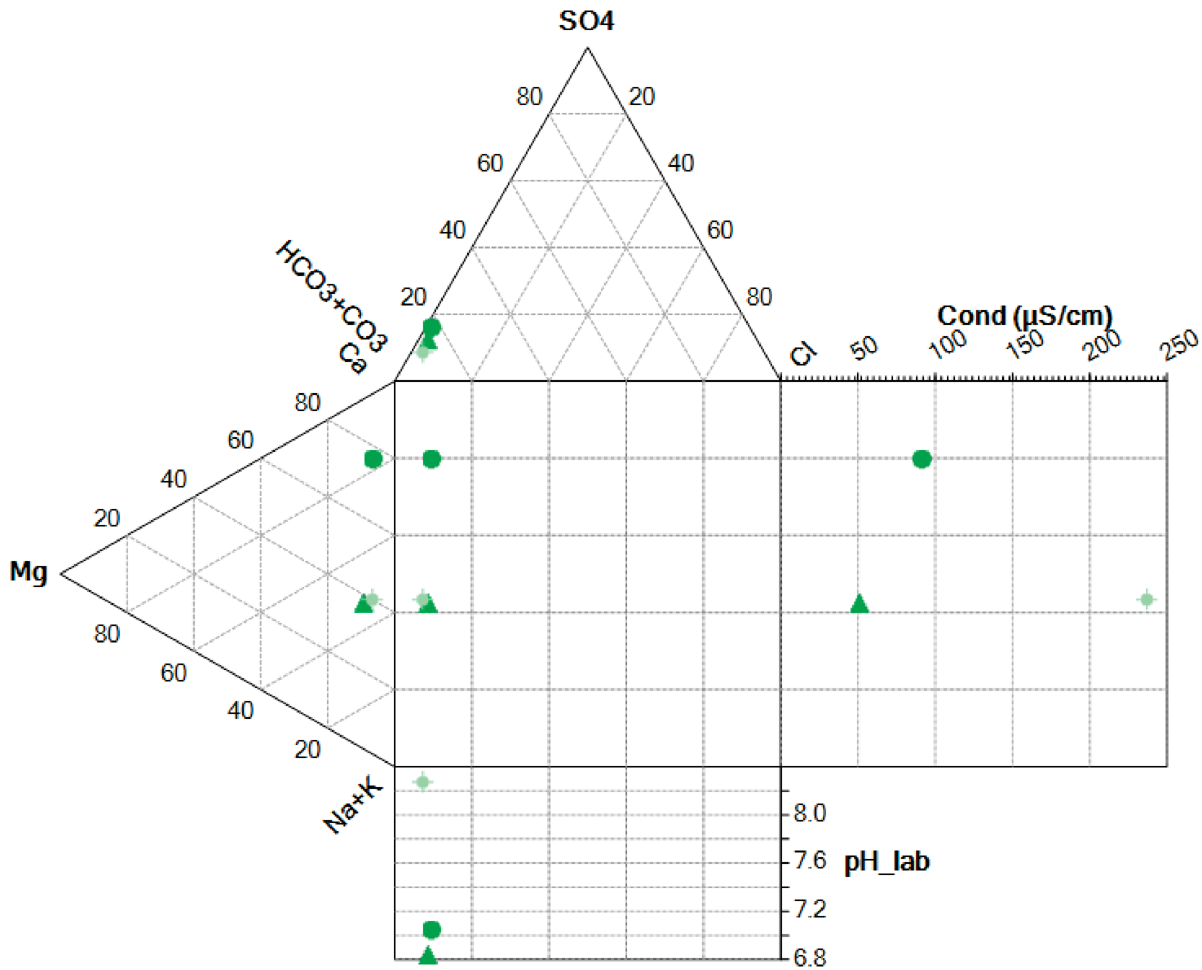
FIGURE 6: DUROV PLOT Q3-SEPTEMBER 2022 SAMPLES (HIGH CONFIDENCE SAMPLES)



Monitoring Event:
Q3 September 2022

Sample ID	Water Type
IG_MWA03_B_GW0002	Na-Ca-SO_4-HCO_3
IG_MWB03_B_GW0003	Na-SO_4
IG_MWC01_A_GW0003	Na-SO_4-HCO_3
IG_MWC01_B_GW0002	Na-SO_4
IG_MWC03_C_GW0001	Na-Ca-HCO_3

FIGURE 7: DUROV PLOT FOR Q4 2022 SAMPLES (HIGH CONFIDENCE SAMPLES)



Monitoring Event:
Q4 2022

Sample ID	Water Type
IG_MWA01_C_GW0001	Na-Ca-HCO_3
IG_MWB01_C_GW0001	Ca-HCO_3
IG_MWC02_A_GW0002	Na-Ca-HCO_3

Additional Durov plots were prepared for high confidence samples collected from each well site IG_MWA01, IG_MWA03, IG_MWB01, IG_MWB03, IG_MWC01, IG_MWC02 and IG_MWC03 on Figures A1-1 through A1-7, respectively in Appendix A1. Data was then grouped by monitoring zone type (i.e., Bedrock zones C, B and A) on Figures A1-8, A1-9 and A1-10, respectively in Appendix A1. Finally, all data was grouped and plotted together on Figure A1-11 of Appendix A1. Each sample has a unique symbol, allowing comparisons over time as well as location.

The specific well site plots can be used to look for any variations in groundwater quality with depth at a single location and changes with time. The monitoring zone plots can be used to look at variations with a single depth zone over the project area. The composite plot (Appendix A1-Figure A1-11) can be used to summarize the characteristics of the site as a whole.

It is important to note that the first spring sampling event did not occur until May 2023, which is not included in this 2022 report. Seasonal changes for the spring melt will be assessed in the 2023 report.

The major ion concentrations of high confidence water samples collected from the Revell Site in 2022 were also compared using Stiff diagrams that displayed the relative concentrations of major ions expressed in milliequivalents per liter (meq). Stiff diagrams for the high confidence samples collected from the Revell Site are included in Appendix B1 of this report. The plots are organized by well and then by monitoring intervals from bedrock intervals A, B and C in order of depth (deepest-A to shallowest-C). Each diagram can be "read" by reading down the page and noting the differences in the plots. A uniform scale was used for all plots for comparison.

To understand the overall groundwater chemistry of the samples collected from the Revell Site, it is crucial to understand the bedrock mineralogy and the potential rock-water interactions that the groundwater may have gone through. In general, the groundwaters found in the crystalline bedrocks have varying concentrations of cations such as calcium and sodium (occasionally enriched with magnesium), and anions such as chloride, sulphate, and bicarbonate (Jacks, 1978). The crystalline rocks are composed of various igneous rock types, e.g. the BGT (Biotite Granodiorite-Tonalite) bedrock at the Revell Site. The groundwaters from the crystalline environments are often classified by chemical type (dominant cations and anions), e.g., Ca-Na-HCO_3 type water. As mentioned earlier, the dominant water type found in the shallow groundwater at the Revell site is Na-Ca-HCO_3. This observation also aligns with the findings outlined by Frape et. al. (1984) in their study done on the rock-water interactions of groundwaters in Canadian Shield. Frape et al (1984) mentioned that the groundwater found in the felsic-granite rocks have the chemistry of fresh and brackish waters and is dominated by Na>Ca>Mg>K ions with HCO_3.

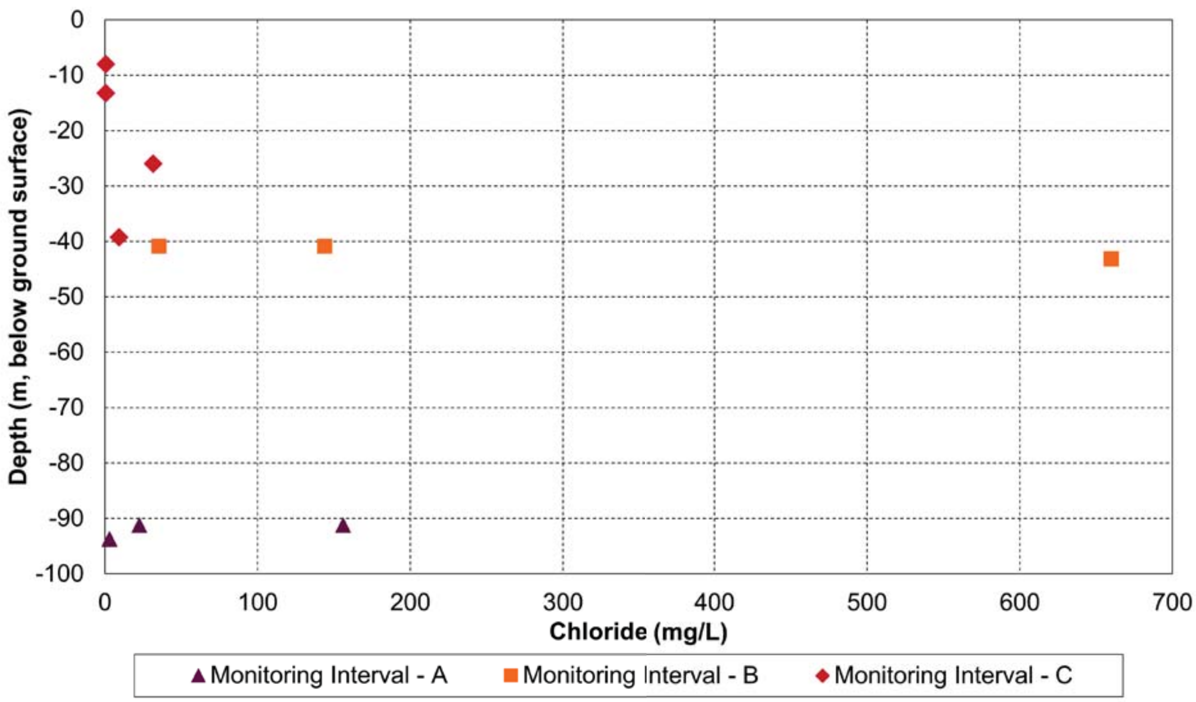
4.3.1.2 Parameters of Interest

Nitrate: None of the high confidence samples had elevated concentrations of nitrate. In fact, it is observed that all monitoring well intervals where field parameter stabilization was achieved had low to non-detectable concentrations of nitrate in the samples analyzed. Nitrate is not typically found in the Canadian Shield bedrock groundwaters and this correlates with the findings from the Revell Site.

Chloride: The chloride concentration for the high confidence samples collected in 2022 was between 0.5 mg/L to 660 mg/L. Eight of the eleven high confidence samples had concentrations below 50 mg/L while the remaining three samples (IG_MWA03_B_GW0001, IG_MWB03_B_GW0001, and IG_MWC01_A_GW0001) collected during the Q3-July 2022 event had chloride concentrations at 144 mg/L, 660 mg/L and 156 mg/L, respectively. These concentrations were observed at considerably lower concentrations during the Q3-

September event (35.4 mg/L and 22.6 mg/L for IG_MWA03_B_GW0002 and IG_MWC01_A_GW0003 respectively), while the monitoring well interval IG_MWB03_B was not sampled again in 2022. Additional monitoring will provide more insights about the concentration trends at monitoring intervals IG_MWA03_B, IG_MWB03_B, and IG_MWC01_A. Figure 8 below shows the 2022 chloride concentration results by sample and with depth.

FIGURE 8 CHLORIDE VERSUS DEPTH PLOT



Sodium:

Sodium has been found to be the dominant cation in the shallow bedrock groundwater (<100 m) at the Revell Site. For all high confidence samples, the sodium concentrations were above the laboratory detection limits and ranged between 2.7 mg/L to 2010 mg/L. Five of the eleven high confidence samples had sodium concentrations below 50 mg/L while the remaining six samples were above 100 mg/L with the highest concentration of 2010 mg/L for the sample IG_MWB03_B_GW0001 in Q3-July 2022. As mentioned earlier, the monitoring well interval IG_MWB03_B was not sampled again for the rest of 2022, a trend in concentration changes for this monitoring interval in not observed.

The concentration at monitoring well interval, IG_MWC01_A, decreased in concentration to 127 mg/L during the Q3-September 2022 event from 580 mg/L observed during Q3-July 2022 event. Similarly, the concentration of sodium in IG_MWA03_B decreased from 476 mg/L in Q3-July 2022 to 132 mg/L in Q3-September 2022. Figure 9 below shows the 2022 sodium concentration results by sample and with depth.

Sulphate:

Sulphate has been found to be the dominant anion in the shallow bedrock groundwater at the Revell Site. For all high confidence samples, the sulphate concentrations were above the laboratory detection limits and at a range between 2.9 mg/L to 3710 mg/L. Five of the eleven high confidence samples had sulphate concentrations below 20 mg/L while the remaining five samples were above 180 mg/L with the highest concentration of 3710 mg/L for the sample IG_MWB03_B_GW0001 in Q3-July 2022.

The sodium concentration of 1150 mg/L was also observed at the monitoring well interval IG_MWC01_A during the Q3-July 2022 monitoring event, while sodium at this monitoring well decreased to 186 mg/L during the Q3-September 2022 event. Similarly, the concentration of sodium in IG_MWA03_B decreased from 938 mg/L in Q3-July 2022 to 228 mg/L in Q3-September 2022. Additional monitoring will help to understand more about the concentration trends at monitoring intervals IG_MWA03_B, IG_MWB03_B, and IG_MWC01_A.

Figure 10 below shows the 2022 sulphate concentration results by sample and with depth.

FIGURE 9 SODIUM VERSUS DEPTH PLOT

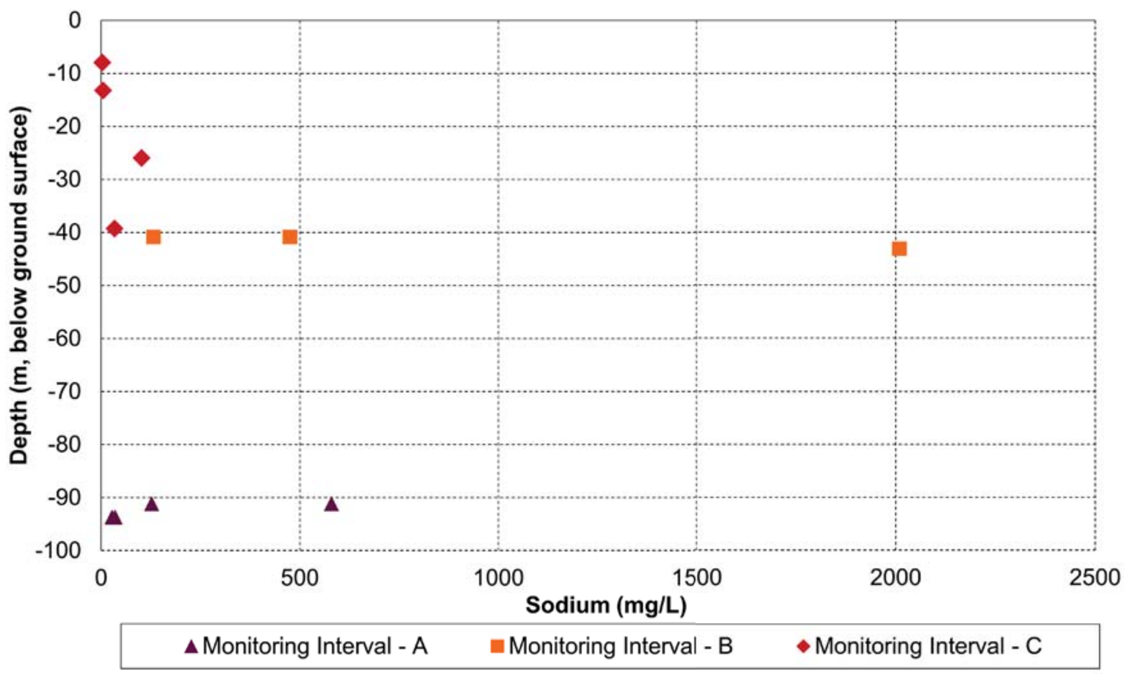
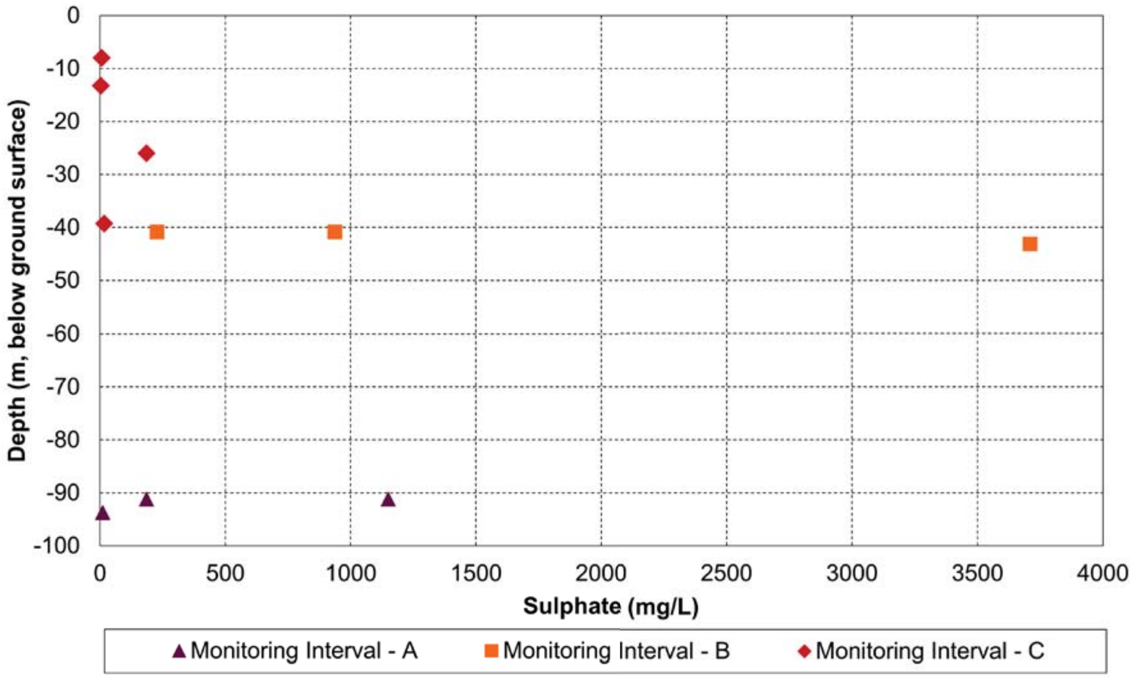


FIGURE 10 SULPHATE VERSUS DEPTH PLOT



Calcium and Magnesium:

No specific trends of concentrations with depth were observed for calcium and magnesium concentrations at the Revell Site. The calcium and magnesium concentrations are typical for the Canadian Shield groundwater. The concentrations of both calcium and magnesium remained consistent for observations across all the field events of 2022.

Alkalinity:

The Total Alkalinity (as $CaCO_3$ equivalent) of groundwater at the Revell Site is in the range of 20.9 mg/L to 469 mg/L. Two of eleven high confidence samples had Total Alkalinity (as $CaCO_3$) concentrations less than 40 mg/L while the remaining nine samples were above 100 mg/L. The primary contributing species of these concentrations of Total Alkalinity in all samples is bicarbonate. The concentration of bicarbonate ions was in the range of 25.5 mg/L to 572 mg/L while the concentration of carbonate ions remained below the laboratory detection limit of 0.6 mg/L for all high confidence samples. Similarly, the hydroxide concentration in each sample was below the laboratory detection limit of 0.34 mg/L.

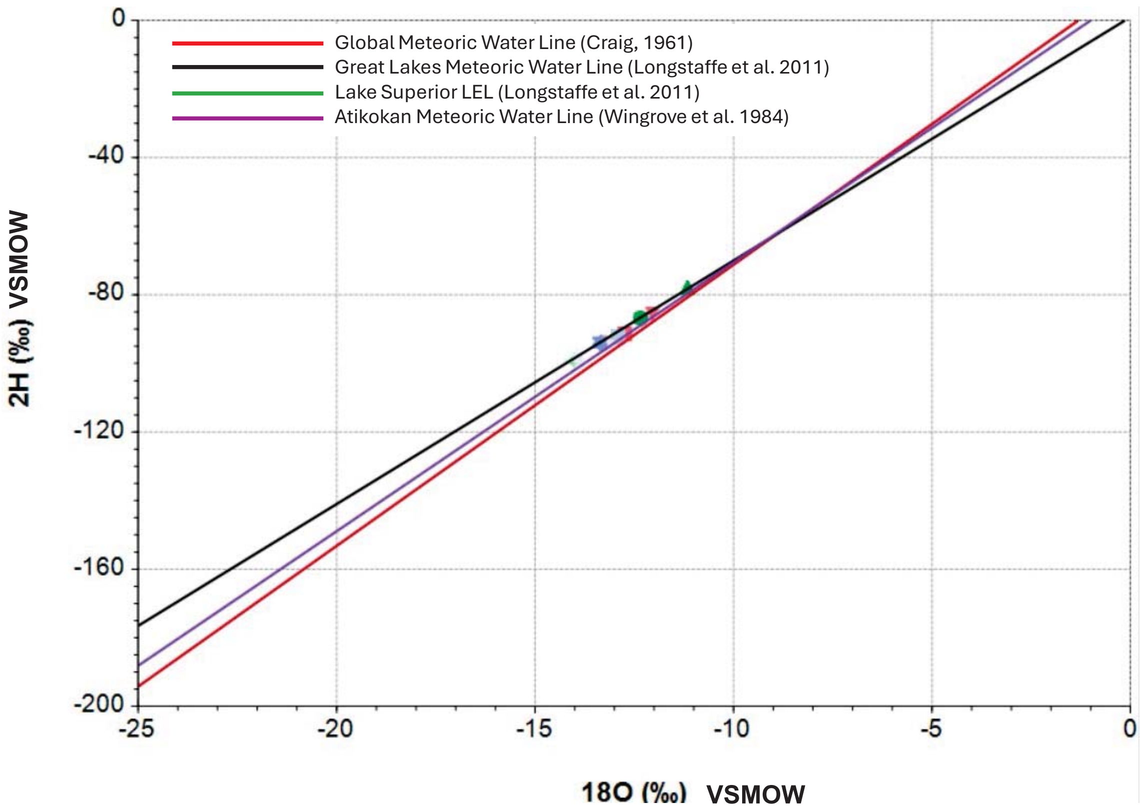
4.3.1.3 Quarterly Isotope Analysis

Oxygen-18 ($\delta^{18}O$) and Deuterium ($\delta^{2}D$)

Isotope parameters Oxygen-18 ($\delta^{18}O$) and Deuterium ($\delta^{2}D$) were collected during quarterly sample events.

The 2022 data for high confidence samples is presented on Figure 11 relative to the Great Lakes Meteoric Water Line (GLMWL) ($\delta^{2}H=7.1*\delta^{18}O+1.0$; (Longstaffe et al., 2011)), the Global Meteoric Water Line (GMWL, $\delta^{2}H=8.13*\delta^{18}O+10.8$; (Craig, 1961)), and Atikokan Meteoric Water Line ($\delta^{2}H=7.84*\delta^{18}O + 7.88$); Wingrove et al., 1984) for comparison purposes. The GLMWL comprises of samples collected from the region of Great Lakes on a more frequent basis, and is informative in terms of local water movements, water sources, and any precipitation/evaporation processes that these waters may have undergone, in comparison to coarser resolution of information that GMWL provides. The Revell site is located up-wind from the predominant precipitation that occurs nearest the Great Lakes and as such, the Revell site isotopic signature is likely to reflect precipitation that originates locally (e.g. the Atikokan MWL) and from the west, originating from the prairies.

FIGURE 11: SHALLOW GROUNDWATER δ^2H VS $\delta^{18}O$ FOR HIGH CONFIDENCE SAMPLES



Generally, the isotope data plots clustered together somewhat local to the GLMWL and closest to the local Atikokan Meteoric Water Line (AMWL), which suggests the groundwater samples share a local and common origin, namely meteoric water. Local precipitation (e.g. the Atikokan MWL) and precipitation originating upwind and to the west on the prairies would be expected to dominate the isotopic signature at the Revell Site, versus precipitation related to the Great Lakes, originating to the east and downwind of the Revell site.

4.3.1.4 Annual Isotope Analysis

A summary of the 2022 annual isotope analytical results is provided in Table 10 below for high confidence samples. Environmental isotope analysis was planned to be completed once in 2022 from the intervals selected for the first quarterly sample event in July 2022, those being multilevel monitoring wells IG_MWA03, IG_MWB03, IG_MWC01, IG_MWC02, and IG_MWC03. This information would be used for baselining the shallow groundwater geochemistry. However, there are a few points to highlight regarding the completeness of the 2022 dataset and changes that were made late in 2022 that would only be reflected in the second year of environmental isotope sampling, planned for Q2-2023.

For the Q3 2022 September monitoring event, the analysis for Carbon-13 isotope of DIC and Strontium Isotope Ratio (87Sr/86Sr) were not requested for any of the samples submitted within the lab work orders L2735102, L2735225, and L2735577, however, the samples were still analysed for C-13 (for all three lab work orders) and 87Sr/86Sr (for L2735577). It appears that the laboratory used the water from the vials submitted for 2H and 18O analysis to analyse the C-13 and 87Sr/86Sr signatures, and hence, these analyses are not considered to be meeting the required quality standards. Therefore, these additional results are not provided on Table 10 below, however, were provided in the IG_IMP-15_SH_IsotopesRareEarths importer along with Q2 September data package.

TABLE 10: ANNUALLY COLLECTED ISOTOPE RESULTS FOR HIGH CONFIDENCE SAMPLES

Sample ID	Quarter Sample Collected	Gross Alpha (Bq/L)	Gross Beta (Bq/L)	Tritium (^{3}H) Bq/L	Carbon-13 of DIC (d13C-DIC) per mil VPDB	Carbon-14 of DIC (^{14}C-DIC) Bq/L	Chlorine-37 (d37Cl) per mil SMOC	Strontium Isotope Ratio ($^{87}Sr/^{86}Sr$)
IG_MWA03_B_GW0001	Q3-July	1.4	0.46	<101.64	-15.97	<6.7	3.49	0.71183
IG_MWB03_B_GW0001	Q3-July	3.1	1.6	<101.64	-12.43	<6.7	2.85	0.712179
IG_MWC01_A_GW0001	Q3-July	0.88	0.27	<101.64	-21.71	<6.8	2.96	0.71212

During 2022, a change was made to better define the isotope analyses for tritium and carbon-13/carbon-14 of DIC to ensure analyses were completed using the required specific testing methodology, detection limits and units. These changes will be reflected in the 2023 sample event for the annual isotope analysis.

Gross Alpha/Beta

Radionuclides are found in the environment as naturally occurring elements and as products or by-products of nuclear technologies. Gross alpha and gross beta determination is an initial screening for the presence of radioactivity, and the procedures used to analyze the samples are not the same procedures used to determine the identity of the contributing radionuclides. To help with a relative comparison of the presence of radionuclides in groundwater at the study site, the recommended screening values for gross alpha and gross beta activity of 0.5 Bq/L and 1 Bq/L, respectively set by Health Canada Canadian Drinking Water Quality Guidelines (HC-CDWQG) was used. Using the HC-CDWQG, all high confidence samples had gross alpha activity greater than the screening level of 0.5 Bq/L. The highest value of gross alpha activity was observed for the sample IG_MWB03_B_GW0001 at 3.1 Bq/L.

Only one high confidence sample, IG_MWB03_B_GW0001, had gross beta activity measurement (1.6 Bq/L) above the HC-CDWQG recommended screening level of 1.0 Bq/L.

Of the nine total samples analyzed for the annual isotope analytical package, only three samples were considered to be of high confidence. Future groundwater sampling and analysis of specific radionuclides could be a consideration in future monitoring programs to determine the specific baseline radionuclides present in the groundwater at these monitoring intervals.

Tritium (^{3}H) and Carbon-14 (^{14}C)

Tritium and Carbon-14 are naturally occurring radionuclides at very low levels and contribute to natural radioactivity exposure to Canadians. However, these radionuclides have been introduced in greater concentrations into the global environment via the use and expansion of nuclear technologies over the past 60 years, and in particular due to atmospheric nuclear weapon testing prior to 1963. Therefore, tritium as an example is an important parameter to measure and baseline, because its presence and concentration provides insight to the relative “age” or atmospheric interconnection/origin of a groundwater sample, depending on its origin and exposure within the hydrological system prior to, or during activities that occurred globally related to the nuclear industry.

Again, Health Canada has a recommended Maximum Allowable Concentration (MAC) in water for Tritium of 7000 Bq/L. All of the samples submitted for analysis had reported concentrations of <12 Bq/L, far below the HC-CDWQG MAC. The detection limit for 2023 tritium analysis will be significantly lower so that a more detailed assessment can be made.

For comparison purposes, Health Canada has a recommended screening level concentration for Carbon-14 in water of 200 Bq/L. For purpose of baseline data collection, the concentrations of ^{14}C in groundwater sampled at the study site were all below the minimum detection limit, which varied from <6.7 to <6.9.

The detection limits used for the 2022 analysis of tritium and carbon-14 was too high and did not meet NWMO’s data objectives and has been corrected for the 2023 analysis (i.e. methodology has been changed to allow for lower detection limits), as described in Section 3.5.1. This change for 2023 data collection will allow for a more detailed analysis and interpretation of these analytical results, as they become available and are analysed within the 2023 dataset.

Chlorine Isotope ($\delta^{37}Cl$)

The stable isotope of Chlorine (Cl) has been used to estimate the origin of salts and fluids which help in characterization of groundwater. The $\delta^{37}Cl$ results ranged from a low of 2.85‰ in IG_MWB03_B_GW0001 to a high of 3.49‰ in IG_MWA03_B_GW0001. Both samples were collected from the Biotite Granodiorite-Tonalite formation.

Based on a limited dataset, Drever (2005) mentioned in their study that groundwaters in the crystalline bedrock environments have a very narrow range (-1.0 ‰ to +2.0‰) of $\delta^{37}Cl$ signatures, however, Frape et al. (2004) in their study about deep fluids in continental crystalline rocks stated that rocks containing Cl-rich minerals such as apatite, or biotite can have enriched $\delta^{37}Cl$ signatures as high as 4.0 ‰.

As the groundwater moves in crystalline bedrock, it goes through water-rock interaction processes as well as a series of redox reactions. These chemical processes result in changing the chemical composition of groundwater (Gascoyne, 1996).

A significant change that happens in groundwater chemical composition is when the salinity increases due to the uptake of Na, Cl, and Ca ions from various sources such as fluids that remain in the fracture zones from a past low-temperature alteration, or from the presence of chloride bearing minerals such as biotite in the rocks (Gascoyne, 1996). For the Revell Site, the $\delta^{37}Cl$ results are between 2.85‰ and 3.49 ‰ and thus fall within the ranges noted within the studies mentioned above.

Strontium Isotope Ratio $^{87}Sr/^{86}Sr$

The $^{87}Sr/^{86}Sr$ ratio reflects the source of Sr in the rock and water. The present $^{87}Sr/^{86}Sr$ ratio in seawater is a relatively constant value of 0.709. The $^{87}Sr/^{86}Sr$ ratio for Selco Mines that are located in the Uchi Belt of Ontario within the Canadian Shield (about 200 kms North of the Revell Site) is between 0.7100 and 0.7210 (McNutt et. al., 1990). The Selco Mine Site consists of the Rhyolite rock (igneous) deposits within 0 and 300 meters of depth below ground surface, and with a predominant water type of Ca-Na-$HC0_3$-SO_4, and hence was used as a reference site to compare the $^{87}Sr/^{86}Sr$ ratios.

FIGURE 12: STRONTIUM ISOTOPIC RATIOS VS. TOTAL SR^{2+} CONCENTRATIONS

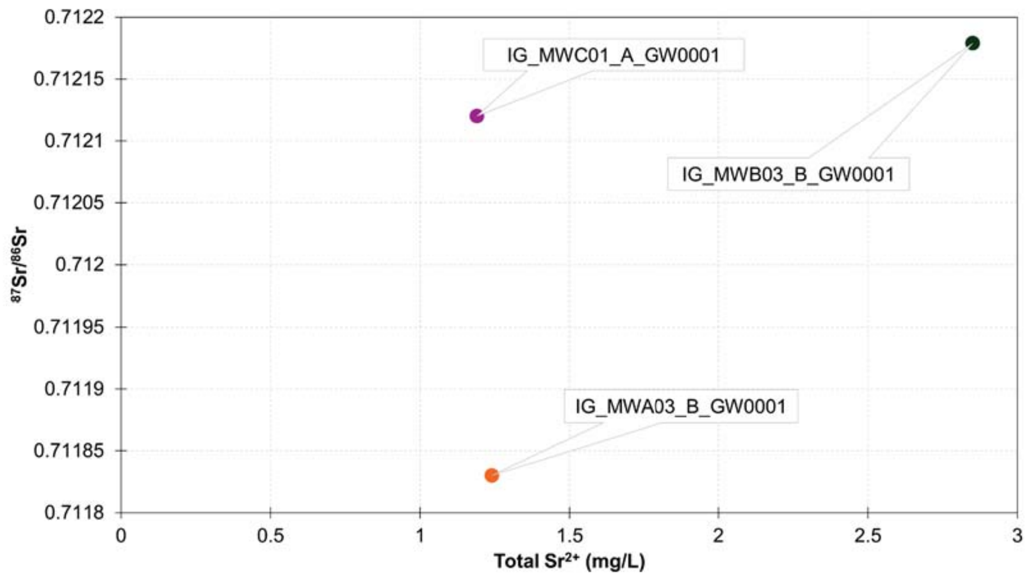


Figure 12 shows the $^{87}Sr/^{86}Sr$ ratios of three high confidence samples which have an overall variation in $^{87}Sr/^{86}Sr$ with a low of 0.71183 in the monitoring well IG_MWA03_B and a high of 0.71217 in the monitoring well IG_MWB03_B. This range falls well within the insights provided by McNutt et. al. (1990) for the Selco Mines and are also within the typical range for groundwaters found in crystalline environments (Drever, 2005).

5.0 SUMMARY

The NWMO Groundwater Monitoring of Shallow Well Networks study objective at the Revell site was to measure groundwater pressures and temperatures on a quarterly basis, from the installed dataloggers, and to collect groundwater samples for chemical analyses. This information is collected to allow NWMO to evaluate the shallow groundwater system behavior and geochemical characteristics.

The field work for the Revell Site started in 2022 in the beginning of the third quarter (Q3-July), followed by field events in Q3-September and Q4-December 2022. Each groundwater monitoring and sampling event in 2022 involved the collection of groundwater pressure measurements and baseline groundwater samples from a selection of the 27 permanently installed shallow groundwater monitoring wells. The quarterly groundwater quality testing included the analysis of parameters including dissolved metals, routine parameters (such as Br, F, Cl, SiO_2, electrical conductivity, alkalinity, see Table 2 for complete list of parameters) nutrients, iodide, and water isotopes ($\delta^{18}O$ and $\delta^{2}H$). Groundwater samples from several monitoring well sites were also collected and analyzed for dissolved ruthenium and other specialized and radioactive isotopes such as tritium, carbon-14, and strontium ratio Sr^{87}/Sr^{86} during the Q3-July monitoring event only.

Due to the very low hydraulic conductivity of many of the monitored intervals and the challenge associated with collecting a sample of high confidence sample (i.e., not able to purge at a steady flow rate until field chemistry stabilization criteria or “purge criteria I” was met), the samples for which “purge criteria I” was achieved were considered high confidence in terms of sample integrity and more likely representative of groundwater at the Revell site.

Of the eleven high confidence samples, the predominant groundwater type of the shallow bedrock at the Revell Site was Na-Ca-HCO_3 (four samples) shown at monitoring intervals IG_MWA01_C, IG_MWC03_C, and IG_MWC02_A. The samples with this water type are all installed in the Biotite Granodiorite-Tonalite (BGT) bedrock. The other water types that exist in the bedrock at the Revell Site include Na-SO_4 (three samples), Na-Ca-HCO_3-SO_4 (two samples), Na-HCO_3-SO_4 (one sample), and Ca-HCO_3 (one sample).

Overall, it is evident that Na^+, Ca^{2+}, SO_4^{2-} and HCO_3^- are the predominant ions in the shallow bedrock groundwater at the Revell Site. All the samples collected from the Revell site had sodium as the most abundant cation, however, a higher percentage of calcium was found in the well IG_MWB01_C than the percentage proportion of sodium. Bicarbonate was the predominant anion found in the groundwater, however, the second most abundant anion at the site was sulphate. Also of note is the change to the water type of samples IG_MWC01_A and IG_MWA03_B between the first and second samples, both showing an increase of HCO_3 and a decrease in SO_4.

The groundwater collected from the Revell Site is from shallow depths (less than 100 m below ground surface) and would be expected to have low concentrations of chloride in the groundwater and not be a dominant anion in the water type at these shallow depths (<300 m). This correlates with the calculation of water types for high confidence samples as none of the samples in Table 9 has chloride as a major anion. The predominant water type found at the Revell site does correlate with the typical shallow groundwater types (Na-Ca-HCO_3) found in the crystalline rocks in the Canadian Shield (Fritz et al, 1994).

Generally, the $\delta^{18}O$ and $\delta^{2}H$ isotope data plots clustered together very close to the GLMWL and to the local Atikokan Meteoric Water Line which suggests the water from these groundwater samples share a common origin, namely meteoric water.

Other isotopes and radiochemical parameters measured during 2022 including gross alpha, gross beta, tritium (^{3}H), carbon-14 (^{14}C), chlorine-37 $\delta^{37}Cl$, and strontium isotope ratio $^{87}Sr/^{86}Sr$, which were all within the expected values of the Canadian Shield groundwaters.

Overall, the data collected from monitoring intervals that were purged at a constant flow rate until field parameter stabilization occurred, returned results that were within the expected concentration ranges and water types for shallow crystalline bedrock groundwaters.

As the monitoring program advances, there may be opportunity to monitor and sample the well intervals that meet the continuous purge criteria and associated pre-sampling field chemistry parameter stabilization. This clearly is key to ensuring that high confidence groundwater samples are collected and submitted for laboratory analysis, and for future geochemical assessments. Based on the experience of the 2022 sample events, it is not feasible to collect a high confidence groundwater sample from monitoring intervals that are known to have very low hydraulic conductivity and thus recharge rates (i.e. they are able to be purged dry 3 times during sampling), though additional future sampling and data analyses may be necessary to confirm this interpretation. In the long term, collection of high confidence groundwater samples will focus on intervals with sufficiently high hydraulic conductivity to allow for collection of high confidence samples.

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APPEDIX A1

Durov Plots – High Confidence Samples

DUROV PLOTS FOR HIGH CONFIDENCE SAMPLES - IGNACE 2022

Red symbols are for samples taken in July 2022

Interval C   Interval B   Interval A

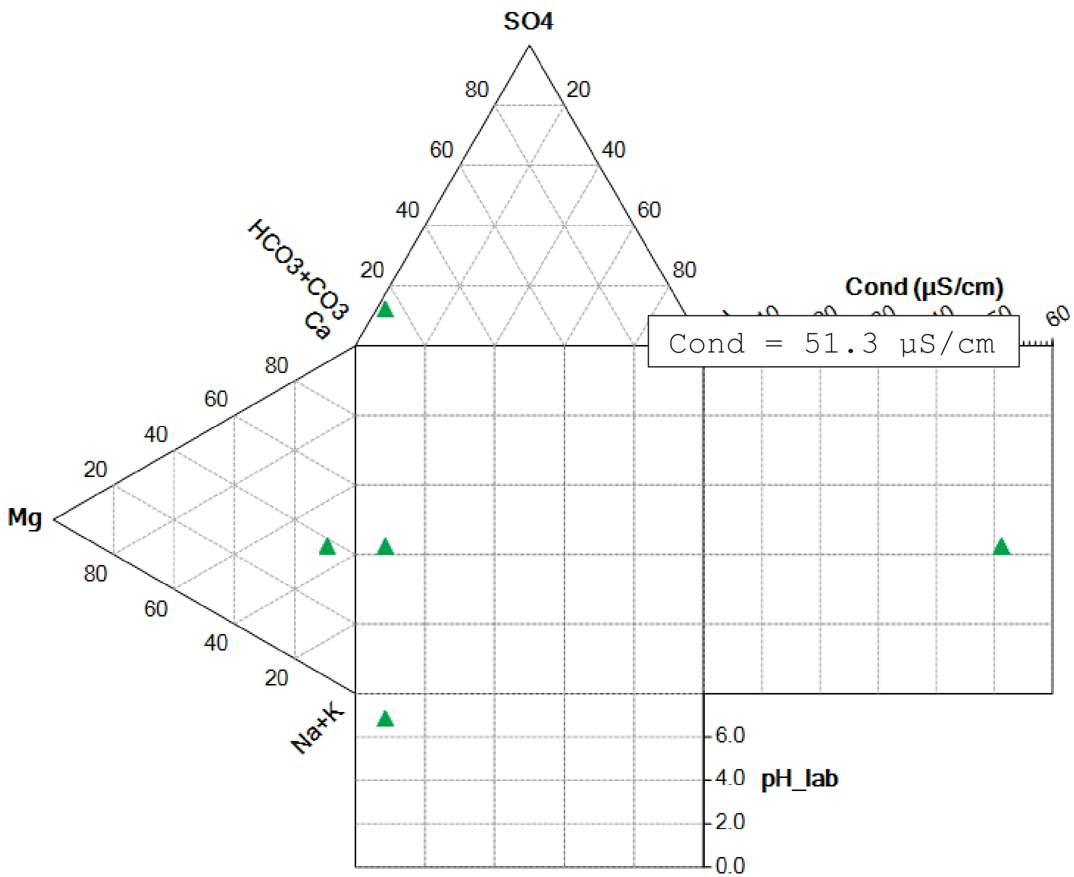
Blue symbols are for samples taken in September 2022

Interval C   Interval B   Interval A

Green symbols are for samples taken in December 2022

Interval C   Interval B   Interval A

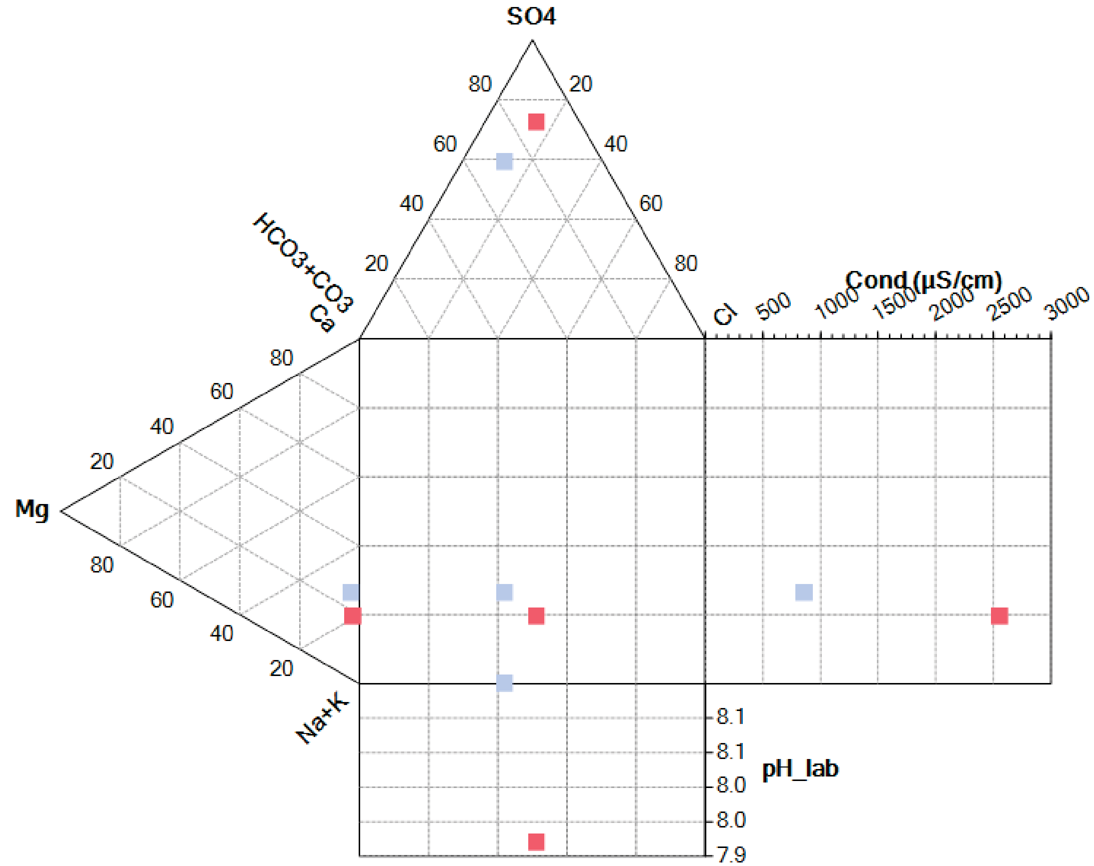
FIGURE A1-1: MWA01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWA01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_C_GW0001	Na-Ca-HCO_3	High

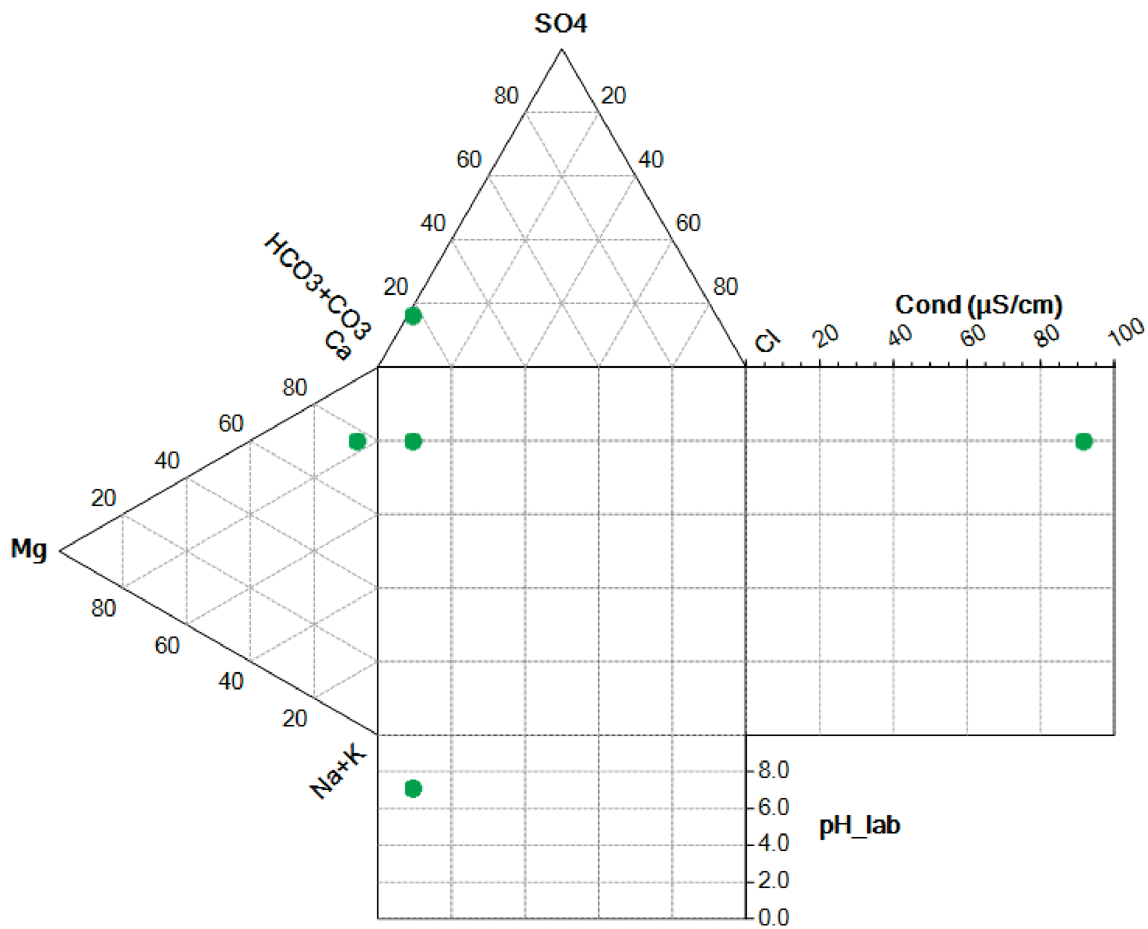
FIGURE A1-2: MWA03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWA03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA03_B_GW0001	Na-SO_4	High
IG_MWA03_B_GW0002	Na-Ca-SO_4-HCO_3	High

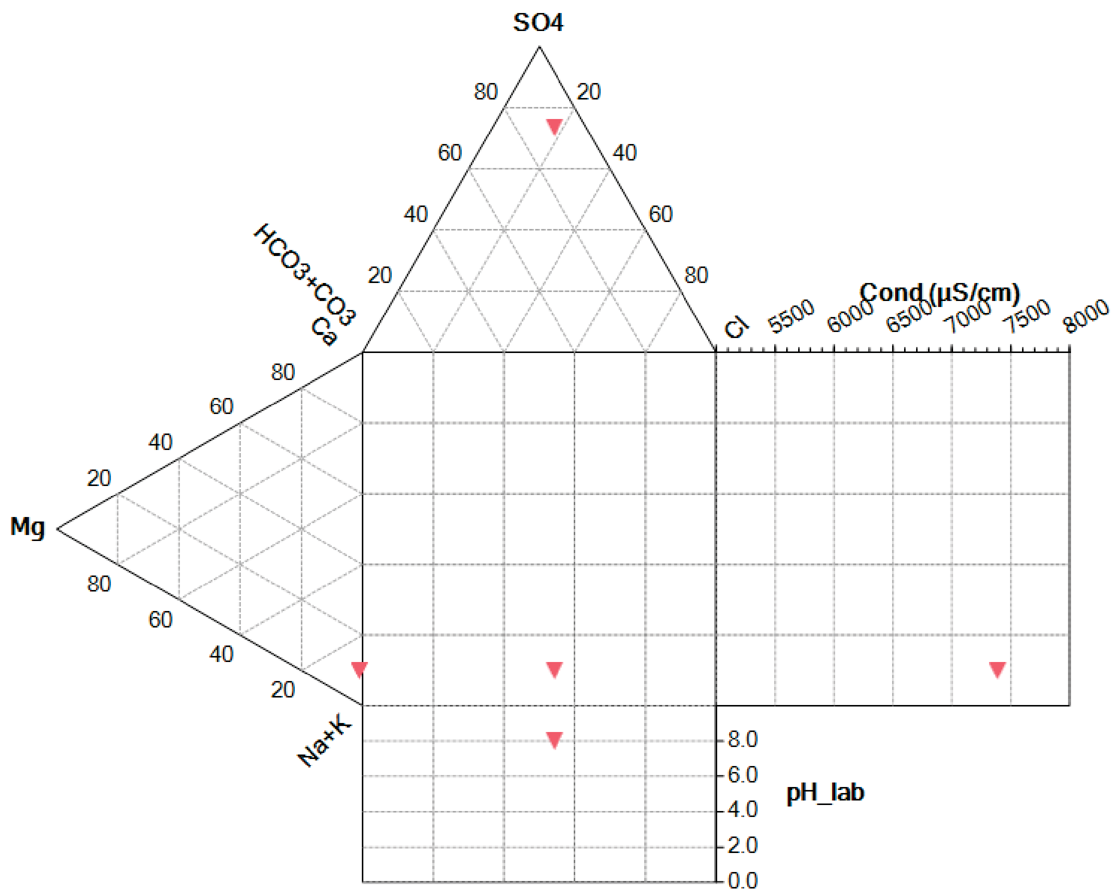
FIGURE A1-3: MWB01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWB01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWB01_C_GW0001	Ca-HCO_3	High

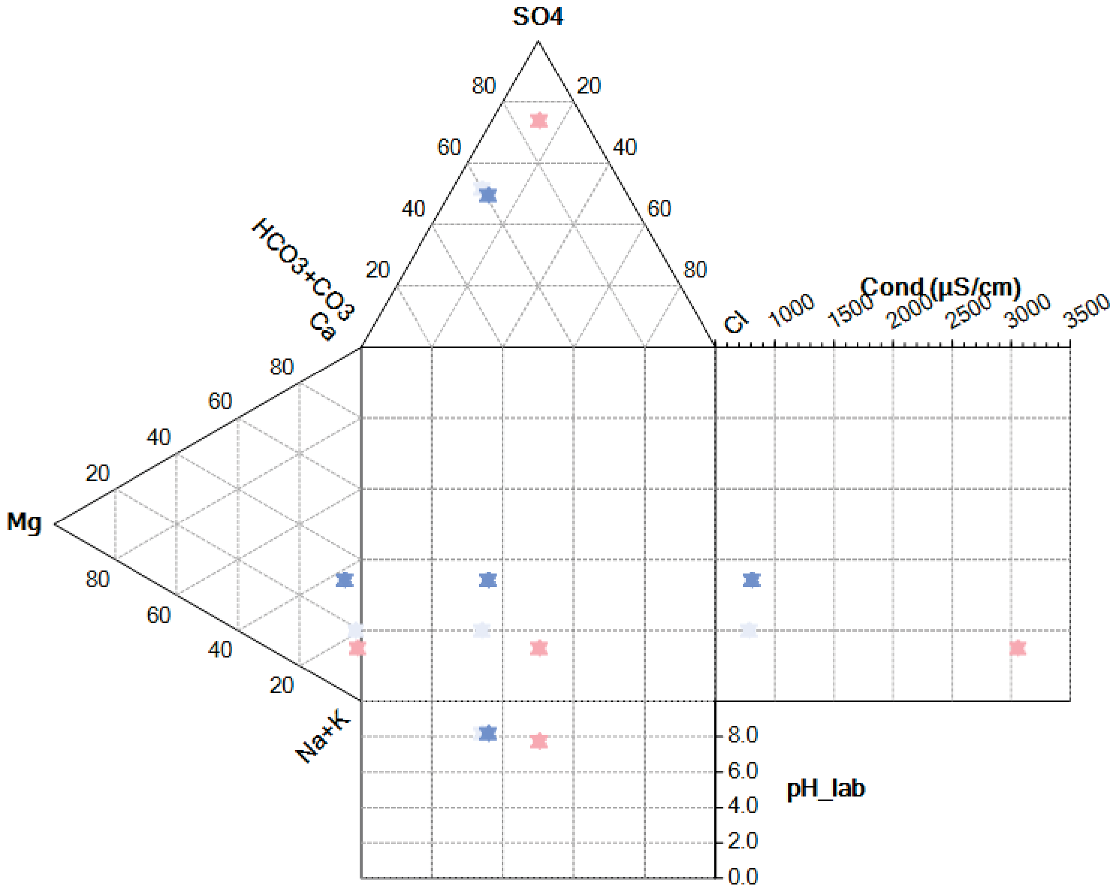
FIGURE A1-4: MWB03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWB03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWB03_B_GW0001	Na-SO_4	High

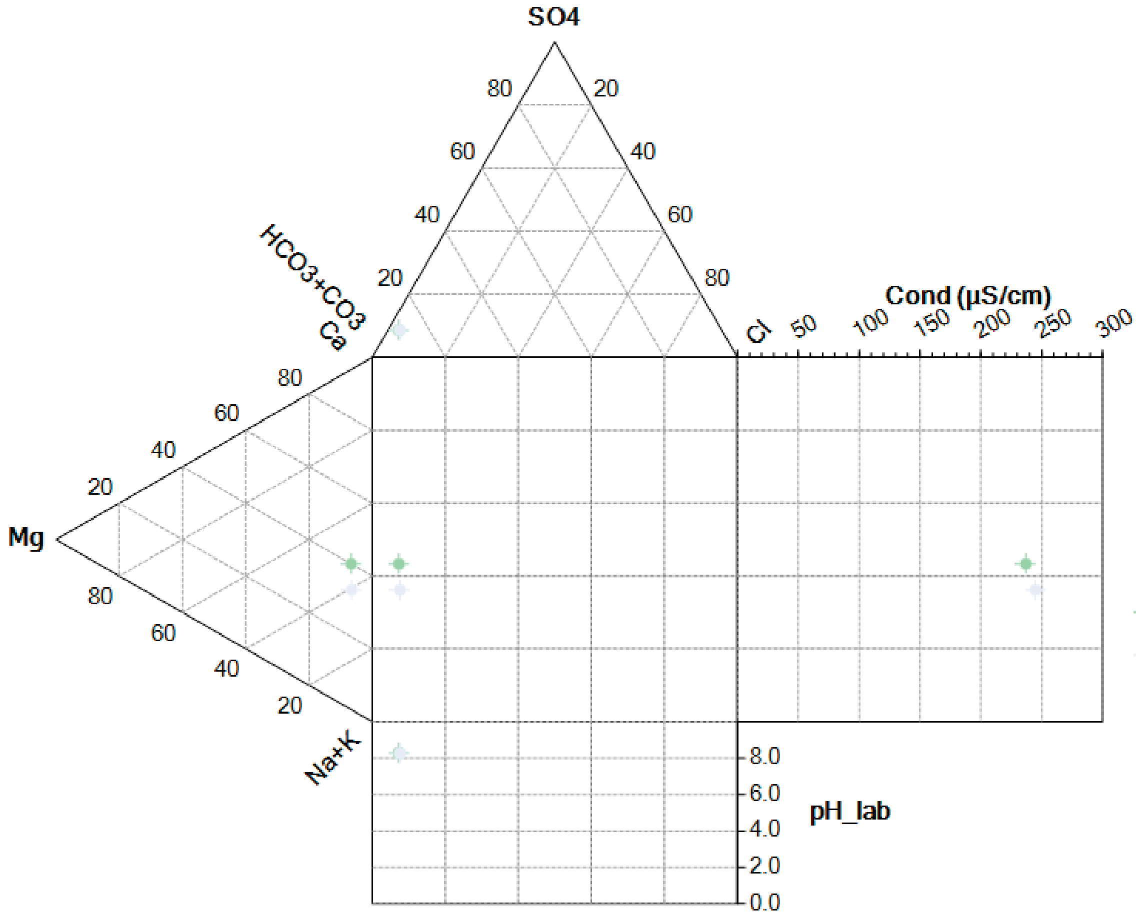
FIGURE A1-5: MWC01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC01_A_GW0001	Na-SO_4	High
IG_MWC01_A_GW0003	Na-SO_4-HCO_3	High
IG_MWC01_C_GW0002	Na-Ca-SO_4-HCO_3	High

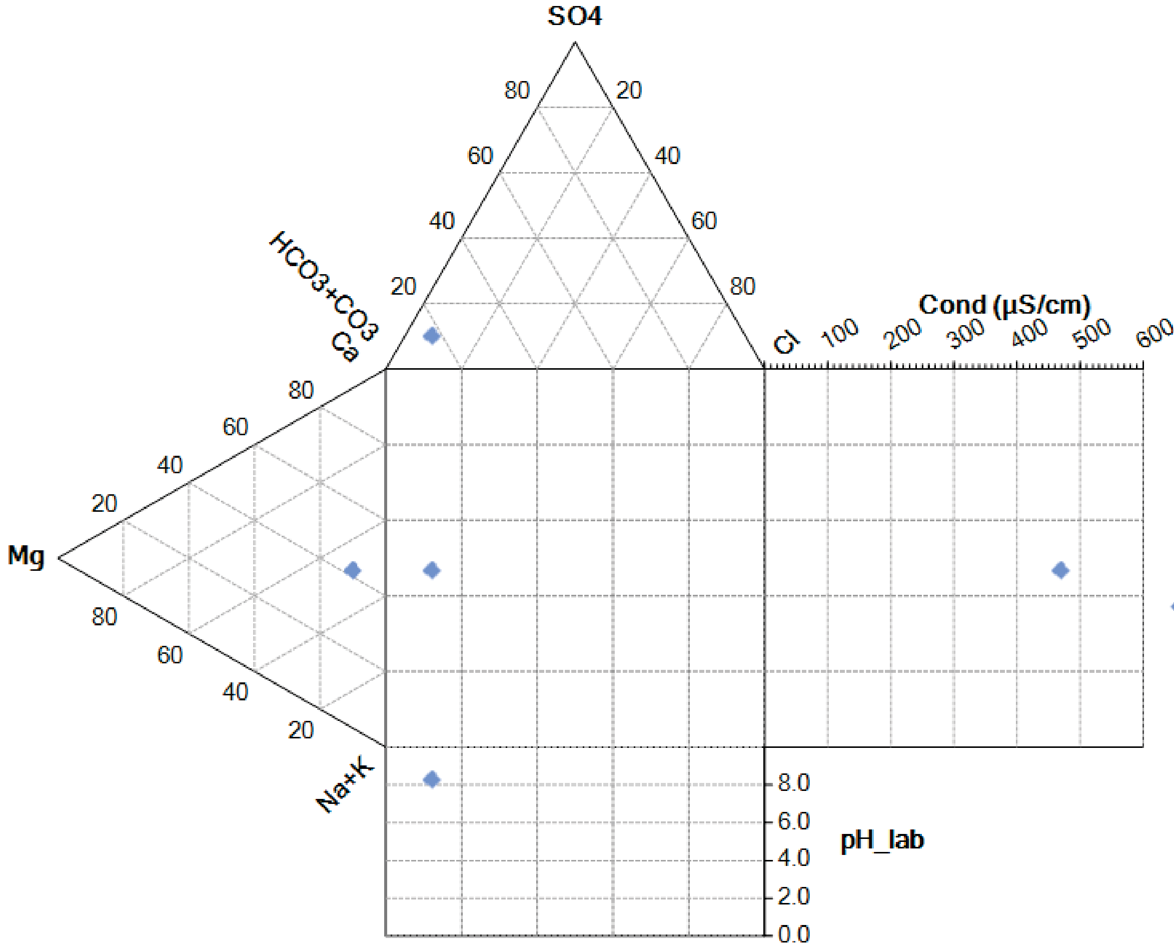
FIGURE A1-6: MWC02 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC02**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC02_A_GW0001	Na-Ca-HCO_3	High
IG_MWC02_A_GW0002	Na-Ca-HCO_3	High

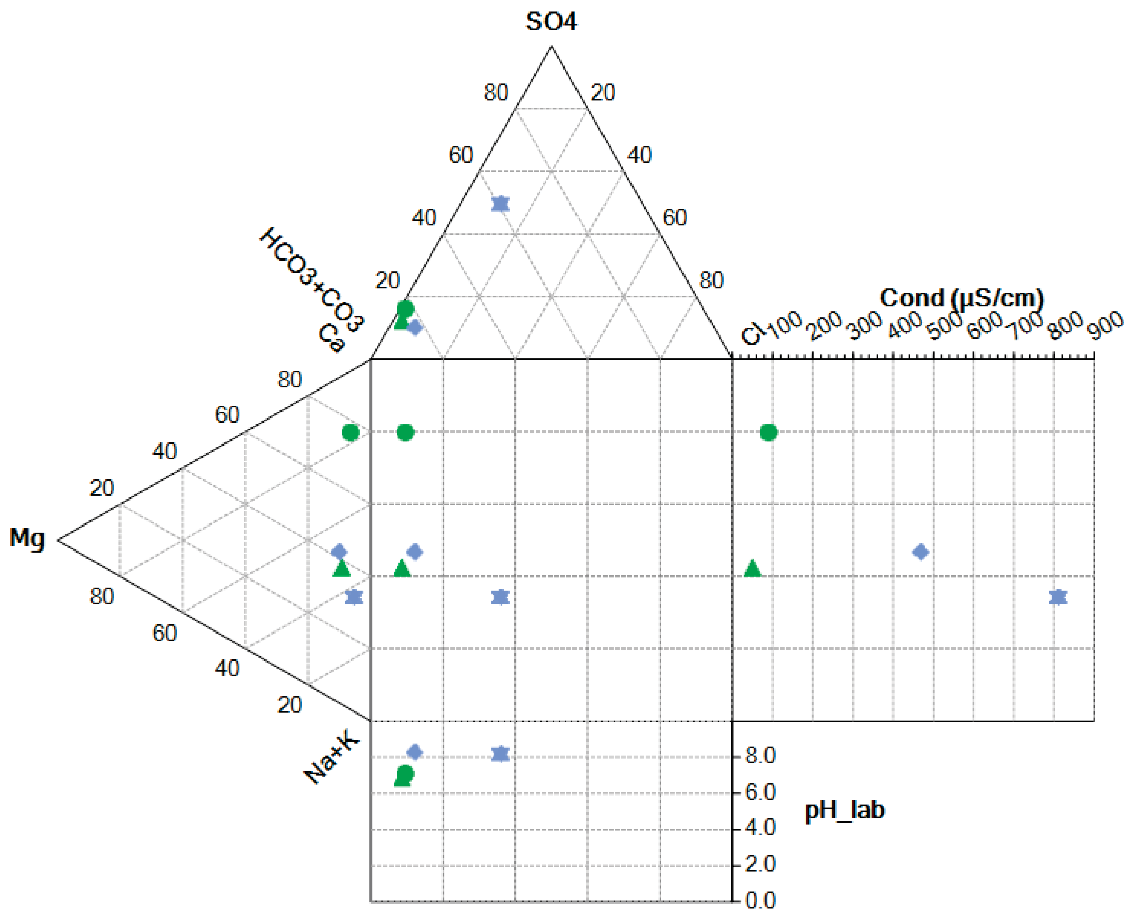
FIGURE A1-7: MWC03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC03_C_GW0001	Na-Ca-HCO_3	High

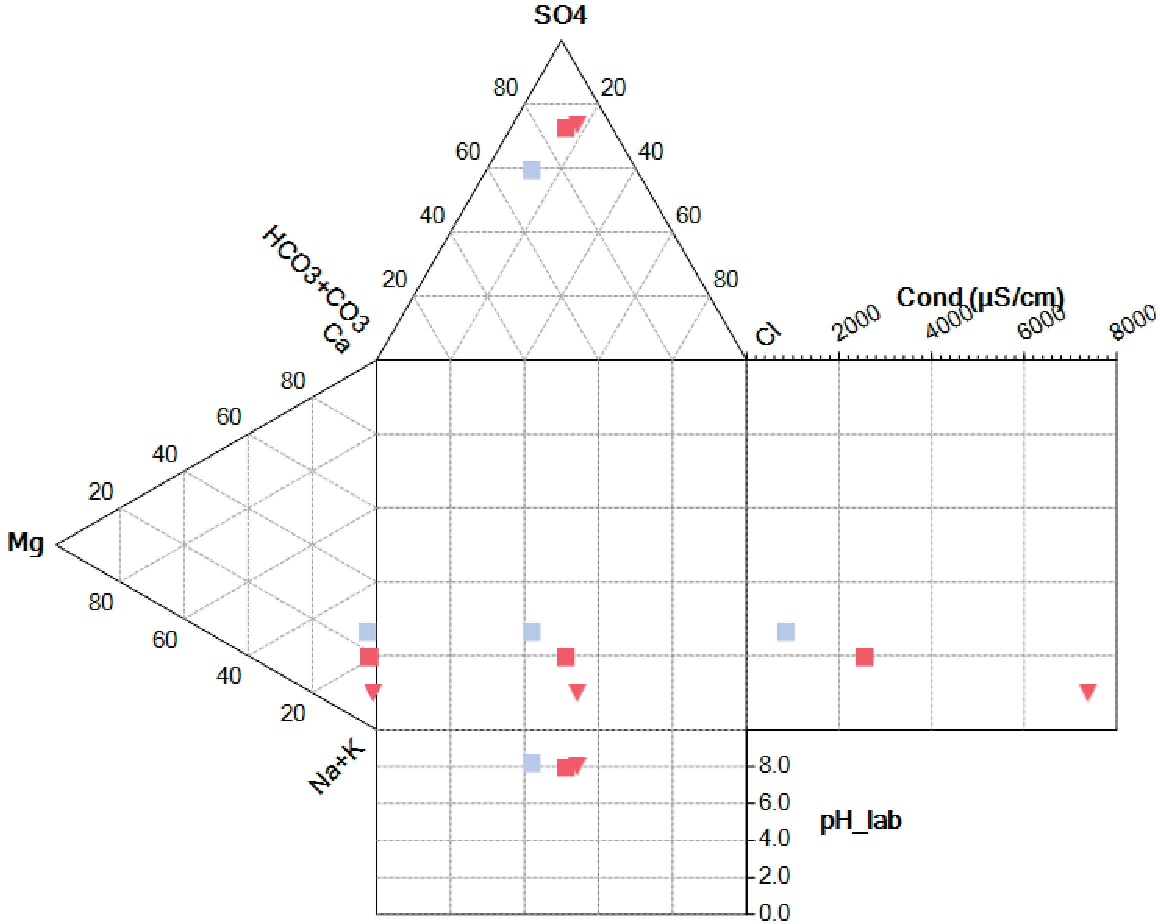
FIGURE A1-8: C-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **C**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_C_GW0001	Na-Ca-HCO_3	High
IG_MWB01_C_GW0001	Na-HCO_3	High
IG_MWC01_C_GW0002	Na-Ca-SO_4-HCO_3	High
IG_MWC03_C_GW0001	Na-Ca-HCO_3	High

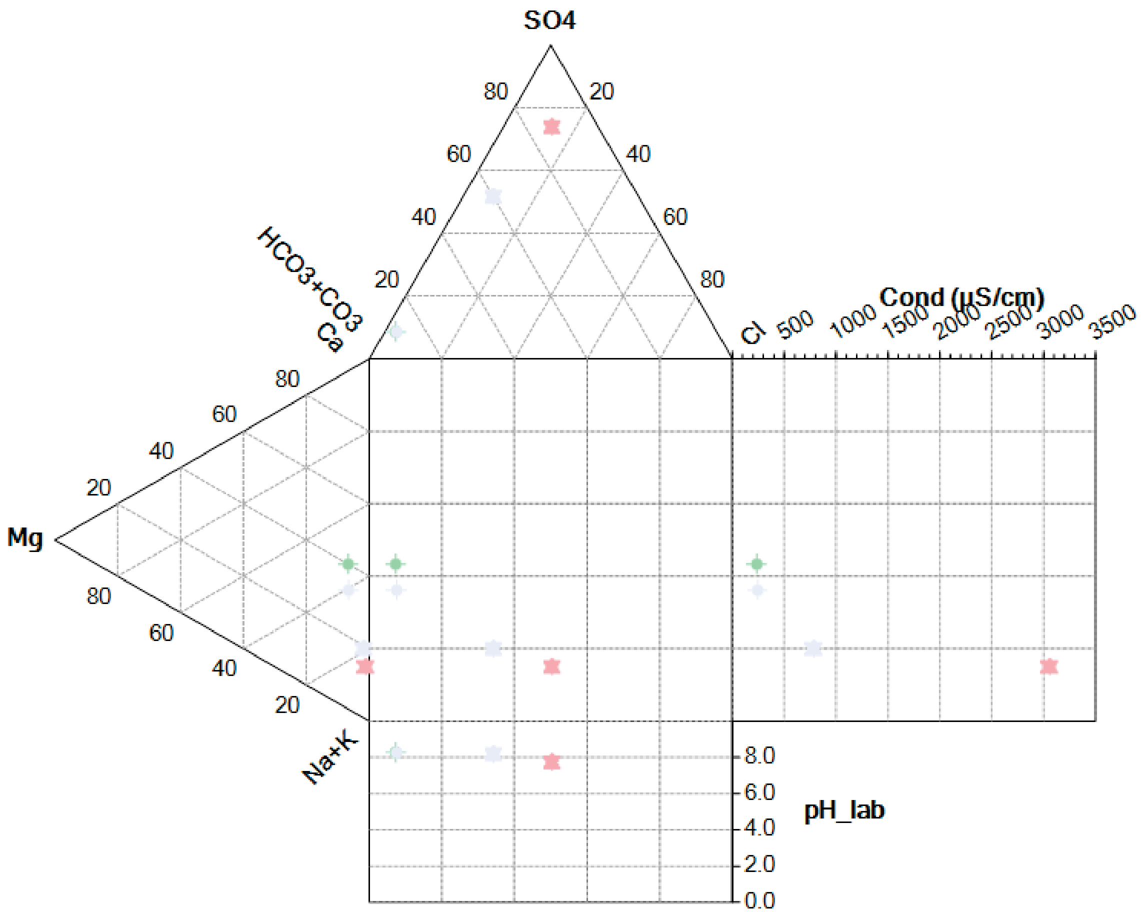
FIGURE A1-9: B-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **B**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA03_B_GW0001	Na-SO_4	High
IG_MWB03_B_GW0001	Na-Ca-SO_4-HCO_3	High
IG_MWA03_B_GW0002	Na-SO_4	High

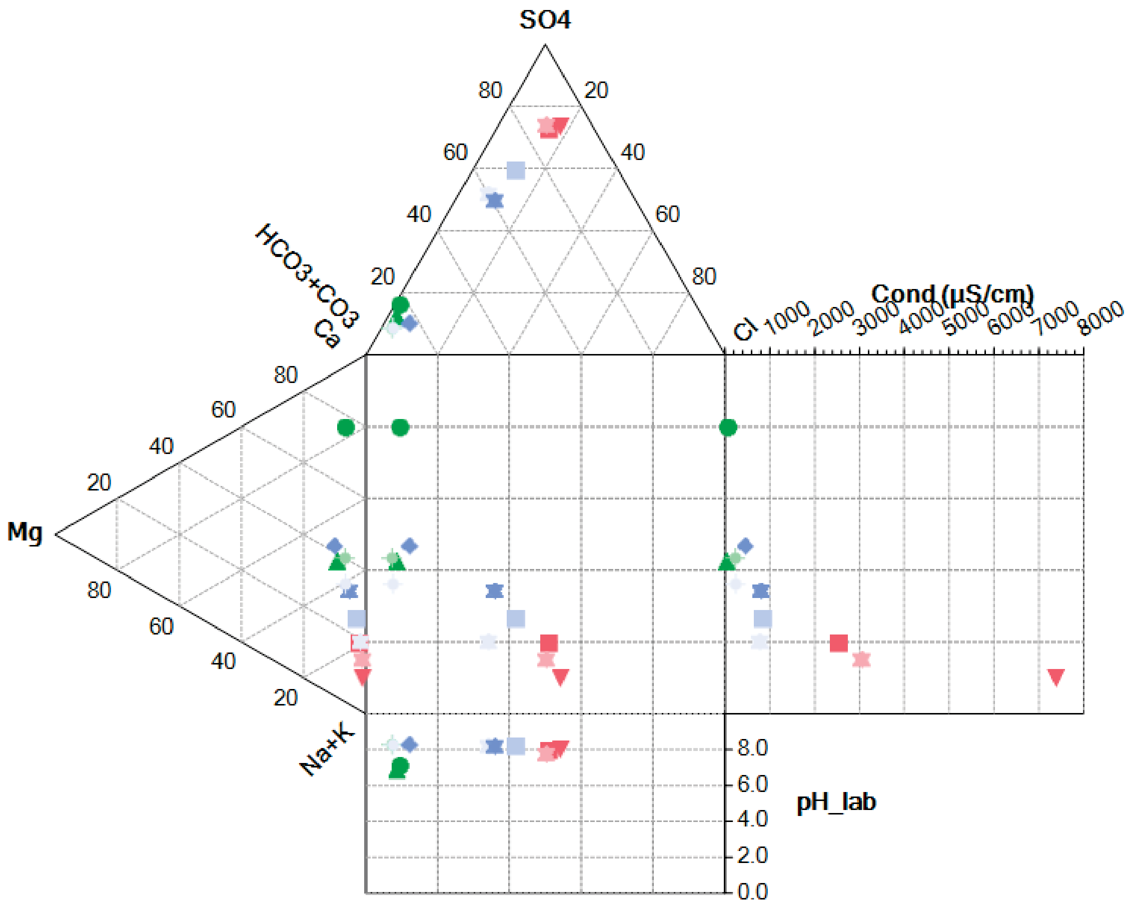
FIGURE A1-10: A-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **A**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC02_A_GW0002	Na-SO_4	High
IG_MWC01_A_GW0001	Na-Ca-SO_4-HCO_3	High
IG_MWC01_A_GW0003	Na-SO_4	High
IG_MWC02_A_GW0001	Na-SO_4	High

FIGURE A1-11: ALL SAMPLES - DUROV



All High Confidence Samples
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_C_GW0001	Na-Ca-HCO_3	High
IG_MWA03_B_GW0001	Na-SO_4	High
IG_MWB01_C_GW0001	Ca-HCO_3	High
IG_MWB03_B_GW0001	Na-SO_4	High
IG_MWC02_A_GW0002	Na-Ca-HCO_3	High
IG_MWA03_B_GW0002	Na-Ca-SO_4-HCO_3	High
IG_MWC01_A_GW0001	Na-SO_4	High
IG_MWC01_A_GW0003	Na-SO_4-HCO_3	High
IG_MWC01_C_GW0002	Na-Ca-SO_4-HCO_3	High
IG_MWC02_A_GW0001	Na-Ca-HCO_3	High
IG_MWC03_C_GW0001	Na-Ca-HCO_3	High

APPENDIX A2

Durov Plots – Low Confidence Samples

DUROV PLOTS FOR LOW-CONFIDENCE SAMPLES - IGNACE 2022

Red symbols are for samples taken in July 2022

Interval C | Interval B | Interval A

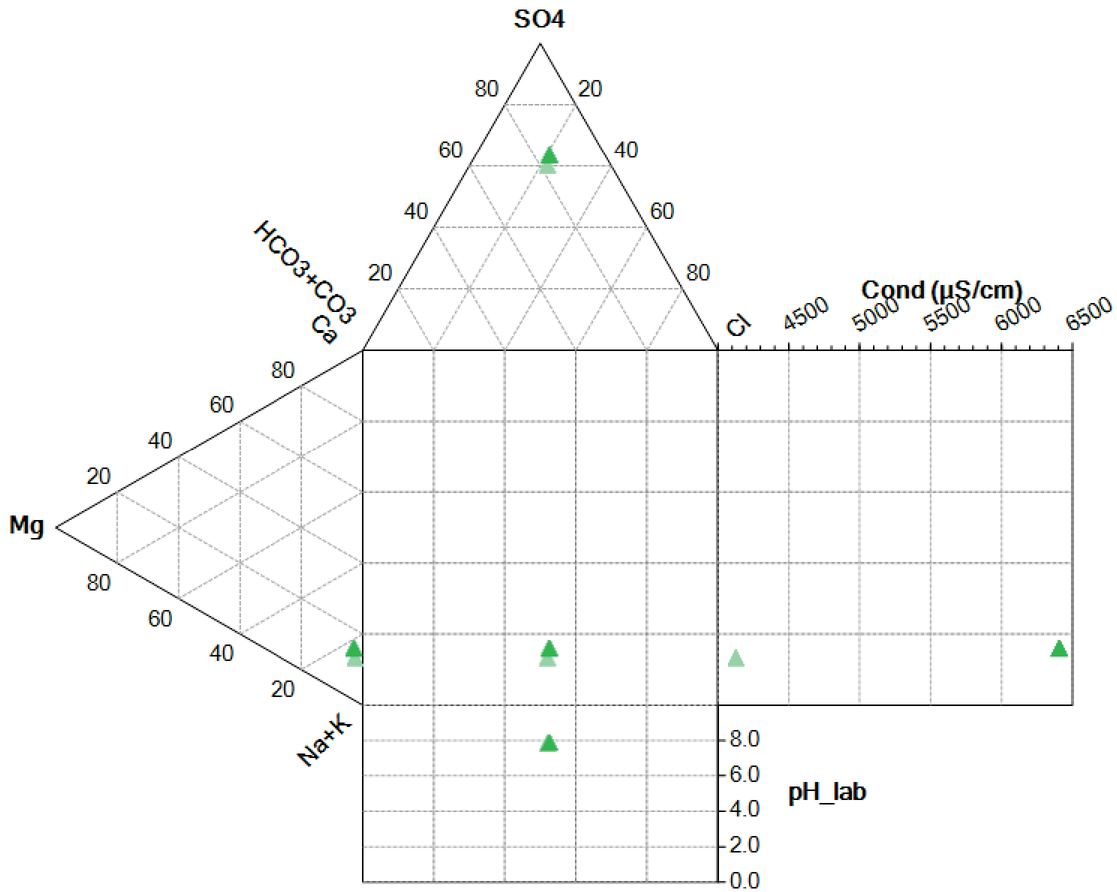
Blue symbols are for samples taken in September 2022

Interval C | Interval B | Interval A

Green symbols are for samples taken in December 2022

Interval C | Interval B | Interval A

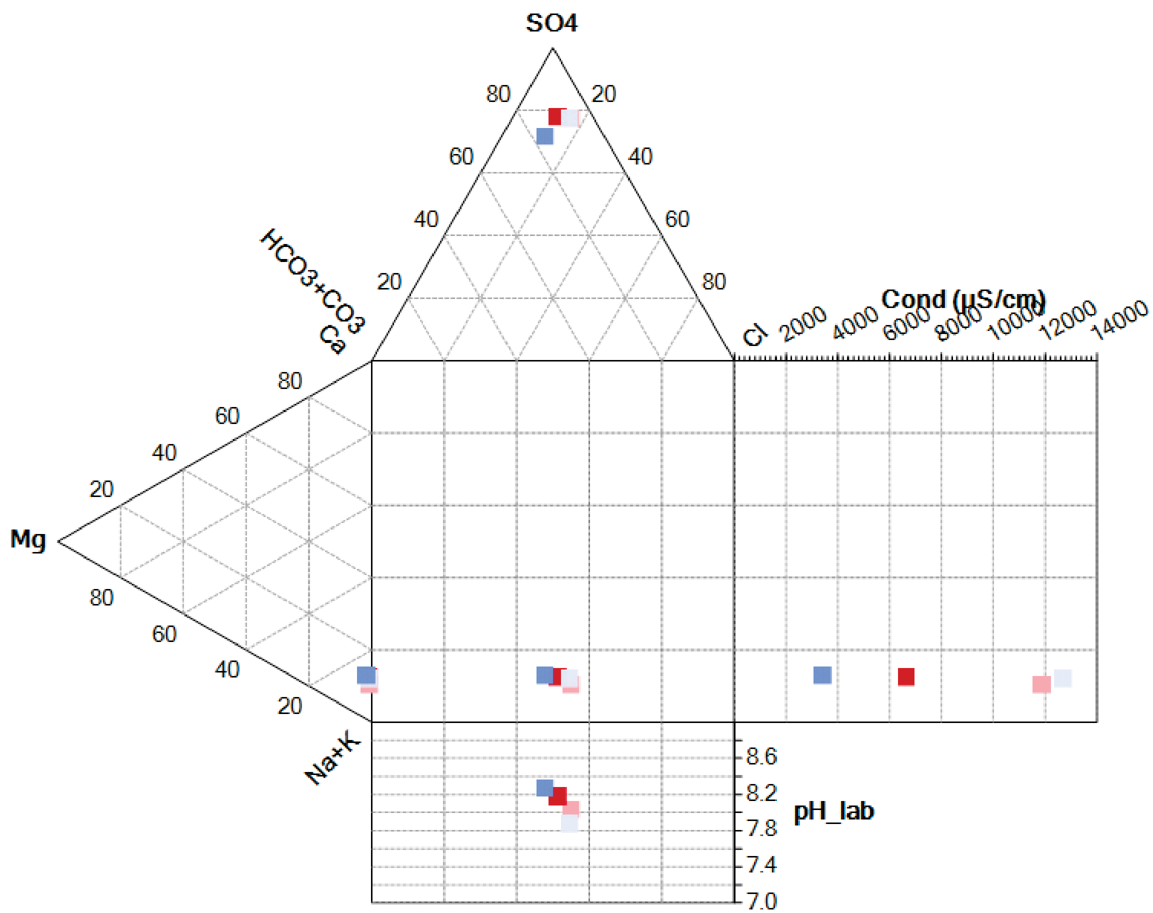
FIGURE A2-1: MWA01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWA01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_A_GW0001	Na-SO_4-Cl	Low
IG_MWA01_B_GW0001	Na-SO_4-Cl	Low

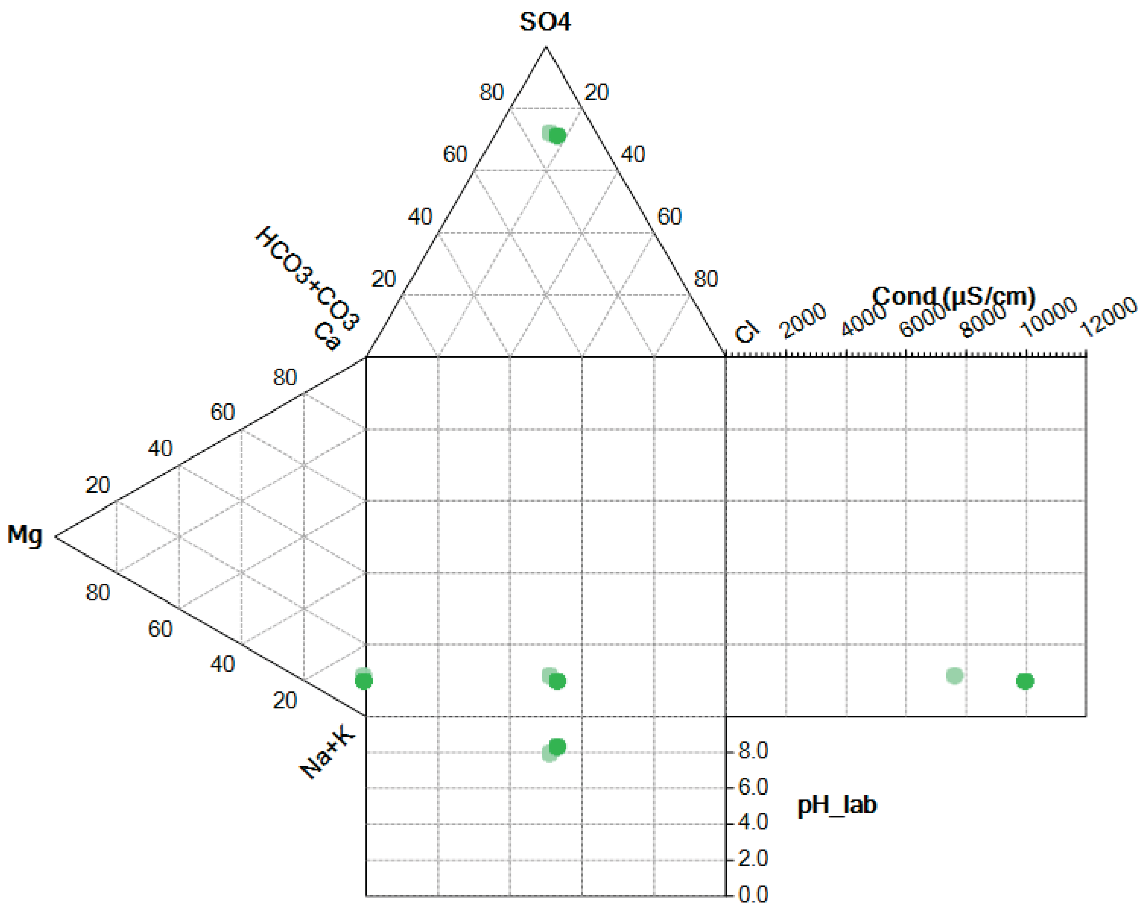
FIGURE A2-2: MWA03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWA03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA03_A_GW0001	Na-SO_4	Low
IG_MWA03_C_GW0001	Na-SO_4	Low
IG_MWA03_A_GW0002	Na-SO_4	Low
IG_MWA03_C_GW0003	Na-SO_4	Low

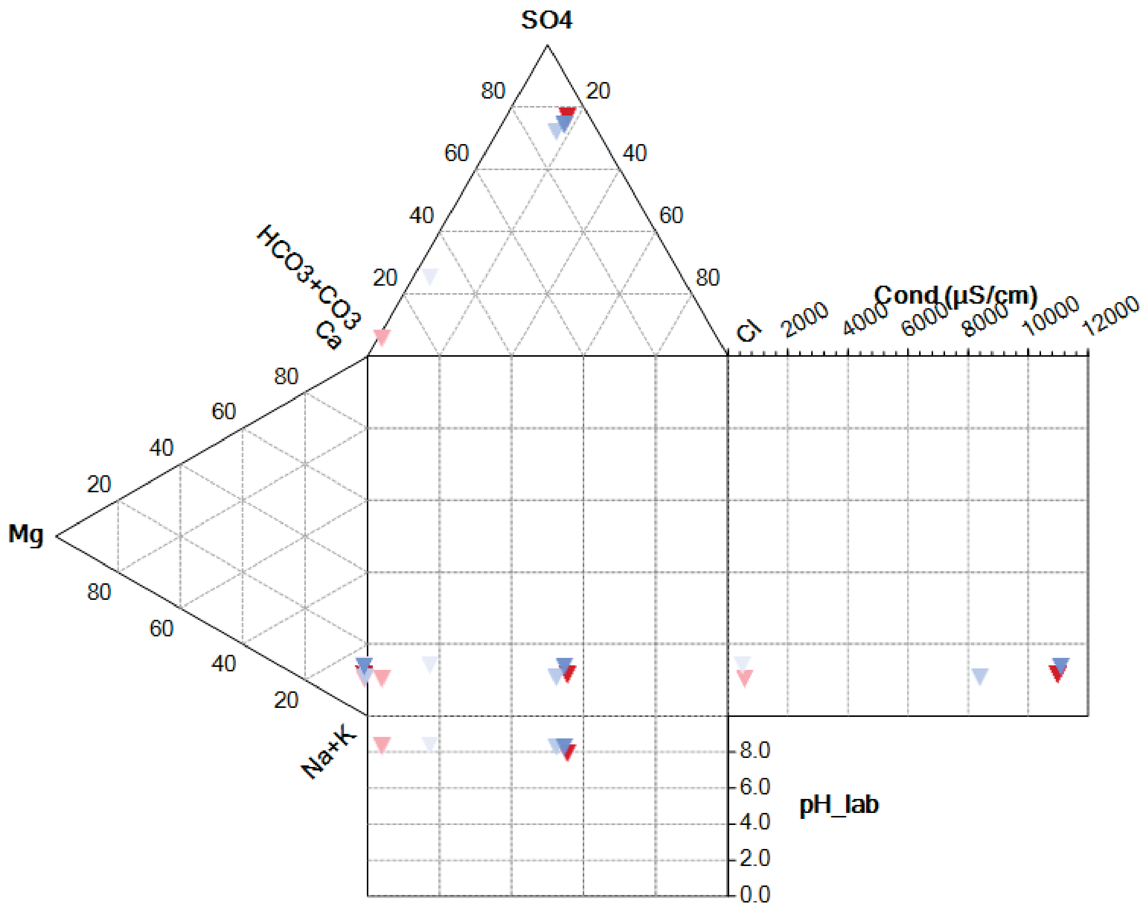
FIGURE A2-3: MWB01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWB01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWB01_A_GW0001	Na-SO_4	Low
IG_MWB01_B_GW0001	Na-SO_4	Low

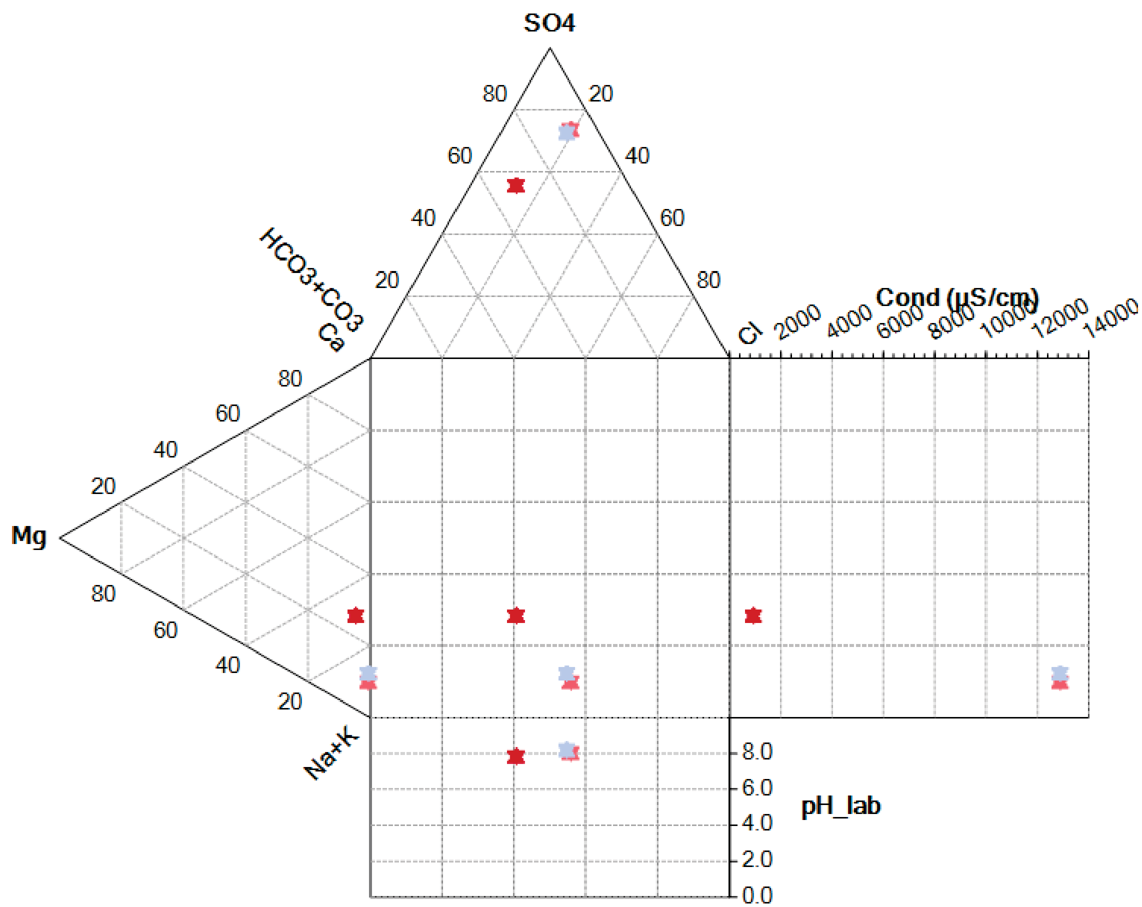
FIGURE A2-4: MWB03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWB03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWB03_C_GW0001	Na-SO_4	Low
IG_MWB03_A_GW0001	Na-HCO_3	Low
IG_MWB03_A_GW0002	Na-HCO_3-SO_4	Low
IG_MWB03_B_GW0003	Na-SO_4	Low
IG_MWB03_C_GW0002	Na-SO_4	Low

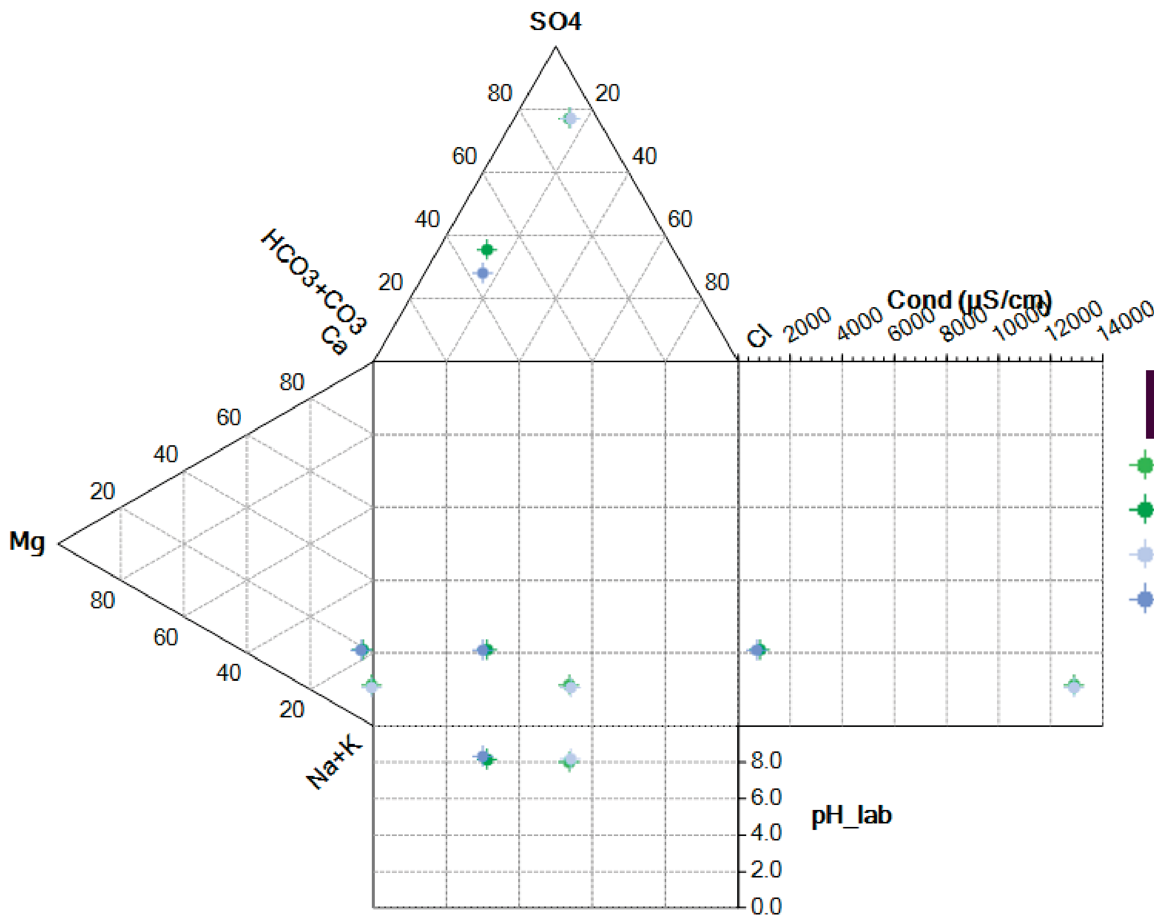
FIGURE A2-5: MWC01 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC01**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC01_B_GW0001	Na-SO_4	Low
IG_MWC01_C_GW0001	Na-Ca-SO_4-HCO_3	Low
IG_MWC01_B_GW0002	Na-SO_4	Low

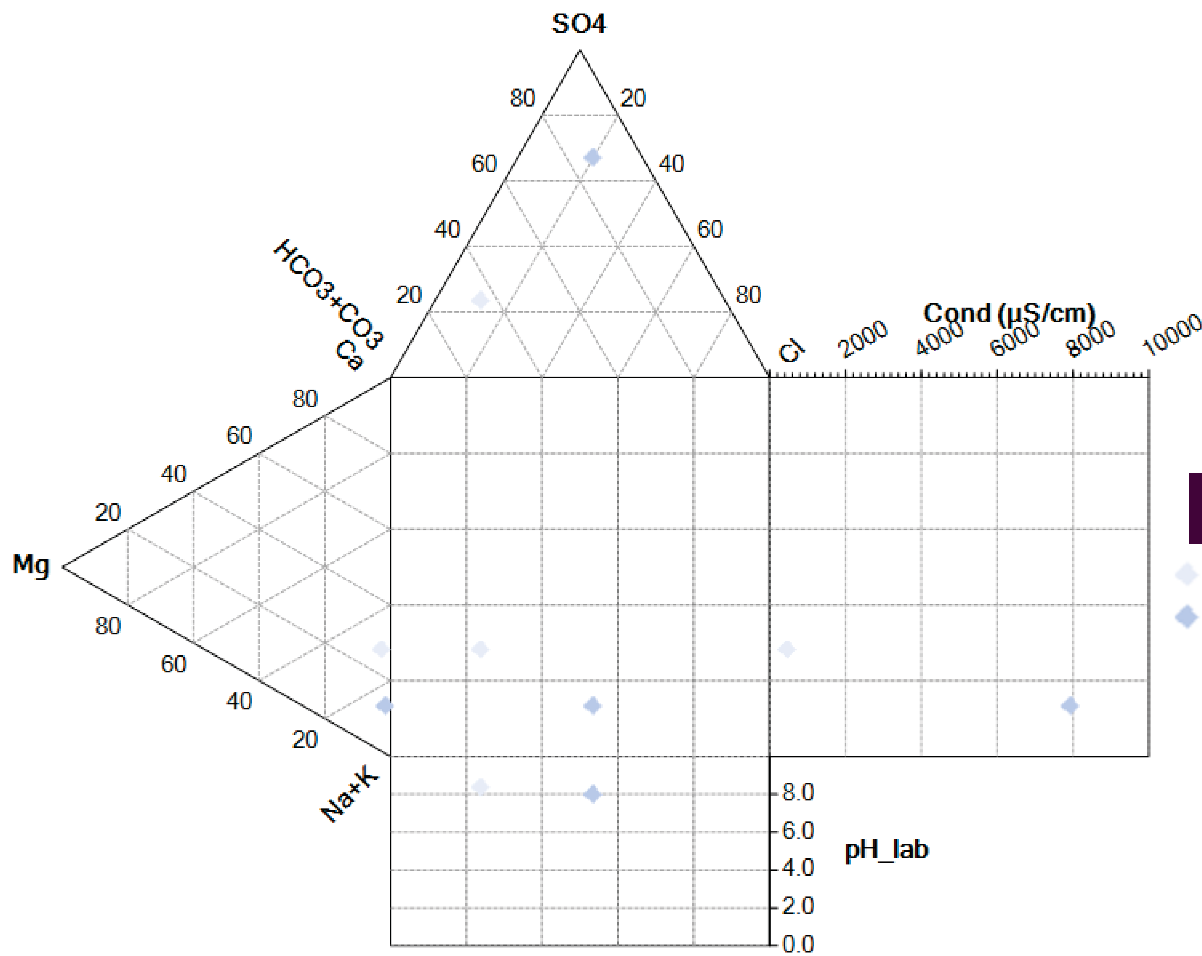
FIGURE A2-6: MWC02 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC02**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC02_B_GW0003	Na-SO_4	Low
IG_MWC02_C_GW0002	Na-HCO_3-SO_4	Low
IG_MWC02_B_GW0001	Na-SO_4	Low
IG_MWC02_C_GW0001	Na-HCO_3-SO_4	Low

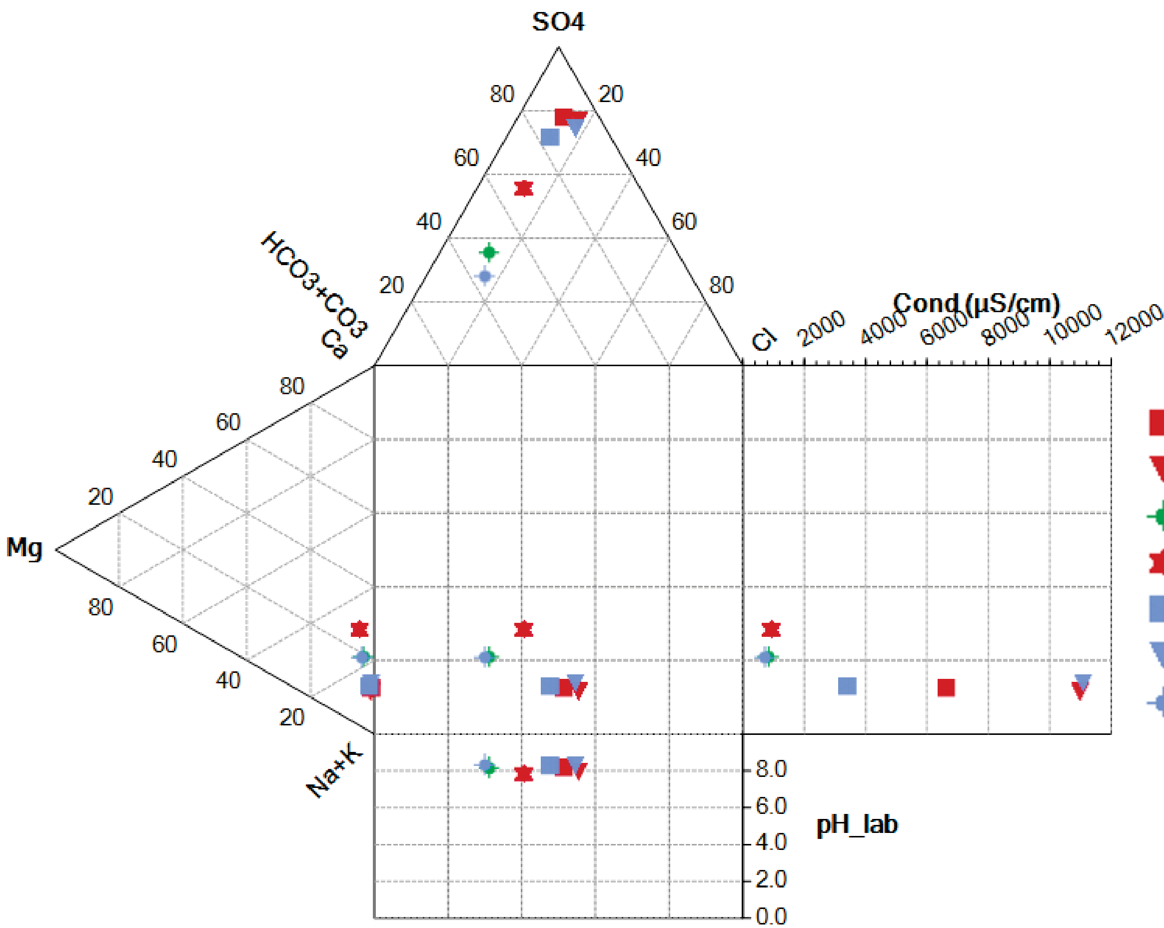
FIGURE A2-7: MWC03 DUROV (ALL FIELD EVENTS)



Monitoring Well: **MWC03**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWC03_A_GW0001	Na-Ca-HCO_3-SO_4	Low
IG_MWC03_B_GW0001	Na-SO_4-Cl	Low

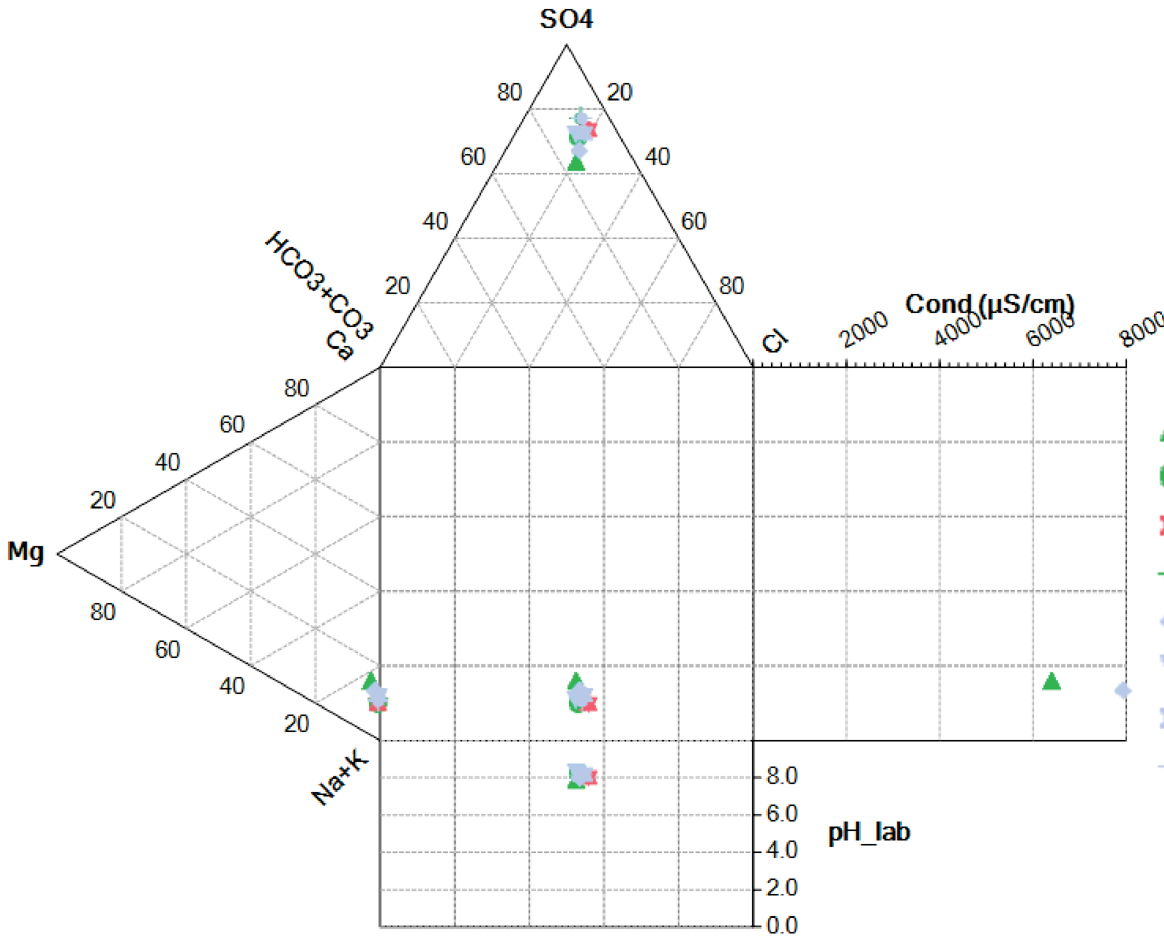
FIGURE A2-8: C-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **C**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA03_C_GW0001	Na-SO_4	Low
IG_MWB03_C_GW0001	Na-SO_4	Low
IG_MWC02_C_GW0002	Na-HCO_3-SO_4	Low
IG_MWC01_C_GW0001	Na-Ca-SO_4-HCO_3	Low
IG_MWA03_C_GW0003	Na-SO_4	Low
IG_MWB03_C_GW0002	Na-SO_4	Low
IG_MWC02_C_GW0001	Na-HCO_3-SO_4	Low

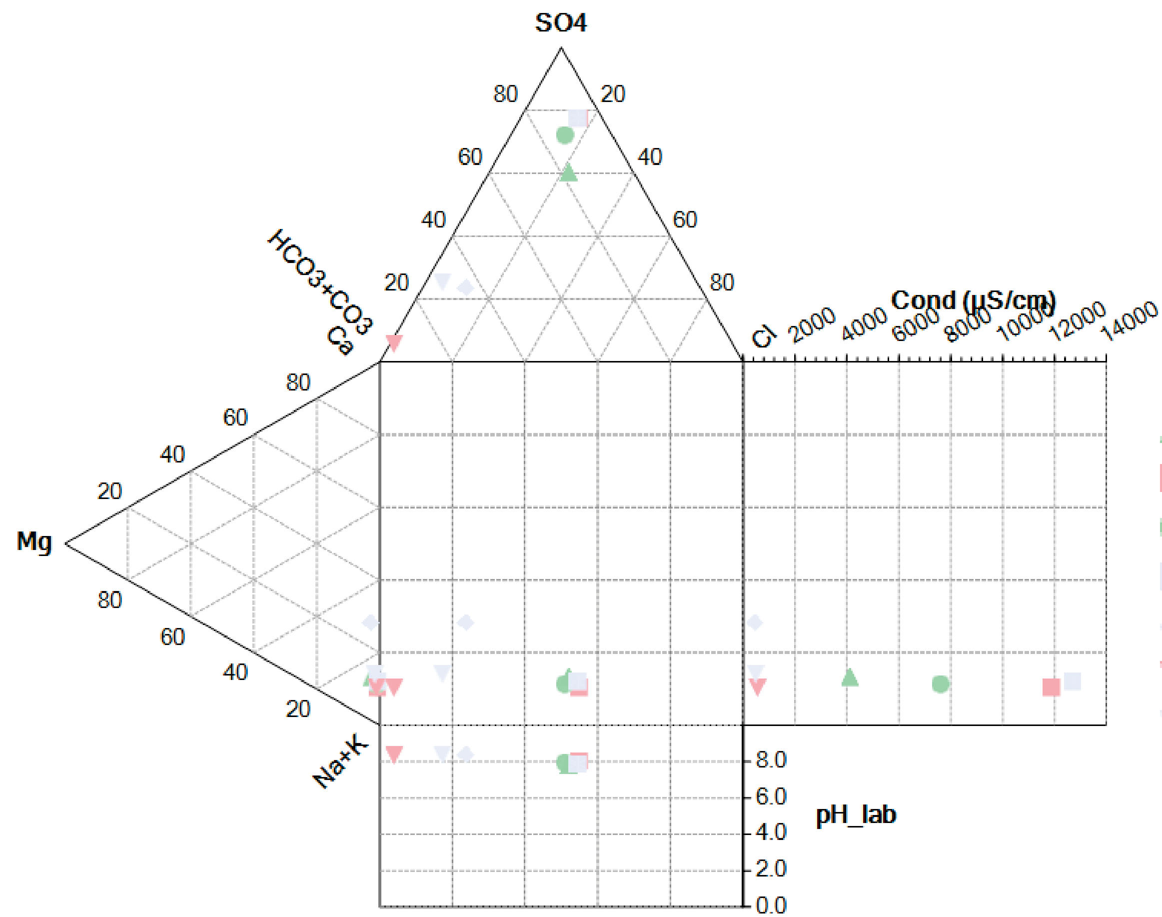
FIGURE A2-9: B-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **B**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_B_GW0001	Na-SO_4-Cl	Low
IG_MWB01_B_GW0001	Na-SO_4	Low
IG_MWC01_B_GW0001	Na-SO_4	Low
IG_MWC02_B_GW0003	Na-SO_4	Low
IG_MWC03_B_GW0001	Na-SO_4-Cl	Low
IG_MWB03_B_GW0003	Na-SO_4	Low
IG_MWC01_B_GW0002	Na-SO_4	Low
IG_MWC02_B_GW0001	Na-SO_4	Low

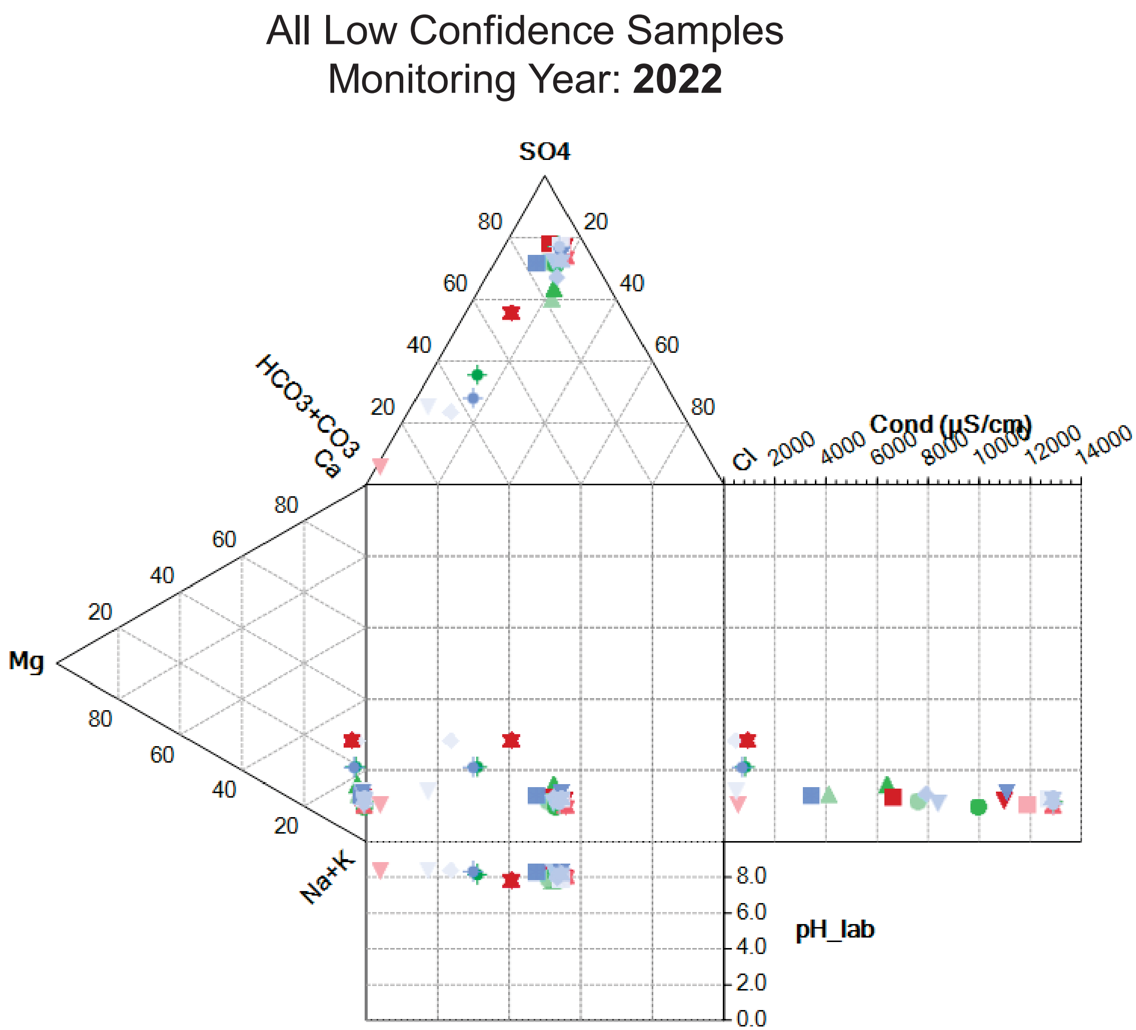
FIGURE A2-10: A-INTERVAL WELLS DUROV (ALL FIELD EVENTS)



Monitoring Interval **A**
Monitoring Year: **2022**

Sample ID	Water Type	Sample Confidence Level
IG_MWA01_A_GW0001	Na-SO_4-Cl	Low
IG_MWA03_A_GW0001	Na-SO_4	Low
IG_MWB01_A_GW0001	Na-SO_4	Low
IG_MWA03_A_GW0002	Na-SO_4	Low
IG_MWC03_A_GW0001	Na-Ca-HCO_3-SO_4	Low
IG_MWB03_A_GW0001	Na-HCO_3	Low
IG_MWB03_A_GW0002	Na-HCO_3-SO_4	Low

FIGURE A2-11: ALL NON-REPRESENTATIVE SAMPLES - DUROV



Sample ID	Water Type	Sample Confidence Level
IG_MWA01_A_GW0001	Na-SO_4-Cl	Low
IG_MWA01_B_GW0001	Na-SO_4-Cl	Low
IG_MWA03_A_GW0001	Na-SO_4	Low
IG_MWA03_C_GW0001	Na-SO_4	Low
IG_MWB01_A_GW0001	Na-SO_4	Low
IG_MWB01_B_GW0001	Na-SO_4	Low
IG_MWB03_C_GW0001	Na-SO_4	Low
IG_MWC01_B_GW0001	Na-SO_4	Low
IG_MWC02_B_GW0003	Na-SO_4	Low
IG_MWC02_C_GW0002	Na-HCO_3-SO_4	Low
IG_MWA03_A_GW0002	Na-SO_4	Low
IG_MWC03_A_GW0001	Na-Ca-HCO_3-SO_4	Low
IG_MWC03_B_GW0001	Na-SO_4-Cl	Low
IG_MWB03_A_GW0001	Na-HCO_3	Low
IG_MWC01_C_GW0001	Na-Ca-SO_4-HCO_3	Low
IG_MWA03_A_GW0003	Na-SO_4	Low
IG_MWB03_A_GW0002	Na-SO_4	Low
IG_MWB03_B_GW0003	Na-HCO_3-SO_4	Low
IG_MWB03_C_GW0002	Na-SO_4	Low
IG_MWC01_B_GW0002	Na-SO_4	Low
IG_MWC02_B_GW0001	Na-SO_4	Low
IG_MWC02_C_GW0001	Na-HCO_3-SO_4	Low

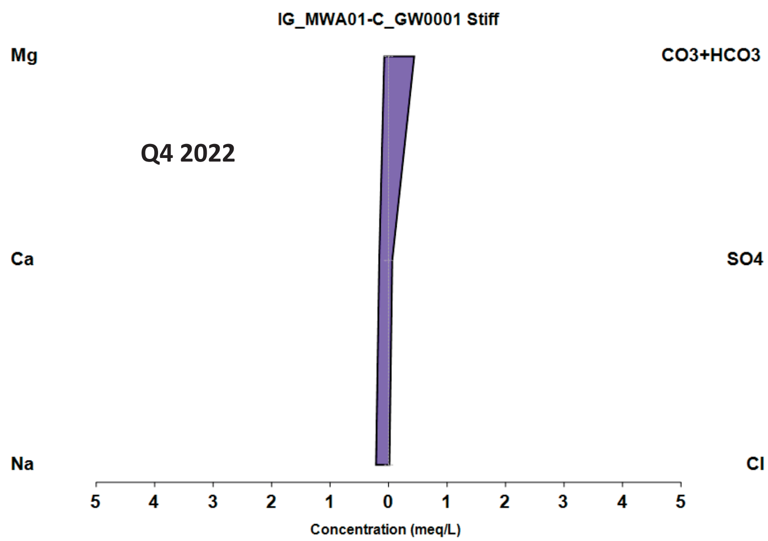
APPENDIX B1

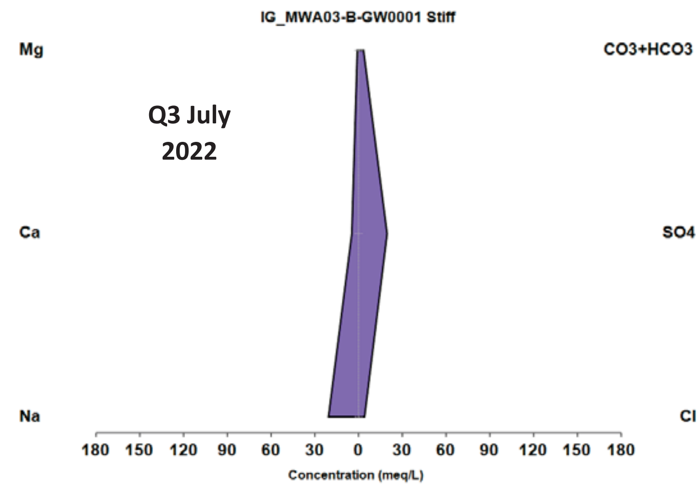
Stiff Diagrams - High Confidence Samples

APPENDIX – B1

STIFF DIAGRAMS FOR HIGH-CONFIDENCE SAMPLES – IGNACE 2022

FIGURE B1-1: STIFF DIAGRAMS FOR WELLS IG_MWA01-C AND IG_MWA03-B





N/A

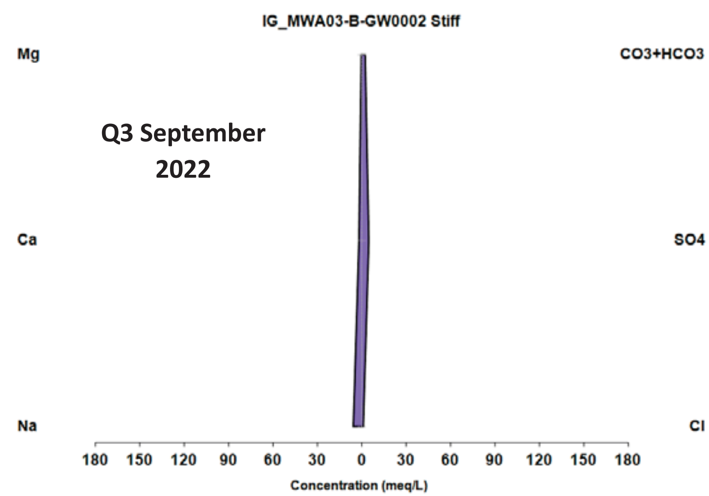
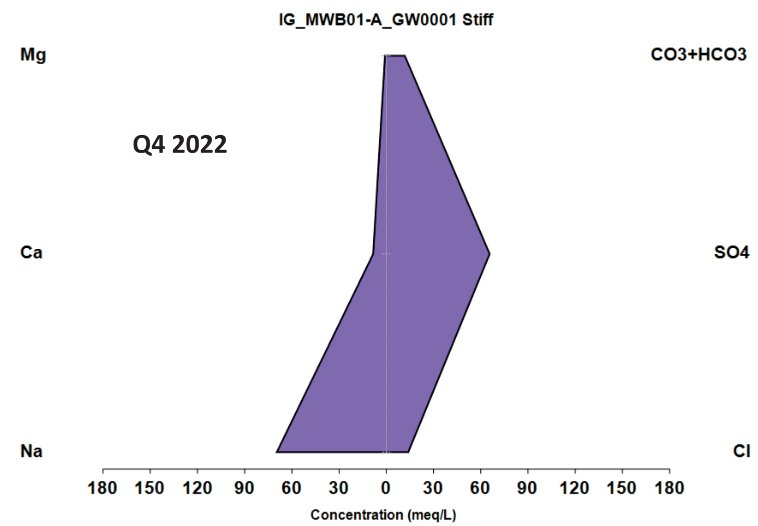
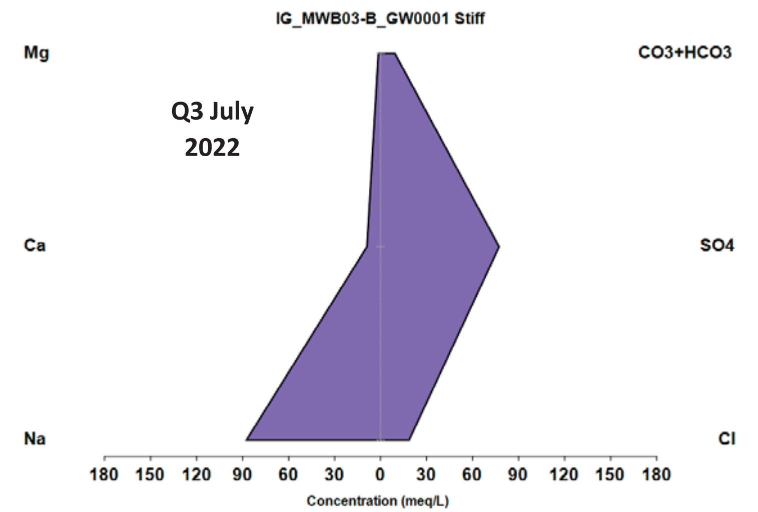


FIGURE B1-2: STIFF DIAGRAMS FOR WELLS IG_MWB01-A AND IG_MWB03-B





N / A

N / A

FIGURE B1-3: STIFF DIAGRAMS FOR WELLS IG_MWC01-A AND IG_MWC01-C

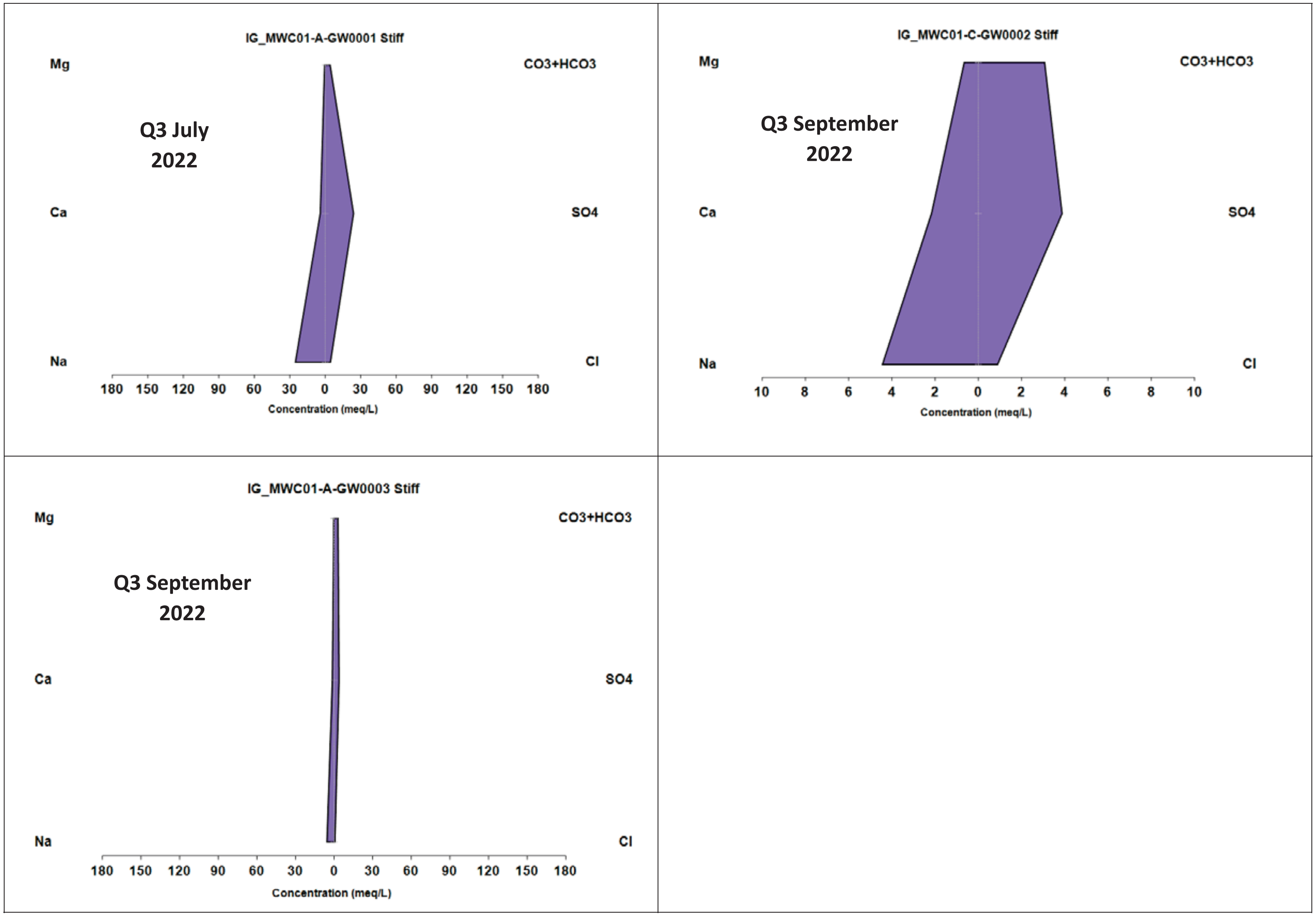
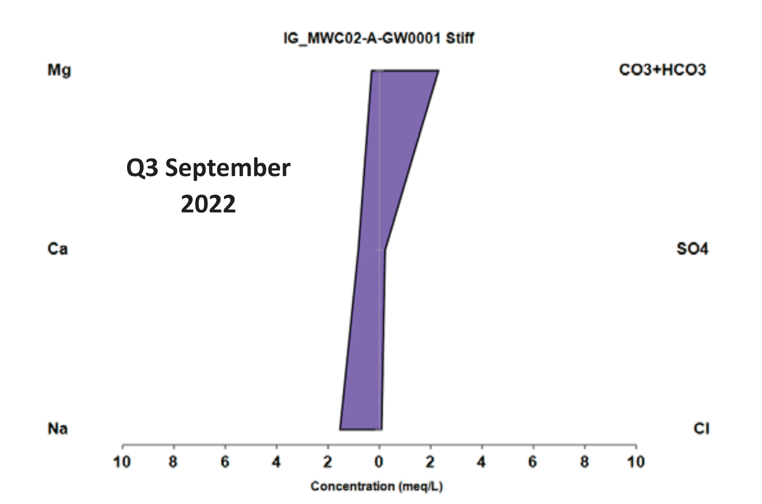
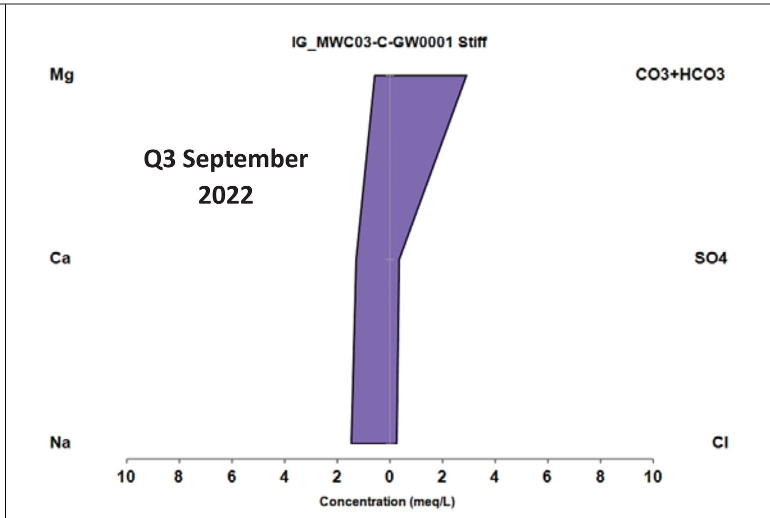
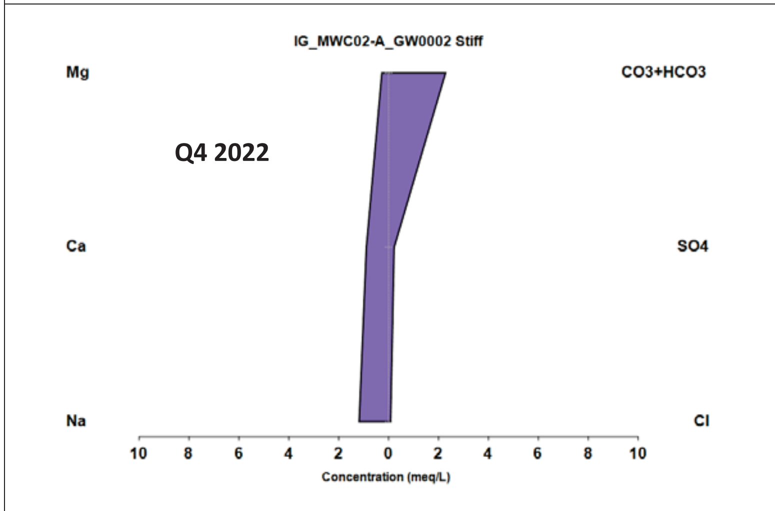


FIGURE B1-4: STIFF DIAGRAMS FOR WELLS IG_MWC02_A AND IG_MWC03_C







N/A

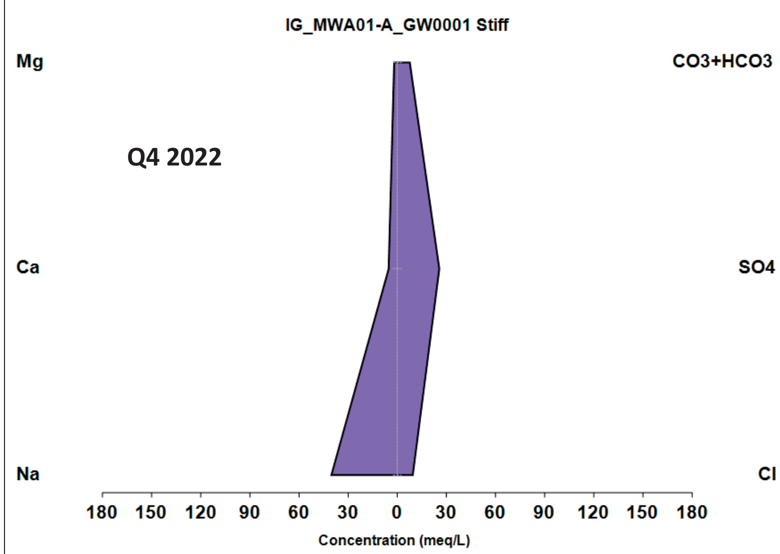
APPENDIX B2

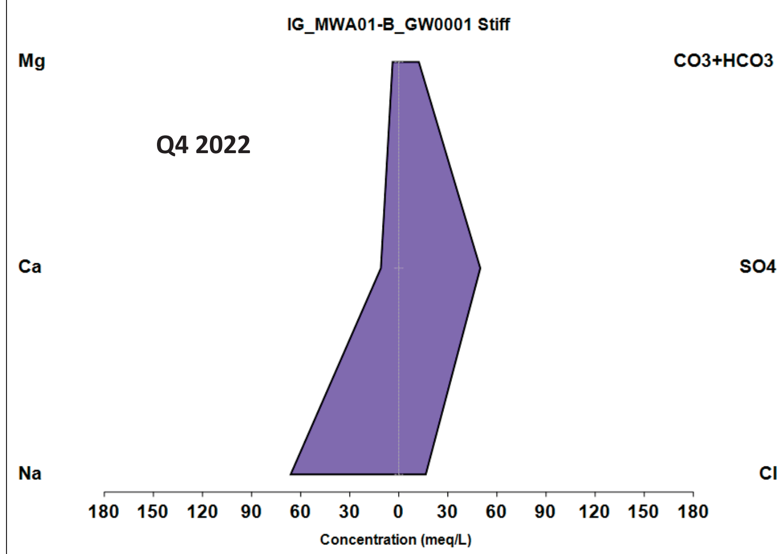
Stiff Diagrams – Low Confidence Samples

APPENDIX – B2

STIFF DIAGRAMS FOR LOW-CONFIDENCE SAMPLES – IGNACE 2022

FIGURE B2-1: STIFF DIAGRAMS FOR WELLS IG_MWA01-A AND IG_MWA01-B





N/A

N/A

FIGURE B2-2: STIFF DIAGRAMS FOR WELLS IG_MWA03-A AND IG_MWA03-C

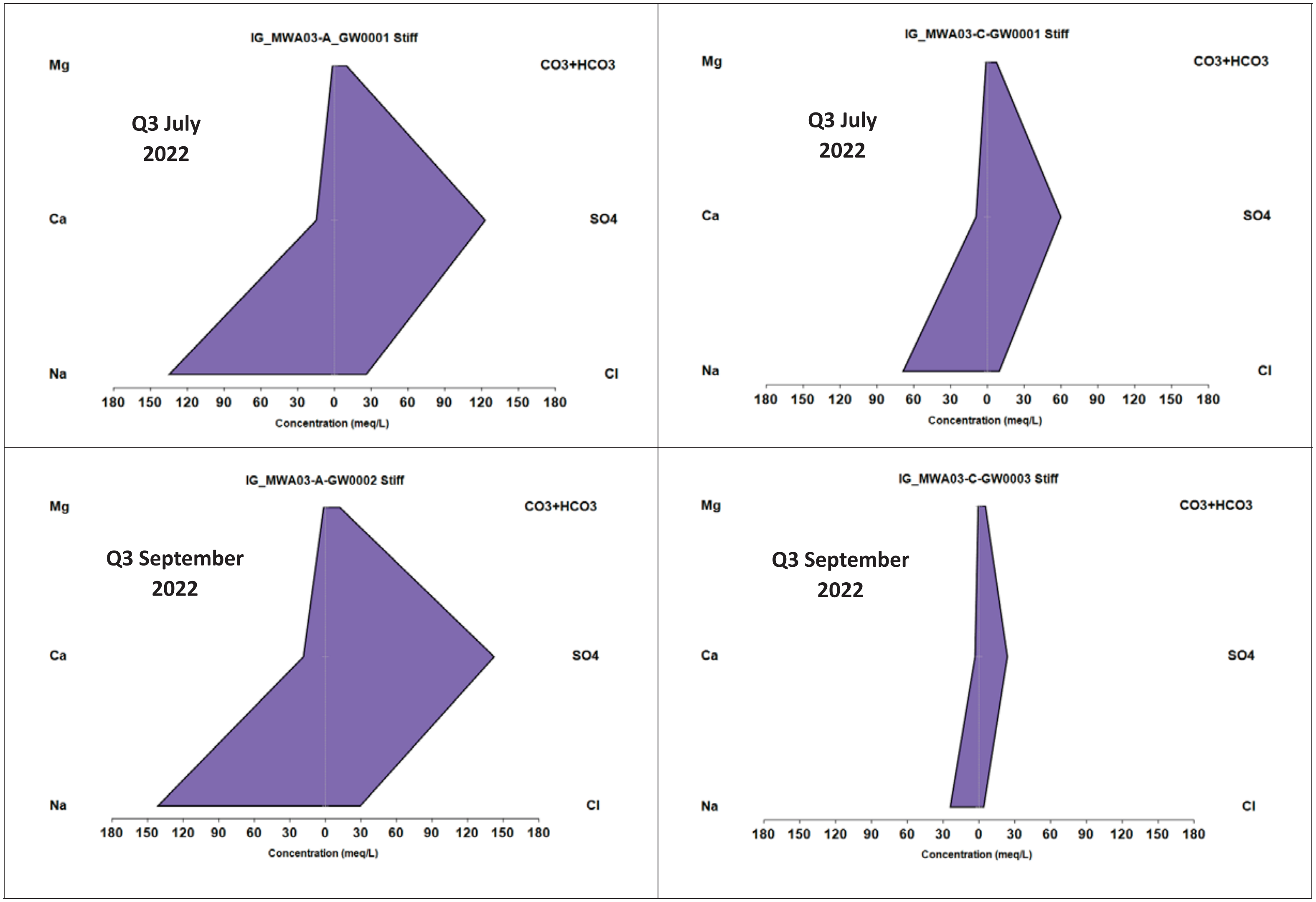
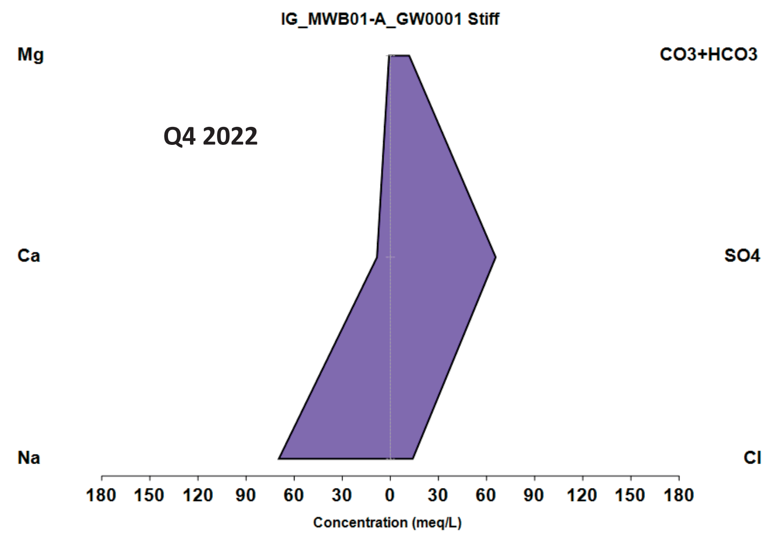
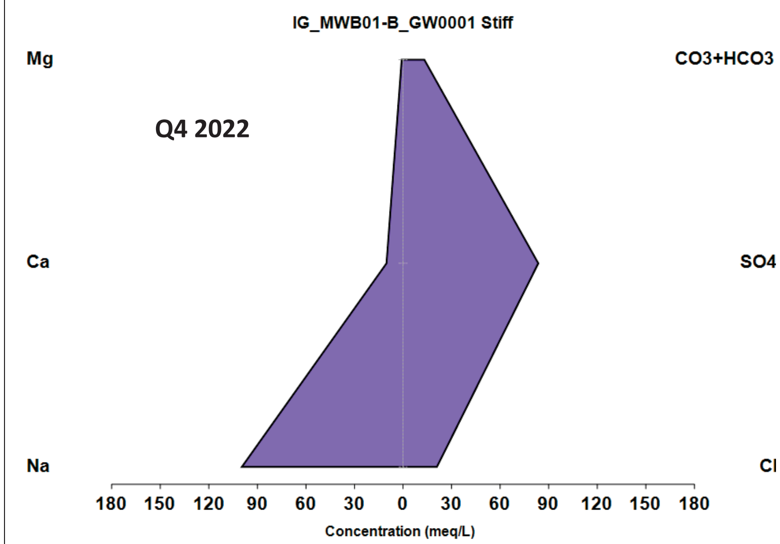


FIGURE B2-3: STIFF DIAGRAMS FOR WELLS IG_MWB01-A AND IG_MWB01-B

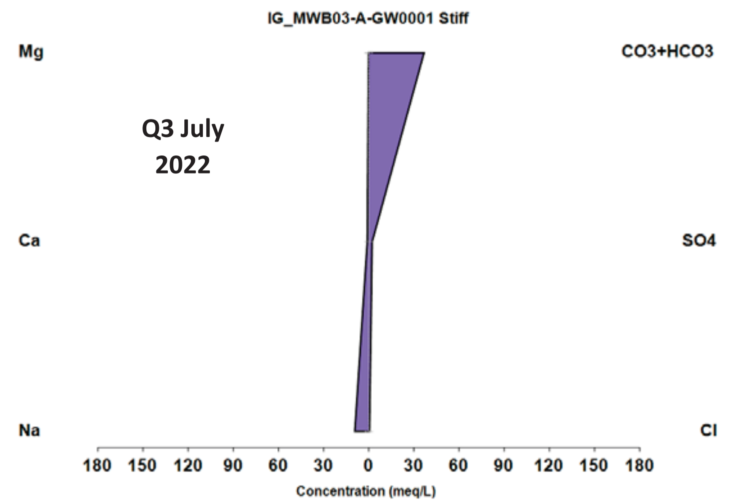


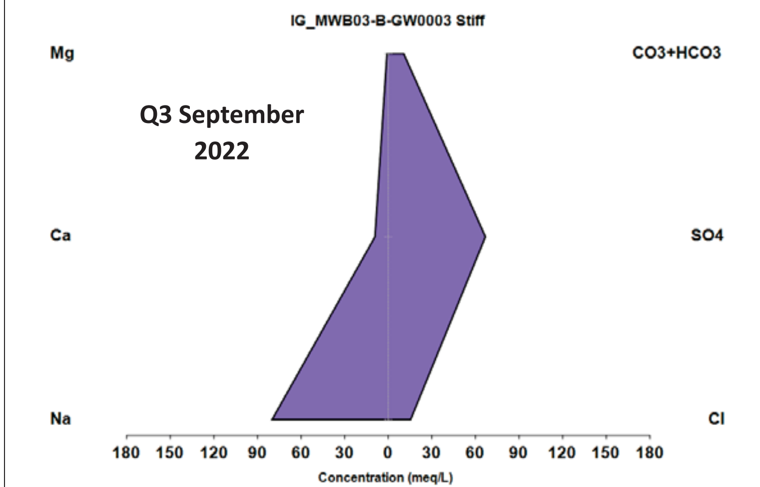


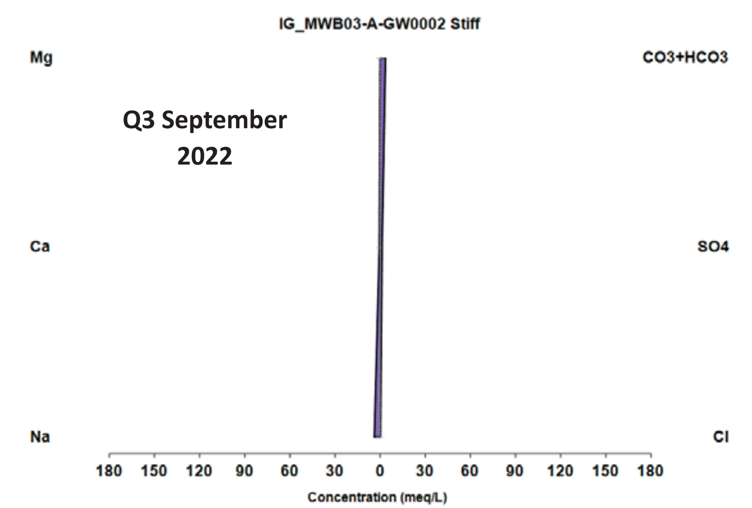
N/A

N/A

FIGURE B2-4: STIFF DIAGRAMS FOR WELLS IG_MWB03-A AND IG_MWB03-B

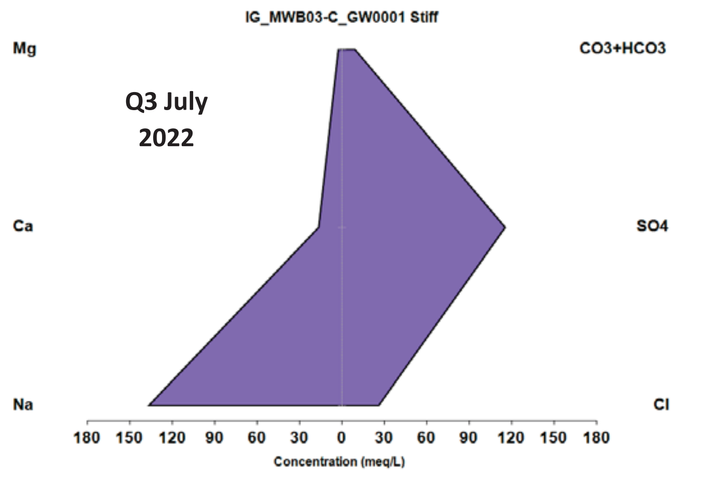


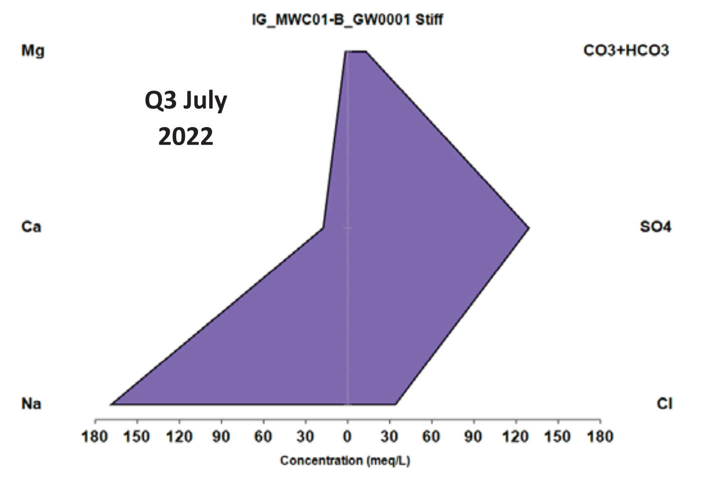


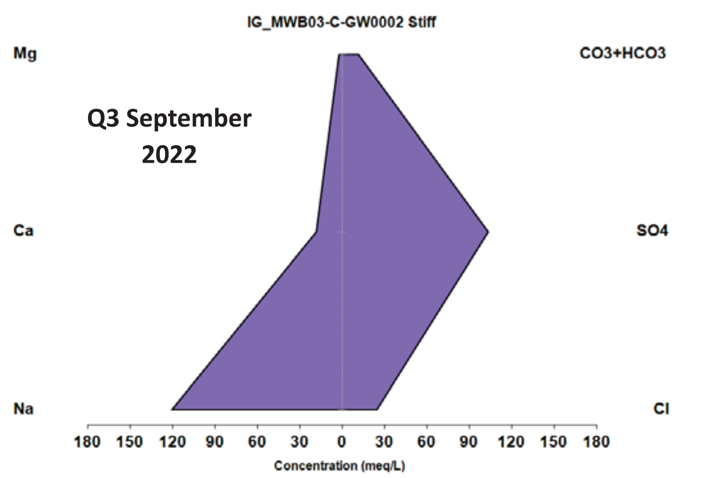


N / A

FIGURE B2-5: STIFF DIAGRAMS FOR WELLS IG_MWB03-C AND IG_MWC01-B







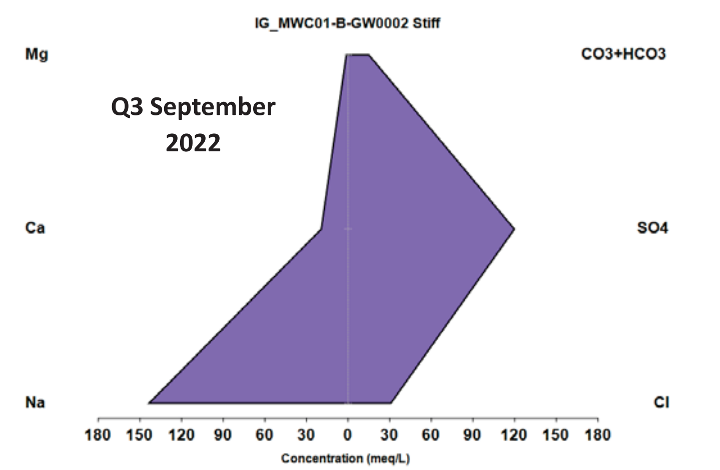
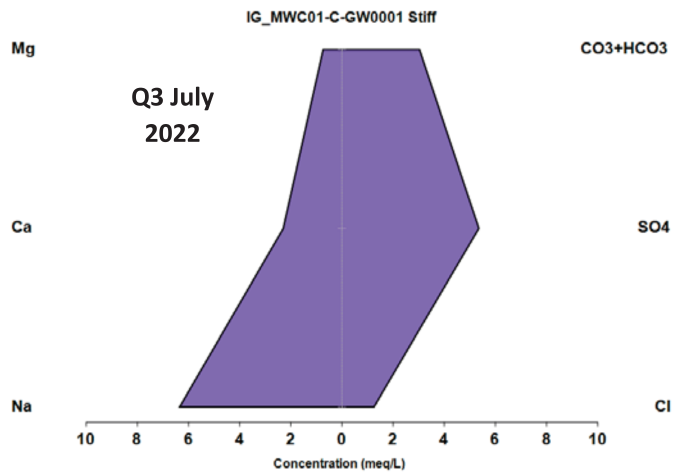
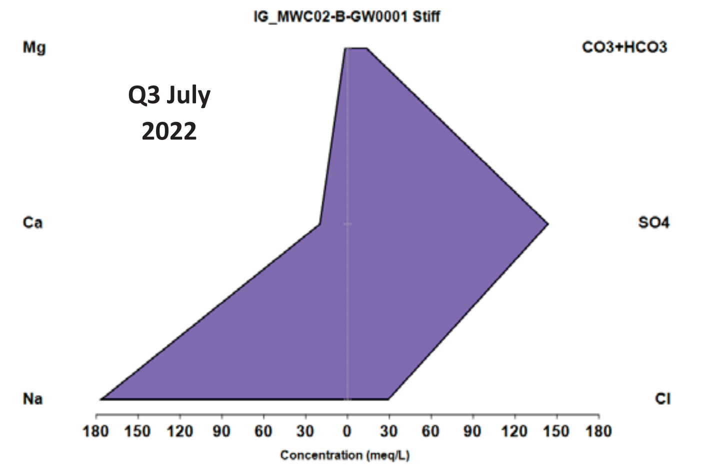


FIGURE B2-6: STIFF DIAGRAMS FOR WELLS IG_MWC01-C AND IG_MWC02-B





N/A

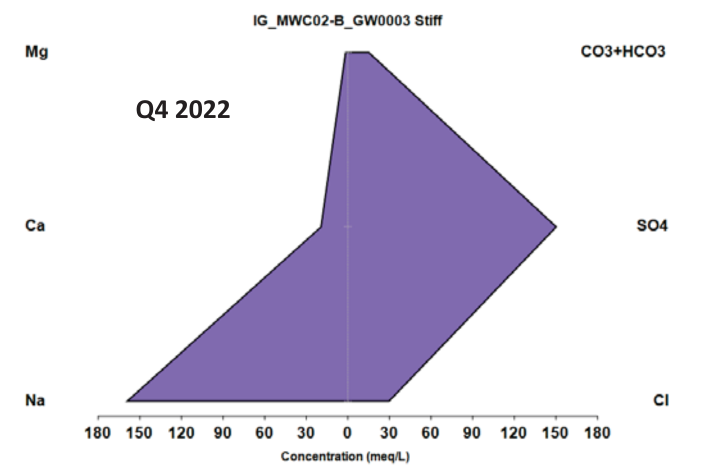


FIGURE B2-7: STIFF DIAGRAMS FOR WELLS IG_MWC02-C AND IG_MWC03-A

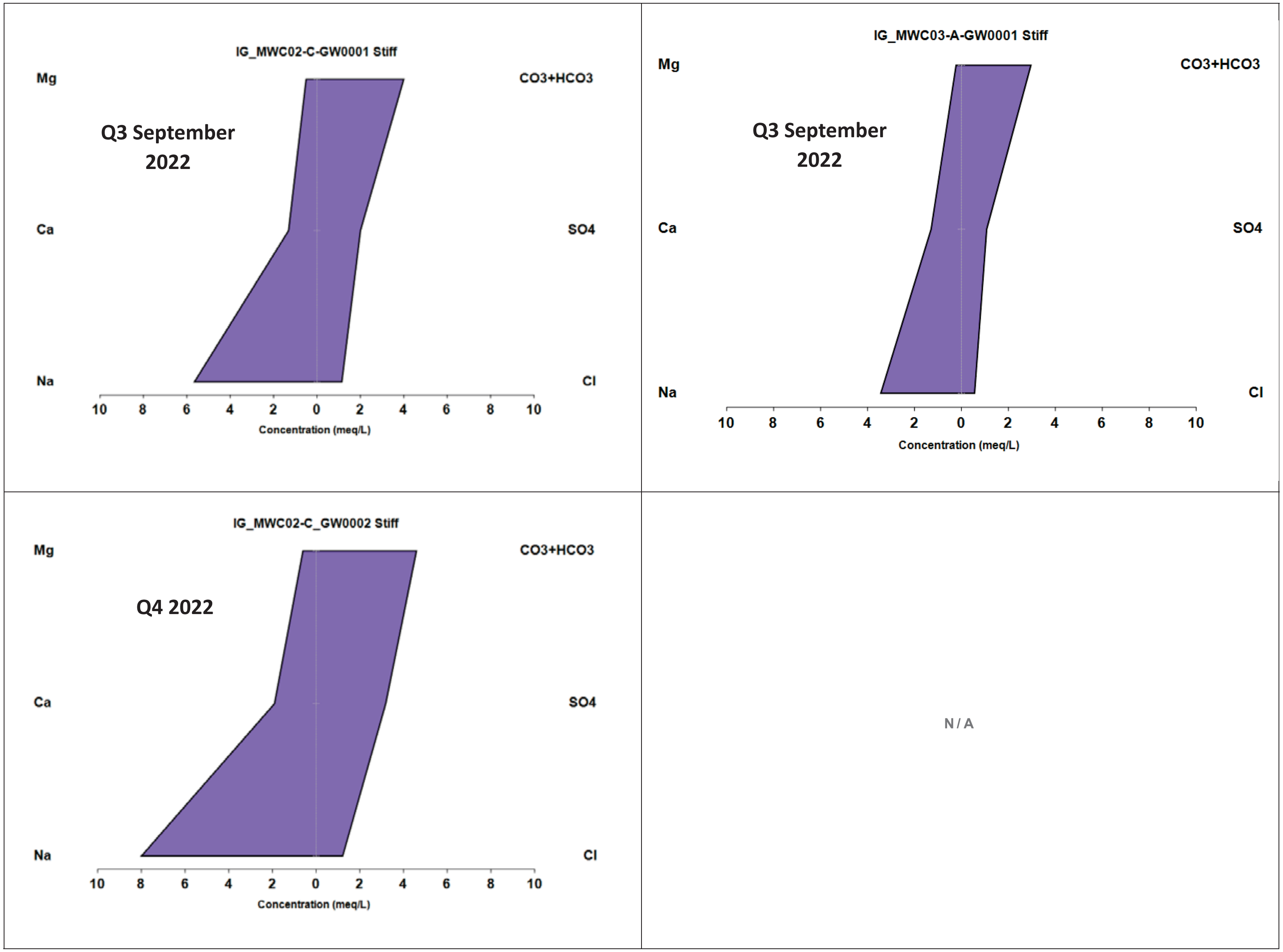
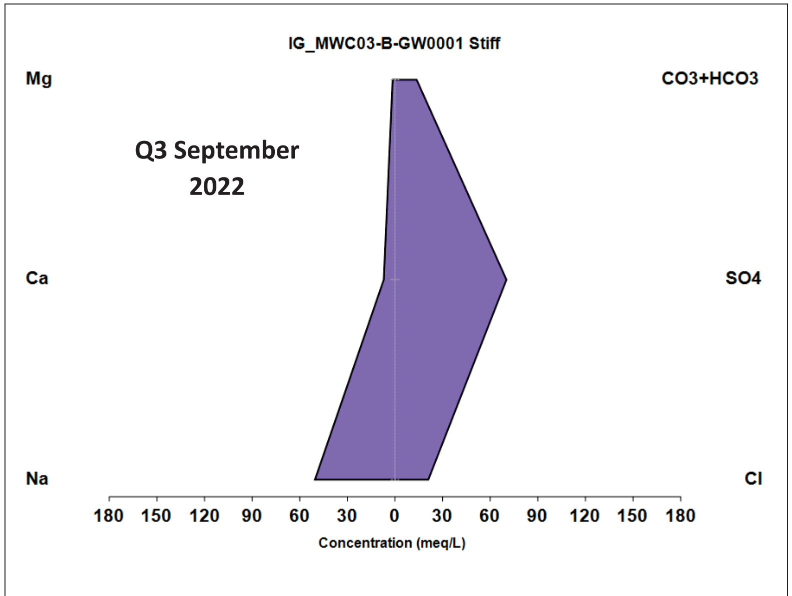


FIGURE B2-8: STIFF DIAGRAMS FOR WELL IG_MWC03-B



N/A

APPENDIX C1

2022 General Chemistry Summary of High Confidence Samples

Sample ID	Lab Tracking Number	Date & Time Sampled (dd/mm/yyyy hh:mm)	Comments	pH (Lab)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Hydroxide (OH)	Total Alkalinity (as $CaCO_3$)	Ammonia as N	Bromide	Chloride	Fluoride	Iodide	Nitrate (as NO_3)	Nitrite (as NO_2)	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen	Total Nitrogen
			Units:	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
			Detection Limit:	0.1	1.2	0.6	0.34	1	0.01	0.1	0.5	0.02	0.2	0.089	0.033	0.07	0.2	0.2
IG_MWA01_C_GW0001	L2742249-6	01-12-2022 12:27		6.83	25.5 (1)	<0.60 (1)	<0.34 (1)	20.9	0.035	<0.10	<0.50	0.090	<0.20	0.354	<0.033	0.080 (1)	<0.20	<0.20 (1)
IG_MWA03_B_GW0001	L2723923-3	18-07-2022 17:00		7.92	206 (1)	<0.60 (1)	<0.34 (1)	169	0.062	1.6	144	0.32	<0.20	<0.89 DLM	<0.33 DLM	<0.22 (1)	0.23	0.23 (1)
IG_MWA03_B_GW0002	L2735225-8	02-10-2022 11:15		8.15	138 (1)	<0.60 (1)	<0.34 (1)	113	<0.010	0.25	35.4	0.237	<0.20	0.359	<0.033	0.081 (1)	<0.20	<0.20 (1)
IG_MWB01_C_GW0001	L2742249-1	01-12-2022 09:45		7.04	44.3 (1)	<0.60 (1)	<0.34 (1)	36.3	<0.010	<0.10	0.61	0.047	<0.20	0.647	<0.033	0.146 (1)	<0.20	<0.20 (1)
IG_MWB03_B_GW0001	L2724030-6	20-07-2022 09:40		7.99	572 (1)	<0.60 (1)	<0.34 (1)	469	0.054	48	660	1.4	<0.20	12.404	<1.64 DLM	2.8 (1)	1.44	4.3 (1)
IG_MWC01_A_GW0001	L2723923-6	19-07-2022 17:30		7.71	251 (1)	<0.60 (1)	<0.34 (1)	206	0.121	13.9	156	0.42	<0.20	<1.77 DLM	<0.66 DLM	<0.45 (1)	0.44	<0.45 (1)
IG_MWC01_A_GW0002	L2723923-7	19-07-2022 17:30	Field Duplicate of IG_MWC01_A_GW0001	7.64	253 (1)	<0.60 (1)	<0.34 (1)	208	0.025	12.7	169	0.45	<0.20	<1.77 DLM	<0.66 DLM	<0.45 (1)	0.36	<0.45 (1)
IG_MWC01_A_GW0003	L2735225-1	30-09-2022 15:55		8.16	182 (1)	<0.60 (1)	<0.34 (1)	149	0.017	0.23	22.6	0.361	<0.20	0.164	<0.033	<0.070 (1)	<0.20	<0.20 (1)
IG_MWC01_C_GW0002	L2735225-2	30-09-2022 16:35		8.15	186 (1)	<0.60 (1)	<0.34 (1)	153	0.033	0.29	31.5	0.327	<0.20	0.363	<0.033	0.082 (1)	<0.20	<0.20 (1)
IG_MWC02_A_GW0001	L2734823-1	27-09-2022 17:15		8.25	139 (1)	<0.60 (1)	<0.34 (1)	114	<0.010	<0.10	3.10	0.508	<0.20	<0.089	<0.033	<0.070 (1)	<0.20	-
IG_MWC02_A_GW0002	L2742249-4	01-12-2022 16:30		8.27	138 (1)	<0.60 (1)	<0.34 (1)	113	<0.010	<0.10	2.82	0.513	<0.20	<0.089	<0.033	<0.070 (1)	<0.20	<0.20 (1)
IG_MWC03_C_GW0001	L2735102-4	29-09-2022 16:35		8.25	176 (1)	<0.60 (1)	<0.34 (1)	144	0.022	<0.10	9.16	0.447	<0.20	0.106	<0.033	<0.070 (1)	<0.20	<0.20 (1)

Sample ID	Orthophosphate (PO_4)	Total Phosphorus (P_{tot})	Total Reactive Phosphorus (TRP)	Sulphate (SO_4)	Dissolved Inorganic Carbon (DIC)	Reactive Silica	Aluminum (Al) diss.	Antimony (Sb) diss.	Arsenic (As) diss.	Barium (Ba) diss.	Beryllium (Be) diss.	Bismuth (Bi) diss.	Boron (B) diss.	Cadmium (Cd) diss.
Units:	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection Limit:	0.001	0.001	0.001	0.3	0.5	0.01	0.001	0.0001	0.0001	0.0001	0.0001	0.00005	0.01	0.000005
IG_MWA01_C_GW0001	0.0980 OPF	0.292	0.0994 OPF	2.98	4.72	11.9	0.0879	<0.00010	0.00018	0.00280	<0.00010	<0.000050	<0.010	0.0000172
IG_MWA03_B_GW0001	0.0045	0.0116	0.0022	938	26.5	13.2	0.0032	<0.00010	0.00277	0.0849	<0.00010	<0.000050	0.082	0.0000123
IG_MWA03_B_GW0002	<0.0010 OPF	0.0133	0.0025 OPF	228	24.4	13.6	0.0064	<0.00010	0.00104	0.0155	<0.00010	<0.000050	0.038	<0.0000050
IG_MWB01_C_GW0001	0.0077 OPF	0.0117	0.0070 OPF	6.89	9.24	13.2	0.0279	<0.00010	0.00023	0.0133	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWB03_B_GW0001	0.724 HTD	0.309 RRV	0.500 HTD	3,710	73.3	17.6	0.0044	<0.00010	0.00226	0.0373	<0.00010	<0.000050	0.151	0.0000065
IG_MWC01_A_GW0001	0.0011 OPF	0.0194	0.0046 OPF	1,150	39.3	12.3	0.0037	<0.00010	0.00042	0.0182	<0.00010	<0.000050	0.159	<0.0000050
IG_MWC01_A_GW0002	0.0141 OPF	0.0210 RRV	0.0770 OPF	1,260	39.0	12.3	0.0027	<0.00010	0.00038	0.0118	<0.00010	<0.000050	0.161	<0.0000050
IG_MWC01_A_GW0003	<0.0010 OPF	0.0104	<0.0010 OPF	186	27.4	13.7	0.0060	<0.00010	0.00022	0.00824	<0.00010	<0.000050	0.133	<0.0000050
IG_MWC01_C_GW0002	<0.0010 OPF	0.0260	<0.0010 OPF	186	26.3	18.6	0.0048	<0.00010	0.00065	0.0144	<0.00010	<0.000050	0.040	<0.0000050
IG_MWC02_A_GW0001	0.0070 HTP	0.0103	0.0080 HTD	10.7	19.9	12.8	0.0040	<0.00010	0.00026	0.0111	<0.00010	<0.000050	0.063	<0.0000050
IG_MWC02_A_GW0002	0.0075 OPF	0.0106	0.0069 OPF	10.6	22.6	12.7	0.0046	<0.00010	0.00025	0.0104	<0.00010	<0.000050	0.064	<0.0000050
IG_MWC03_C_GW0001	0.0023 OPF	0.0124	0.0036 OPF	16.8	27.0	15.2	0.0080	<0.00010	0.00023	0.0248	<0.00010	<0.000050	0.049	<0.0000050

Notes

(1) - Calculated by lab
PEHT - Parameter Exceeded Recommended Holding Time Prior to Analysis
PEHR - Parameter Exceeded Recommended Holding Time On Receipt: Proceed With Analysis As Requested
DLM - Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
DLA - Detection Limit Adjusted for required dilution
DLHC - Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
OPF - Orthophosphate test was conducted on frozen (preserved) sample. CCME hold time (72 hrs) was exceeded, but freezing can extend hold time to 30 days according to ISO 5667-3 (2012).
RRV - Reported Result Verified By Repeat Analysis
HTD - Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.
Nitrate is reported by lab as Nitrate (as N) in mg/L. "Nitrate as N" is converted to "Nitrate as NO3" using the expression: Nitrate-NO3 = (Nitrate-N)*4.43. Nitrate molecule weighs 62 g/mole; the nitrogen content of nitrate is 22.5% of the total weight of the molecule.
Nitrite is reported by lab as Nitrite (as N) in mg/L. "Nitrite as N" is converted to "Nitrite as NO2" using the expression: Nitrite-NO2 = (Nitrite-N)*3.28. Nitrite molecule weighs 46 g/mole; the nitrogen content of nitrite is 30.4% of the total weight of the molecule.

Calcium (Ca) diss.	Cesium (Cs) diss.	Chromium (Cr) diss.	Cobalt (Co) diss.	Copper (Cu) diss.	Iron (Fe) diss.	Lead (Pb) diss.	Lithium (Li) diss.	Magnesium (Mg) diss.	Manganese (Mn) diss.	Molybdenum (Mo) diss.	Nickel (Ni) diss.
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.05	0.00001	0.0001	0.0001	0.0002	0.01	0.00005	0.001	0.005	0.0001	0.00005	0.0005
3.21	<0.000010	0.00044	<0.00010	0.00366	0.027	<0.000050	0.0024	0.889	0.0134	0.000224	<0.00050
94.1	<0.000010	<0.00010	0.00247	0.00198	2.92	0.000054	0.0450	11.1	1.53	0.0123	0.00498
39.0	<0.000010	<0.00010	0.00024	0.00164	0.512	0.000068	0.0220	4.69	0.294	0.00239	0.00071
12.7	<0.000010	0.00019	0.00029	0.00267	0.059	<0.000050	0.0024	1.11	0.0927	0.000136	0.00097
179	0.000024	0.00024	0.00382	0.00025	3.55	0.000144	0.133	18.2	3.87	0.0331	0.00403
84.5	<0.000010	0.00011	0.00071	0.00106	2.96	0.000099	0.0461	6.53	0.849	0.00848	0.00068
88.5	<0.000010	0.00012	0.00071	<0.00020	3.12	0.000067	0.0481	6.84	0.883	0.00865	0.00070
26.2	<0.000010	<0.00010	0.00024	0.00170	0.960	0.000070	0.0240	2.44	0.190	0.00132	<0.00050
43.4	<0.000010	<0.00010	0.00043	0.00075	0.922	<0.000050	0.0209	7.92	0.411	0.000837	<0.00050
16.5	<0.000010	<0.00010	<0.00010	<0.00020	0.021	<0.000050	0.0242	3.68	0.110	0.00285	<0.00050
17.9	<0.000010	<0.00010	<0.00010	0.00140	0.093	<0.000050	0.0260	3.31	0.0944	0.00277	<0.00050
25.8	<0.000010	<0.00010	<0.00010	0.00228	0.225	0.000053	0.0280	7.05	0.285	0.00154	<0.00050

Phosphorus (P) diss.	Potassium (K) diss.	Rubidium (Rb) diss.	Ruthenium (Ru) diss.	Selenium (Se) diss.	Silicon (Si) diss.	Silver (Ag) diss.	Sodium (Na) diss.	Strontium (Sr) diss.	Sulfur (S) diss.	Tellurium (Te) diss.	Thallium (Tl) diss.
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.03	0.05	0.0002	0.001	0.00005	0.05	0.00001	0.05	0.0001	0.5	0.0002	0.00001
0.103	0.718	0.00071	-	0.000135	6.08	<0.000010	4.93	0.0262	1.06	<0.00020	<0.000010
<0.030	5.52	0.00398	<0.0010	0.000752	6.93	<0.000010	476	1.24	326	<0.00020	<0.000010
<0.030	2.56	0.00161	-	0.000559	6.34	<0.000010	132	0.389	81.5	<0.00020	<0.000010
<0.030	0.442	0.00046	-	0.000102	6.39	<0.000010	2.70	0.0539	2.29	0.00027	<0.000010
<0.030	16.2	0.00923	<0.0050	0.00140	11.0	<0.000010	2,010	2.85	1,170	<0.00020	<0.000010
<0.030	3.80	0.00152	<0.0010	0.000389	6.75	<0.000010	580	1.19	366	<0.00020	<0.000010
<0.030	3.97	0.00161	<0.0010	0.000225	6.77	<0.000010	565	1.23	358	<0.00020	<0.000010
<0.030	1.72	0.00077	-	<0.000050	6.17	<0.000010	127	0.306	67.8	<0.00020	<0.000010
<0.030	1.92	0.00056	-	0.000057	8.00	<0.000010	102	0.471	64.8	<0.00020	<0.000010
<0.030	1.49	0.00085	-	<0.000050	6.80	<0.000010	35.3	0.207	4.09	<0.00020	<0.000010
<0.030	1.16	0.00059	-	<0.000050	6.46	<0.000010	27.2	0.183	3.74	<0.00020	<0.000010
<0.030	1.83	0.00070	-	<0.000050	7.94	<0.000010	33.8	0.297	6.83	<0.00020	<0.000010

Thorium (Th) diss.	Tin (Sn) diss.	Titanium (Ti) diss.	Tungsten (W) diss.	Uranium (U) diss.	Vanadium (V) diss.	Zinc (Zn) diss.	Zirconium (Zr) diss.	Cations Total	Anions Total	Cation - Anion Balance
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mEq/L	mEq/L	%
0.0001	0.0001	0.0003	0.0001	0.00001	0.0005	0.001	0.0002	0.1	0.1	
<0.00010	<0.00010	0.00104	<0.00010	0.000252	<0.00050	0.0053	<0.00020	0.47 [1]	0.49 [1]	-
<0.00010	<0.00010	0.00076	<0.00010	0.0952	<0.00050	0.0018	0.00032	26.5 [1]	27.0 [1]	-1.0
<0.00010	<0.00010	<0.00030	<0.00010	0.0175	<0.00050	0.0026	<0.00020	8.14 [1]	8.03 [1]	0.7 [1]
<0.00010	<0.00010	<0.00030	<0.00010	0.000976	<0.00050	0.0025	<0.00020	0.85 [1]	0.90 [1]	-
<0.00010	<0.00010	0.00138	<0.00010	0.189	0.00158	<0.0010	0.00132	98.3 [1]	106 [1]	-3.5
<0.00010	<0.00010	0.00073	<0.00010	0.0562	0.00055	0.0028	0.00062	30.1 [1]	32.5 [1]	-3.8
<0.00010	<0.00010	0.00036	<0.00010	0.0563	0.00061	0.0012	0.00063	29.7 [1]	35.2 [1]	-8.5
<0.00010	0.00010	<0.00030	<0.00010	0.00684	<0.00050	0.0027	<0.00020	7.08 [1]	7.51 [1]	-3.0
<0.00010	0.00022	<0.00030	<0.00010	0.00633	<0.00050	0.0034	<0.00020	7.31 [1]	7.83 [1]	-3.5
<0.00010	<0.00010	<0.00030	0.00019	0.0189	<0.00050	<0.0010	<0.00020	2.70 [1]	2.61 [1]	1.6 [1]
<0.00010	<0.00010	<0.00030	0.00012	0.0194	<0.00050	0.0018	<0.00020	2.38 [1]	2.59 [1]	-4.2
<0.00010	<0.00010	<0.00030	<0.00010	0.0100	<0.00050	0.0028	<0.00020	3.39 [1]	3.52 [1]	-1.9

APPENDIX C2

2022 General Chemistry Summary of Low Confidence Samples

Sample ID	Lab Tracking Number	Date & Time Sampled (dd/mm/yyyy hh:mm)	Comments	pH (Lab)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Hydroxide (OH)	Total Alkalinity (as $CaCO_3$)	Ammonia as N	Bromide	Chloride	Fluoride	Iodide	Nitrate (as NO_3)	Nitrite (as NO_2)	Nitrate and Nitrite (as N)
			Units:	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
			Detection Limit:	0.1	1.2	0.6	0.34	1	0.01	0.1	0.5	0.02	0.2	0.089	0.033	0.07
IG_MWA01_A_GW0001	L2742622-1	06-12-2022 16:30		7.79	463 (1)	<0.60 (1)	<0.34 (1)	380	0.053	2.2	335	1.83	<0.20	5.360	<0.66 DLM	1.21 (1)
IG_MWA01_B_GW0001	L2742320-3	02-12-2022 13:00		-	-	-	-	-	0.059	-	-	-	<0.20	-	-	-
IG_MWA01_B_GW0001	L2742320-4	03-12-2022 15:30		7.85	746 (1)	<0.60 (1)	<0.34 (1)	612	-	6.3	584	0.74	-	11.252	<0.66 DLM	2.54 (1)
IG_MWA01_C_GW0002	L2742622-2		Trip Blank	5.54	<1.2 (1)	<0.60 (1)	<0.34 (1)	<1.0	<0.010	<0.10	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWA03_A_GW0001	L2724030-5	20-07-2022 08:45		8.03	599 (1)	<0.60 (1)	<0.34 (1)	491	0.060	67	916	1.5	<0.20	14.176	<1.64 DLM	3.2 (1)
IG_MWA03_A_GW0002	L2735577-4	03-10-2022 12:20		7.87	742 (1)	<0.60 (1)	<0.34 (1)	608	0.197	10.8	1,040	1.4	<0.20	15.505	<1.64 DLM	3.5 (1)
IG_MWA03_C_GW0001	L2723923-1	18-07-2022 15:30		8.17	447 (1)	<0.60 (1)	<0.34 (1)	366	0.024	<2.0 DLM	340	1.17	<0.20	<1.77 DLM	<0.66 DLM	<0.45 (1)
IG_MWA03_C_GW0002	L2723923-2	18-07-2022 16:00	Field Blank	5.49	<1.2 (1)	<0.60 (1)	<0.34 (1)	<1.0	0.079	1.15	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWA03_C_GW0003	L2735225-9	02-10-2022 15:14		-	-	-	-	-	0.014	-	-	-	-	-	-	-
IG_MWA03_C_GW0003	L2735225-10	02-10-2022 16:25		8.27	329 (1)	<0.60 (1)	<0.34 (1)	269	-	<2.0 DLM	142	0.82	<0.20	<1.77 DLM	<0.66 DLM	<0.45 (1)
IG_MWB01_A_GW0001	L2742320-2	03-12-2022 11:55		7.90	713 (1)	<0.60 (1)	<0.34 (1)	585	0.74	7.6	493	1.9	<0.20	11.518	<1.64 DLM	2.6 (1)
IG_MWB01_A_GW0002	L2741958-1	29-11-2022 15:30	Field Blank	5.51	<1.2 (1)	<0.60 (1)	<0.34 (1)	<1.0	<0.010	<0.10	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWB01_B_GW0001	L2742249-7	01-12-2022 17:15		8.27	801 (1)	<0.60 (1)	<0.34 (1)	657	-	5.0	741	1.7	<0.20	16.834	<1.64 DLM	3.8 (1)
IG_MWB01_B_GW0001	L2742320-1	02-12-2022 09:15		-	-	-	-	-	0.11	-	-	-	-	-	-	-
IG_MWB03_A_GW0001	L2723923-4	19-07-2022 13:30		8.32	2,240 (1)	1.56 (1)	<0.34 (1)	1,840	0.075	1.08	18.2	0.769	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWB03_A_GW0002	L2735102-5	29-09-2022 18:30		8.36	206 (1)	4.68 (1)	<0.34 (1)	177	0.196	0.11	8.62	0.892	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWB03_B_GW0002	L2724030-7	20-07-2022 09:40	Trip Blank	5.64	<1.2 (1)	<0.60 (1)	<0.34 (1)	<1.0	<0.010	<0.10	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWB03_B_GW0003	L2735225-5	01-10-2022 14:05		8.28	650 (1)	<0.60 (1)	<0.34 (1)	533	0.037	<5.0 DLM	544	<1.0 DLM	<0.20	9.746	<1.64 DLM	2.2 (1)
IG_MWB03_C_GW0001	L2724030-1	19-07-2022 13:10		-	-	-	-	-	-	-	-	-	<0.20	-	-	-
IG_MWB03_C_GW0001	L2724030-2	20-07-2022 10:15		7.92	558 (1)	<0.60 (1)	<0.34 (1)	458	0.055	11	922	1.7	-	17.277	<1.64 DLM	3.9 (1)
IG_MWB03_C_GW0002	L2735225-6	01-10-2022 14:15		-	-	-	-	-	0.034	-	-	-	<0.20	-	-	-
IG_MWB03_C_GW0002	L2735225-7	01-10-2022 18:35		8.27	696 (1)	<0.60 (1)	<0.34 (1)	570	-	5.6	871	1.3	-	15.505	<1.64 DLM	3.5 (1)
IG_MWC01_B_GW0001	L2724030-4	20-07-2022 12:25		8.00	786 (1)	<0.60 (1)	<0.34 (1)	644	0.186	53	1,200	1.3	<0.20	20.378	<1.64 DLM	4.6 (1)
IG_MWC01_B_GW0002	L2735225-4	01-10-2022 09:45		8.16	912 (1)	<0.60 (1)	<0.34 (1)	747	0.030	10.1	1,090	1.3	<0.20	18.606	<1.64 DLM	4.2 (1)
IG_MWC01_C_GW0001	L2723923-5	19-07-2022 16:30		7.80	184 (1)	<0.60 (1)	<0.34 (1)	151	0.063	1.45	44.3	0.329	<0.20	0.780	<0.066 DLM	0.176 (1)
IG_MWC02_B_GW0001	L2735102-1	28-09-2022 17:10		8.17	831 (1)	<0.60 (1)	<0.34 (1)	681	0.079	7.6	1,030	1.3	<0.20	<4.43 DLM	<1.64 DLM	<1.1 (1)
IG_MWC02_B_GW0002	L2735102-2	28-09-2022 17:10	Field Duplicate of IG_MWC02_B_GW0001	8.15	821 (1)	<0.60 (1)	<0.34 (1)	673	0.077	5.0	1,040	1.4	<0.20	4.430	<1.64 DLM	<1.1 (1)
IG_MWC02_B_GW0003	L2742249-3	01-12-2022 15:30		8.00	920 (1)	<0.60 (1)	<0.34 (1)	754	0.040	<5.0 DLM	1,050	1.5	<0.20	4.430	<1.64 DLM	<1.1 (1)
IG_MWC02_B_GW0004	L2742249-5	01-12-2022 15:30	Field Duplicate of IG_MWC02_B_GW0003	7.98	912 (1)	<0.60 (1)	<0.34 (1)	748	0.055	10.0	1,020	1.5	<0.20	4.430	<1.64 DLM	<1.1 (1)
IG_MWC02_C_GW0001	L2735102-3	28-09-2022 17:10		8.31	238 (1)	3.00 (1)	<0.34 (1)	200	0.075	0.17	40.6	0.787	<0.20	0.425	<0.033	0.096 (1)
IG_MWC02_C_GW0002	L2742249-2	01-12-2022 16:00		8.14	279 (1)	<0.60 (1)	<0.34 (1)	229	<0.010	0.35	43.0	0.720	<0.20	0.744	<0.033	0.168 (1)
IG_MWC03_A_GW0001	L2735225-3	30-09-2022 17:20		8.36	172 (1)	4.20 (1)	<0.34 (1)	148	0.016	0.12	19.8	0.958	<0.20	0.275	<0.033	<0.070 (1)
IG_MWC03_A_GW0002	L2735577-2	03-10-2022 14:45	Field Blank	5.59	2.7 (1)	<0.60 (1)	<0.34 (1)	2.2	0.035	<0.10	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWC03_A_GW0003	L2735577-3		Trip Blank	5.19	<1.2 (1)	<0.60 (1)	<0.34 (1)	<1.0	0.018	<0.10	<0.50	<0.020	<0.20	<0.089	<0.033	<0.070 (1)
IG_MWC03_B_GW0001	L2735577-1	04-10-2022 08:30		7.97	829 (1)	<0.60 (1)	<0.34 (1)	680	0.023	7.5	744	1.6	<0.20	16.834	<1.64 DLM	3.8 (1)

Sample ID	Total Kjeldahl Nitrogen	Total Nitrogen	Orthophosphate (PO_4)	Total Phosphorus (P_{tot})	Total Reactive Phosphorus (TRP)	Sulphate (SO_4)	Dissolved Inorganic Carbon (DIC)	Reactive Silica	Aluminum (Al) diss.	Antimony (Sb) diss.	Arsenic (As) diss.	Barium (Ba) diss.	Beryllium (Be) diss.	Bismuth (Bi) diss.	Boron (B) diss.	Cadmium (Cd) diss.
Units:	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection Limit:	0.2	0.2	0.001	0.001	0.001	0.3	0.5	0.01	0.001	0.0001	0.0001	0.0001	0.0001	0.00005	0.01	0.000005
IG_MWA01_A_GW0001	0.63	1.83 (1)	0.0046 OPF	0.0997	0.0099 OPF	1,230	75.0	-	0.0389	0.00015	0.00422	0.0547	<0.00010	<0.000050	0.137	0.0000053
IG_MWA01_B_GW0001	0.81	0.81 (1)	0.0962 RRV	0.0649	0.129 RRV	-	109	-	0.0037	0.00018	0.00712	0.0316	<0.00010	<0.000050	0.176	<0.0000050
IG_MWA01_B_GW0001	-	-	-	-	-	2,390	-	16.2	-	-	-	-	-	-	-	-
IG_MWA01_C_GW0002	<0.20	<0.20 (1)	<0.0010 OPF	<0.0010	<0.0010 OPF	<0.30	<0.50	-	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWA03_A_GW0001	1.27	4.4 (1)	0.872 HTD	0.0663 RRV	0.686 HTD	5,900	<0.50	14.5	0.0662	0.00024	0.00154	0.0372	<0.00010	<0.000050	0.222	0.0000092
IG_MWA03_A_GW0002	1.46	5.0 (1)	0.426 OPF	0.0657	0.482 OPF	6,830	104	15.2	0.0020	0.00030	0.00137	0.0268	<0.00010	<0.000050	0.439	0.0000091
IG_MWA03_C_GW0001	0.53	0.53 (1)	0.0113 OPF	0.0845	0.0973	2,870	55.9	18.1	0.0029	<0.00010	0.00383	0.0575	<0.00010	<0.000050	0.273	<0.0000050
IG_MWA03_C_GW0002	<0.20	<0.20 (1)	<0.0010	<0.0010	<0.0010 OPF	<0.30	3.39	0.059	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWA03_C_GW0003	<0.20	<0.20 (1)	0.0249 OPF	0.113	0.0314 HTD	-	46.3	-	0.0065	<0.00010	0.00560	0.0267	<0.00010	<0.000050	0.123	<0.0000050
IG_MWA03_C_GW0003	-	-	-	-	-	1,140	-	19.8	-	-	-	-	-	-	-	-
IG_MWB01_A_GW0001	<2.0 DLM	2.6 (1)	0.135 RRV	0.111	0.117 RRV	3,150	112	15.8	0.0045	<0.00010	0.00260	0.0225	<0.00010	<0.000050	0.275	0.0000079
IG_MWB01_A_GW0002	<0.20	<0.20 (1)	<0.0010	0.0014	<0.0010 HTD	<0.30	<0.50	<0.010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWB01_B_GW0001	-	-	-	-	-	4,010	-	17.0	-	-	-	-	-	-	-	-
IG_MWB01_B_GW0001	<2.0 DLM	<2.0 (1)	0.542 RRV	0.527 RRV	0.571 RRV	-	118	-	0.0231	0.00017	0.00361	0.0181	<0.00010	<0.000050	0.353	0.0000291
IG_MWB03_A_GW0001	0.35	0.35 (1)	0.0101	1.93	<0.10 DLM	107	14.5	14.0	0.0030	<0.00010	0.00052	0.0290	<0.00010	<0.000050	0.087	0.0000100
IG_MWB03_A_GW0002	<0.20	<0.20 (1)	0.0154 HTD	0.437	<0.010 RRV	61.1	31.9	13.5	0.0239	<0.00010	0.00046	0.0170	<0.00010	<0.000050	0.076	0.0000083
IG_MWB03_B_GW0002	<0.20	<0.20 (1)	<0.0010 OPF	0.0016	<0.0010 OPF	<0.30	<0.50	0.020	0.0021	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWB03_B_GW0003	1.21	3.4 (1)	0.440 RRV	0.201	0.386 RRV	3,210	79.1	19.8	0.0073	<0.00010	0.00613	0.0295	<0.00010	<0.000050	0.222	0.0000068
IG_MWB03_C_GW0001	-	-	-	-	-	-	71.2	-	-	-	-	-	-	-	-	-
IG_MWB03_C_GW0001	1.65	5.6 (1)	0.720 HTD	0.146 RRV	0.696 HTD	5,540	-	16.9	0.0046	0.00012	0.00643	0.0400	<0.00010	<0.000050	0.204	<0.0000050
IG_MWB03_C_GW0002	1.69	1.69 (1)	0.428 OPF	0.268	0.371 OPF	-	91.5	-	0.0030	0.00011	0.00859	0.0305	<0.00010	<0.000050	0.284	<0.0000050
IG_MWB03_C_GW0002	-	-	-	-	-	4,960	-	20.2	-	-	-	-	-	-	-	-
IG_MWC01_B_GW0001	1.78	6.4 (1)	0.251 OPF	0.0708 RRV	0.341 OPF	6,200	107	16.3	0.0024	0.00019	0.00500	0.0423	<0.00010	<0.000050	0.256	<0.0000050
IG_MWC01_B_GW0002	1.52	5.7 (1)	0.751 RRV	0.0912	0.526 RRV	5,750	136	17.1	<0.0010	0.00018	0.0112	0.0278	<0.00010	<0.000050	0.365	0.0000061
IG_MWC01_C_GW0001	<0.20	<0.20 (1)	<0.0010 OPF	0.0606	<0.0010 OPF	257	32.0	18.9	0.0027	<0.00010	0.00078	0.0224	<0.00010	<0.000050	0.052	0.0000052
IG_MWC02_B_GW0001	1.09	<1.1 (1)	0.707 RRV	0.0932	0.694 RRV	6,890	109	16.4	0.0126	0.00035	0.00264	0.0444	0.00013	<0.000050	0.490	0.0000080
IG_MWC02_B_GW0002	0.98	<1.1 (1)	0.744 RRV	0.0940	0.750 RRV	6,960	106	17.1	0.0126	0.00030	0.00248	0.0433	0.00011	<0.000050	0.375	0.0000086
IG_MWC02_B_GW0003	1.84	1.8 (1)	0.632 OPF	0.0777 RRV	0.709 OPF	7,210	0.70	18.5	0.0043	0.00037	0.00301	0.0348	<0.00010	<0.000050	0.614	0.0000083
IG_MWC02_B_GW0004	1.71	1.7 (1)	0.819 OPF	0.0818 RRV	0.803 OPF	7,100	<0.50	18.6	0.0059	0.00033	0.00291	0.0357	<0.00010	<0.000050	0.619	0.0000108
IG_MWC02_C_GW0001	<0.20	<0.20 (1)	0.0111 OPF	0.149	0.0107 OPF	96.2	39.2	19.8	0.0083	<0.00010	0.00214	0.0521	<0.00010	<0.000050	0.056	0.0000169
IG_MWC02_C_GW0002	<0.20	<0.20 (1)	<0.0010 OPF	0.0794	0.0046 OPF	153	49.4	21.7	0.0019	<0.00010	0.00237	0.0728	<0.00010	<0.000050	0.066	<0.0000050
IG_MWC03_A_GW0001	<0.20	<0.20 (1)	0.0045 OPF	0.0143	0.0052 OPF	51.6	29.5	12.8	0.0113	<0.00010	0.00031	0.0294	<0.00010	<0.000050	0.105	<0.0000050
IG_MWC03_A_GW0002	<0.20	<0.20 (1)	<0.0010 HTD	<0.0010	<0.0010	<0.30	0.71	<0.010	0.0054	<0.00010	<0.00010	0.00122	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWC03_A_GW0003	<0.20	<0.20 (1)	<0.0010 OPF	<0.0010	<0.0010 OPF	<0.30	0.70	<0.010	0.0037	<0.00010	<0.00010	0.00053	<0.00010	<0.000050	<0.010	<0.0000050
IG_MWC03_B_GW0001	1.10	4.9 (1)	0.317 OPF	0.102	0.389 OPF	3,370	117	20.0	0.0110	0.00010	0.00403	0.0527	<0.00010	<0.000050	0.192	<0.0000050

Notes

(1) - Calculated by lab
PEHT - Parameter Exceeded Recommended Holding Time Prior to Analysis
PEHR - Parameter Exceeded Recommended Holding Time On Receipt: Proceed With Analysis As Requested
DLM - Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
DLA - Detection Limit Adjusted for required dilution
DLHC - Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
OPF - Orthophosphate test was conducted on frozen (preserved) sample. CCME hold time (72 hrs) was exceeded, but freezing can extend hold time to 30 days according to ISO 5667-3 (2012).
RRV - Reported Result Verified By Repeat Analysis
HTD - Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.
Nitrate is reported by lab as Nitrate (as N) in mg/L. "Nitrate as N" is converted to "Nitrate as NO3" using the expression: Nitrate-NO3 = (Nitrate-N)*4.43. Nitrate molecule weighs 62 g/mole; the nitrogen content of nitrate is 22.5% of the total weight of the molecule.
Nitrite is reported by lab as Nitrite (as N) in mg/L. "Nitrite as N" is converted to "Nitrite as NO2" using the expression: Nitrite-NO2 = (Nitrate-N)*3.28. Nitrite molecule weighs 46 g/mole; the nitrogen content of nitrite is 30.4% of the total weight of the molecule.

KGS GROUP

Calcium (Ca) diss.	Cesium (Cs) diss.	Chromium (Cr) diss.	Cobalt (Co) diss.	Copper (Cu) diss.	Iron (Fe) diss.	Lead (Pb) diss.	Lithium (Li) diss.	Magnesium (Mg) diss.	Manganese (Mn) diss.	Molybdenum (Mo) diss.	Nickel (Ni) diss.	Phosphorus (P) diss.	Potassium (K) diss.	Rubidium (Rb) diss.	Ruthenium (Ru) diss.	Selenium (Se) diss.	Silicon (Si) diss.	Silver (Ag) diss.	Sodium (Na) diss.	Strontium (Sr) diss.	Sulfur (S) diss.	Tellurium (Te) diss.	Thallium (Tl) diss.	Thorium (Th) diss.	Tin (Sn) diss.	Titanium (Ti) diss.	Tungsten (W) diss.	Uranium (U) diss.	Vanadium (V) diss.	Zinc (Zn) diss.	Zirconium (Zr) diss.	Cations Total	Anions Total	Cation - Anion Balance
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mEq/L	mEq/L	%
0.05	0.00001	0.0001	0.0001	0.0002	0.01	0.00005	0.001	0.005	0.0001	0.00005	0.0005	0.03	0.05	0.0002	0.001	0.00005	0.05	0.00001	0.05	0.0001	0.5	0.0002	0.00001	0.0001	0.0001	0.0003	0.0001	0.00001	0.0005	0.001	0.0002	0.1	0.1	
106	0.000017	0.00026	0.00160	0.00125	1.63	0.00262	0.0983	23.4	6.51	0.0170	0.00416	0.035	7.12	0.00314	-	0.000980	9.98	<0.000010	926	1.47	494	<0.00020	<0.000010	<0.00010	<0.00010	0.00115	<0.00010	0.0314	<0.00050	0.0029	0.00051	47.7 [1]	42.8 [1]	5.4 [1]
220	0.000016	0.00025	0.00078	0.00130	5.62	0.000083	0.135	46.1	1.44	0.00763	0.00154	0.076	9.30	0.00347	-	0.00100	9.39	<0.000010	1,520	2.96	839	<0.00020	<0.000010	<0.00010	<0.00010	0.00147	<0.00010	0.118	0.00138	0.0029	0.00319	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<0.050	<0.000010	<0.00010	<0.00010	<0.00020	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	<0.000050	<0.00050	<0.030	<0.050	<0.00020	-	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	<0.00010	<0.000010	<0.00050	<0.0010	<0.00020	<0.10 [1]	<0.10 [1]	-
296	<0.000010	0.00066	0.00343	0.00167	5.54	0.000197	0.150	19.6	5.75	0.0543	0.00918	<0.030	18.8	0.00755	<0.010	0.00154	8.53	<0.000010	3,100	4.34	1,910	<0.00020	<0.000010	<0.00010	<0.00010	0.00255	<0.00010	0.323	0.00122	0.0056	0.00122	152 [1]	159 [1]	-2.3
372	0.000025	0.00028	0.00290	0.00404	1.72	0.000196	0.264	18.4	5.64	0.0508	0.00450	<0.030	16.0	0.00745	-	0.00117	9.01	<0.000010	3,250	4.73	2,000	<0.00020	<0.000010	0.00013	<0.00010	0.00260	<0.00010	0.415	0.00080	0.0041	0.00132	162 [1]	184 [1]	-6.4
186	<0.000010	0.00021	0.00134	0.00025	2.41	0.000082	0.105	13.4	2.54	0.0472	0.00284	0.061	11.2	0.00609	<0.0010	0.000288	11.2	<0.000010	1,580	2.55	1,010	<0.00020	<0.000010	<0.00010	<0.00010	0.00056	<0.00010	0.392	0.00114	<0.0010	0.00076	79.4 [1]	76.7 [1]	1.7 [1]
<0.050	<0.000010	<0.00010	<0.00010	<0.00020	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	<0.000050	<0.00050	<0.030	<0.050	<0.00020	<0.0010	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	<0.00010	<0.000010	<0.00050	<0.0010	<0.00020	<0.10 [1]	<0.10 [1]	-
65.5	<0.000010	0.00015	0.00028	0.00118	0.390	<0.000050	0.0516	8.50	1.95	0.0129	0.00096	0.053	5.80	0.00336	-	0.000203	10.5	<0.000010	552	0.879	380	<0.00020	<0.000010	<0.00010	<0.00010	0.00035	0.00014	0.0207	<0.00050	0.0020	0.00026	-	-	-
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168	<0.000010	0.00030	0.00146	0.00142	0.736	0.000088	0.134	10.3	5.55	0.0267	0.00352	<0.030	14.9	0.0108	-	0.00118	7.89	<0.000010	1,600	2.75	946	<0.00020	<0.000010	<0.00010	<0.00010	0.00120	<0.00010	0.0673	0.00094	0.0033	0.00202	79.3 [1]	91.5 [1]	-7.1
<0.050	<0.000010	<0.00010	<0.00010	0.00092	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	<0.000050	<0.00050	<0.030	<0.050	<0.00020	-	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	<0.00010	<0.000010	<0.00050	<0.0010	<0.00020	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
205	0.000025	0.00031	0.00207	0.00430	0.020	0.000437	0.163	10.2	1.17	0.0776	0.0122	<0.030	15.8	0.00544	-	0.00151	8.97	<0.000010	2,290	4.27	1,320	<0.00020	0.000047	<0.00010	<0.00010	0.00170	<0.00010	0.506	0.00330	0.0029	0.00094	-	-	-
20.1	0.000017	<0.00010	0.00013	0.00136	<0.010	0.000061	0.0426	1.83	0.146	0.0169	0.00054	<0.030	3.26	0.00161	<0.0010	0.000272	7.32	<0.000010	214	0.724	98.4	<0.00020	<0.000010	<0.00010	<0.00010	0.00035	0.00022	0.0489	0.00068	0.0014	<0.00020	10.6 [1]	39.5 [1]	-57.9
12.0	<0.000010	<0.00010	<0.00010	0.00085	0.014	<0.000050	0.0356	1.35	0.118	0.00749	<0.00050	<0.030	1.83	0.00077	-	<0.000050	7.10	<0.000010	90.0	0.432	19.6	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	0.00024	0.0207	<0.00050	0.0014	<0.00020	4.69 [1]	5.09 [1]	-4.2
<0.050	<0.000010	<0.00010	<0.00010	<0.00020	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	<0.000050	<0.00050	<0.030	<0.050	<0.00020	<0.0010	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	<0.00010	<0.000010	<0.00050	<0.0010	<0.00020	-	-	-
184	0.000017	0.00041	0.00312	0.00255	6.63	0.000129	0.161	11.2	1.92	0.0217	0.00385	0.122	11.9	0.00797	-	0.00102	11.5	<0.000010	1,840	2.79	1,140	<0.00020	<0.000010	<0.00010	0.00012	0.00122	<0.00010	0.189	0.00220	0.0031	0.00196	90.4 [1]	93.0 [1]	-1.4
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330	0.000013	0.00066	0.00294	0.00051	10.8	0.000092	0.205	31.4	5.39	0.0374	0.00418	0.196	24.1	0.0140	<0.010	0.00183	13.0	<0.000010	3,140	4.44	1,940	0.00026	<0.000010	<0.00010	<0.00010	0.00221	0.00016	0.141	0.00520	0.0034	0.00306	156 [1]	151 [1]	1.8 [1]
367	0.000013	0.00102	0.00151	0.00133	9.16	0.000070	0.225	27.7	4.61	0.00634	0.00251	0.237	19.0	0.0117	-	0.00158	13.2	0.000012	2,770	4.63	1,880	<0.00020	<0.000010	0.00011	<0.00010	0.00247	0.00016	0.119	0.00493	0.0019	0.00417	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
351	<0.000010	0.00038	0.00572	0.00267	2.61	0.000062	0.166	20.7	3.80	0.0500	0.00485	<0.030	23.0	0.00612	<0.010	0.00233	11.1	<0.000010	3,880	7.12	2,310	0.00022	<0.000010	<0.00010	<0.00010	0.00131	<0.00010	0.497	0.00088	0.0050	0.00276	-	-	-
388	0.000011	0.00041	0.00302	0.00074	1.34	0.000051	0.193	15.8	3.45	0.0128	0.00319	<0.030	15.8	0.00501	-	0.00152	10.3	0.000014	3,300	6.66	2,070	0.00034	<0.000010	0.00022	<0.00010	0.00118	<0.00010	0.260	0.00066	0.0059	0.00373	-	-	-
46.0	<0.000010	<0.00010	0.00065	<0.00020	2.12	<0.000050	0.0204	8.96	0.710	0.00102	0.00055	<0.030	2.31	0.00066	<0.0010	0.000247	9.19	<0.000010	146	0.520	87.9	<0.00020	<0.000010	<0.00010	<0.00010	0.00047	<0.00010	0.00430	<0.00050	0.0011	<0.00020	9.45 [1]	9.65 [1]	-1.0
398	0.000019	0.00160	0.00439	0.00187	5.90	0.000243	0.167	22.0	4.66	0.0501	0.00949	0.111	18.2	0.0122	-	0.00141	12.4	0.000013	4,060	7.18	2,730	0.00032	<0.000010	0.00016	<0.00010	0.00637	<0.00010	1.17	0.00563	0.0026	0.00429	-	-	-
404	0.000020	0.00159	0.00425	0.00140	5.75	0.000235	0.166	22.1	4.63	0.0508	0.00941	0.105	18.4	0.0119	-	0.00138	13.2	0.000013	3,850	7.33	2,570	<0.00020	<0.000010	0.00012	<0.00010	0.00630	<0.00010	1.15	0.00562	0.0011	0.00464	-	-	-
388	0.000018	0.00101	0.00259	0.00117	0.374	<0.000050	0.264	20.5	4.23	0.0322	0.00548	<0.030 RRV	18.9	0.0108	-	0.00161	11.5	0.000014	3,660	6.48	2,370	0.00026	<0.000010	<0.00010	<0.00010	0.00557	<0.00010	1.14	0.00159	0.0049	0.00491	-	-	-
398	0.000017	0.00109	0.00262	0.00138	1.07	0.000056	0.263	20.2	4.23	0.0336	0.00551	<0.030 RRV	18.6	0.0111	-	0.00168	12.0	0.000014	3,690	6.40	2,300	<0.00020	<0.000010	<0.00010	<0.00010	0.00546	<0.00010	1.17	0.00153	0.0055	0.00499	-	-	-
26.3	<0.000010	<0.00010	0.00045	0.00123	1.02	<0.000050	0.0202	6.10	1.80	0.00673	0.00280	0.058	2.86	0.00109	-	<0.000050	11.3	<0.000010	130	0.291	42.1	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	0.00012	0.00610	<0.00050	0.0014	<0.00020	7.55 [1]	7.20 [1]	2.4 [1]
38.2	<0.000010	0.00015	0.00053	0.00276	0.275	0.000061	0.0249	7.36	2.22	0.00658	0.00535	<0.030	3.09	0.00127	-	0.000118	11.1	<0.000010	184	0.330	72.4	<0.00020	<0.000010	<0.00010	0.00013	<0.00030	0.00011	0.00663	<0.00050	0.0045	<0.00020	10.6 [1]	9.02 [1]	8.0 [1]
25.9	<0.000010	<0.00010	0.00016	0.00339	0.023	0.000094	0.0183	2.78	0.426	0.00361	0.00172	<0.030	1.41	0.00078	-	0.000119	5.41	<0.000010	79.0	0.349	24.0	0.00031	<0.000010	<0.00010	0.00021	<0.00030	0.00012	0.0139	<0.00050	0.0049	<0.00020	4.99 [1]	4.65 [1]	3.6 [1]
<0.050	<0.000010	<0.00010	<0.00010	0.00859	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	0.000089	<0.00050	<0.030	<0.050	<0.00020	-	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	0.00013	<0.00030	<0.00010	<0.000010	<0.00050	0.0014	<0.00020	<0.10 [1]	<0.10 [1]	-
<0.050	<0.000010	<0.00010	<0.00010	<0.00020	<0.010	<0.000050	<0.0010	<0.0050	<0.00010	<0.000050	<0.00050	<0.030	<0.050	<0.00020	-	<0.000050	<0.050	<0.000010	<0.050	<0.00010	<0.50	<0.00020	<0.000010	<0.00010	<0.00010	<0.00030	<0.00010	<0.000010	<0.00050	<0.0010	<0.00020	-	-	-
142	<0.000010	0.00046	0.00053	0.00367	0.065	0.000183	0.127	18.3	4.09	0.0142	0.00329	0.037	8.24	0.00242	-	0.000936	10.4	<0.000010	1,160	2.17	627	<0.00020	<0.000010	<0.00010	0.00015	0.00158	0.00013	0.0278	0.00156	0.0062	0.00216	59.3 [1]	105 [1]	-27.8

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