PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, SOUTH BRUCE

WP13 Technical Report: Ongoing Monitoring of Monitoring Wells SB_MW01-01, SB_MW01-02 and MECP1401064 During Drilling of SB_BH01 and SB_BH02

APM-REP-01332-0295 **April 2023**

Geofirma Engineering

nwmo
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Phase 2 Initial Borehole Drilling and Testing, South Bruce

WP13 Technical Report: Ongoing Monitoring of Monitoring Wells SB_MW01-01, SB_MW01-02 and MECP1401064 During Drilling of SB_BH01 and SB_BH02

Revision: 2

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Revision Tracking Table

Revision	Revision Release Date	Description of Modifications/Edits
R0A	October 14, 2022	Initial draft release to NWMO for Review
R0	February 13, 2023	Final release after disposition of NWMO Comments
R1	April 12, 2023	Second release after disposition of additional NWMO Comments
R2	April 20, 2023	Third release with references to planning documents removed

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1 INTRODUCTION

1.1 Background

The Initial Borehole Drilling and Testing project in South Bruce, Ontario is part of the Phase 2 Geoscientific Preliminary Field Investigations for the NWMO's Adaptive Phased Management (APM) Site Selection Phase. Two deep bedrock boreholes, SB_BH01 and SB_BH02, were drilled and tested near Teeswater, Ontario, by Geofirma Engineering Ltd. (Geofirma) as part of the NWMO's Initial Borehole Drilling Project. SB_BH01 and SB_BH01 were drilled to a total target depth of approximately 900 m below ground surface (m BGS), through the entire sedimentary bedrock sequence to the Precambrian basement.

Geofirma conducted a monitoring program at three monitoring wells near the SB_BH01 and SB_BH02 drill sites to monitor for impacts on groundwater water level and chemistry during the Initial Borehole Drilling project.

The monitoring well near SB_BH01 (MECP 1401064) was a domestic water well located at 1021 Concession Road 8, Teeswater, Ontario, approximately 200 m north of the SB_BH01 drill site. The MECP 1401064 well is 41.8 m deep and was completed in the shallow bedrock (Lucas Formation).

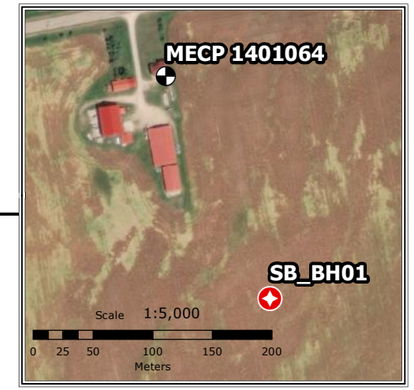
The monitoring wells for SB_BH02 drilling were the SB_MW01 cluster, located approximately 85 m from SB_BH02. The SB_MW01 cluster consists of two monitoring wells: SB_MW01-01 and SB_MW01-02. SB_MW01-01 is 12.8 m deep and is screened across the water table in the unconsolidated overburden. SB_MW01-02 is 38.2 m deep and is completed as an open hole in the shallow bedrock (Lucas Formation). A separate report was prepared by Geofirma that provides details on the drilling, installation, and development of the SB_MW01 well cluster (Geofirma 2022).

1.2 Purpose and Objectives

The primary objective of the monitoring well monitoring program was to obtain high-quality data that was representative of the shallow groundwater conditions near the SB_BH01 and SB_BH02 boreholes. These data were used to monitor for impact on groundwater levels and quality during drilling of SB_BH01 and SB_BH02.

LEGEND

- Wetlands
- Drill Sites
- Water Supply Wells



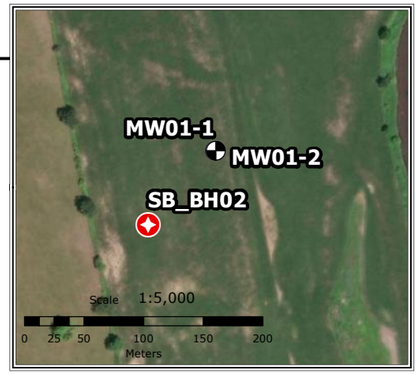


Figure 1
Locations of SB_BH01, SB_BH02, and the Monitoring Wells

Scale 1:25,000
0 100 200 400 600 800 1,000
Meters

N

Projection: NAD 1983 UTM Zone 17N

Source: Ontario GeoBase, MECP

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster

PROJECT No. 20-211

NWMO South Bruce
SB Monitoring Well Report

DESIGN: ADG
CAD/GIS: ADG
CHECK: CAM

DATE: 2023-04-12

GEOFIRMA ENGINEERING

E:\Data\Project\Bruce\Maps\20-211-1_SouthBruce\MNRFDrillingProgram\20-211_SB_MonitoringWellReport_Figure1.mxd

2 DESCRIPTION OF ACTIVITIES

2.1 Instrumentation for Monitoring Activities

2.1.1 Monitoring Well MECP 1401064

A Solinst Levelogger was installed in MECP 1401064 on April 18, 2021, roughly three weeks before the start of drilling activities at borehole SB_BH01. The Levelogger was programmed to record water pressure measurements at a 5-minute sampling interval. The transducer was lowered into the monitoring well and installed at a depth of 24.20 m BGS.

A Solinst Barologger was set up to record barometric pressure and temperature at 5-minute sampling interval. The Barologger was set up in a location where it was protected from direct sunlight. Geofirma staff downloaded and reviewed the Levelogger and Barologger data on a weekly basis. The data was exported as .CSV files and uploaded to the project folder in Geofirma's office server.

2.1.2 Monitoring Well SB_MW01-01

A Solinst Levelogger was installed at a depth of 6.05 m BGS in SB_MW01-01 on May 31, 2021, about three months before the start of drilling activities at SB_BH02. The Levelogger was programmed to record water pressure measurements at a 5-minute sampling interval. An inertial pump consisting of 16 mm high density polyethylene (HDPE) tubing and a foot valve were also installed to enable purging and sample collection from the well.

A Solinst Barologger was set up to record barometric pressure and temperature at a 5-minute sampling interval. Except when removed to download data, the Barologger was placed in a plastic bin inside an ice-fishing tent that covered SB_MW01-01 and SB_MW01-02. Geofirma staff downloaded and reviewed the Levelogger and Barologger data on a weekly basis. The data was exported as .CSV files and uploaded to the project folder in Geofirma's office server.

2.1.3 Monitoring Well SB_MW01-02

A Solinst Levelogger was installed at a depth of 19.10 m BGS in SB_MW01-02 on May 31, 2021, about three months before the start of drilling activities at SB_BH02. The Levelogger was programmed to record water pressure measurements at a 5-minute sampling interval. A submersible 50.8 mm (2 inch) Grundfos pump was also installed to enable purging and sample collection from the well. The Grundfos pump was powered by a generator and connected to a control unit.

Since SB_MW01-01 and SB_MW01-02 were in the same location, the Solinst Barologger at SB_MW01-01 was also used to record barometric pressure and temperature for SB_MW01-02.

2.2 Monitoring of Water Levels

Geofirma field staff collected manual water level measurements from the three monitoring wells at regular intervals throughout the SB_BH01 and SB_BH02 drilling programs. Measurements were collected daily during drilling of the upper bedrock interval, until installation of the production casing to the Salina F Unit was complete. Sampling frequency then decreased to every other day for the duration of the drilling and

coring activities. Manual water levels were measured using an electronic water level tape and were recorded in the DQC Workbook.

2.3 Monitoring of Field Parameters

Field parameters at all three monitoring wells were measured at regular intervals. Similar to the manual water levels, field parameter measurements were collected daily during drilling of the upper bedrock interval, until installation of the production casing to the Salina F Unit. Sampling frequency then decreased to every other day until the completion of coring.

Field parameters were measured using a Horiba U50/52 multiparameter probe in a flow through cell (pH, temperature, electrical conductivity, turbidity, and dissolved oxygen) and a Turner Designs AquaFluor fluorometer (fluorescein tracer concentration). The Horiba probe was calibrated daily before sampling using a standard solution. The fluorometer was calibrated daily using aqueous standards. Records of equipment calibration were recorded on the equipment calibration sheet in the DQC workbook.

Water samples for field parameter measurements were collected using a submersible pump or inertial foot value connected to 16mm (HDPE) tubing. Measurements using the Horiba multiparameter probe in a flow-through cell were recorded after approximately 10 minutes purging, or when the field parameters had stabilized. Fluorescein tracer concentrations were measured using the AquaFluor fluorometer. When pumping produced highly turbid water, the water was field filtered using a 0.45 micron filter prior to the measuring fluorescein concentration.

2.4 Repair of Pump System at MECP 1401064

On July 30, 2021, the MECP 1401064 well's discharge line broke at a heavily corroded connection near the pump controller. No field measurements were obtained until the plumbing was repaired by Geofirma and sampling resumed on Aug 1, 2021.

3 RESULTS

3.1 Water Levels

Pressure measurements from downhole transducers were corrected to remove barometric effects on the water level readings. Occasionally, when reinstalled, the transducers would get hung up at a different depth inside the well than they were previously installed to. Manual corrections were applied to the water level measurements to remove impacts of these transducer hang-ups.

When seasonal water table fluctuations are considered, both the processed pressure transducer data and the manual measurements show negligible changes in water levels throughout the duration of monitoring well monitoring program (Figure 2 - Figure 4). In general, water levels measured in the monitoring wells follow season trends: decreasing levels during the summer and winter when there was less recharge, and increasing levels during the spring and fall.

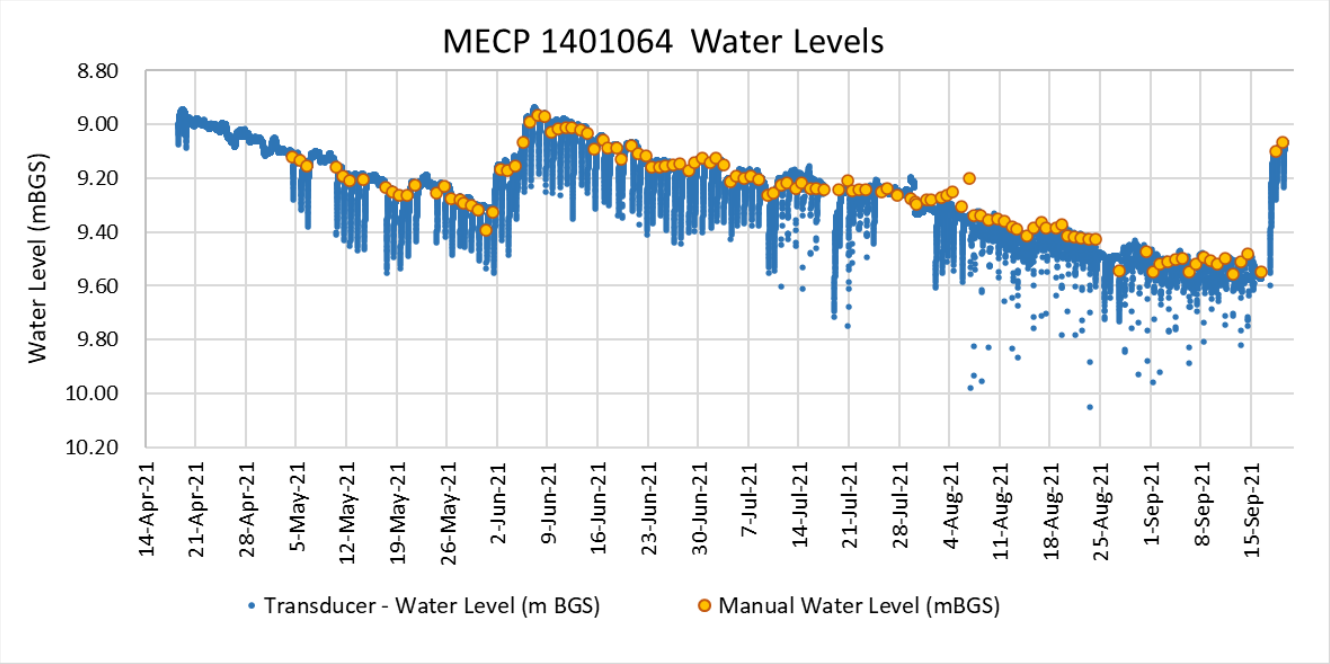


Figure 2. Water Levels, MECP 1401064, Manual and Processed Transducer Measurements

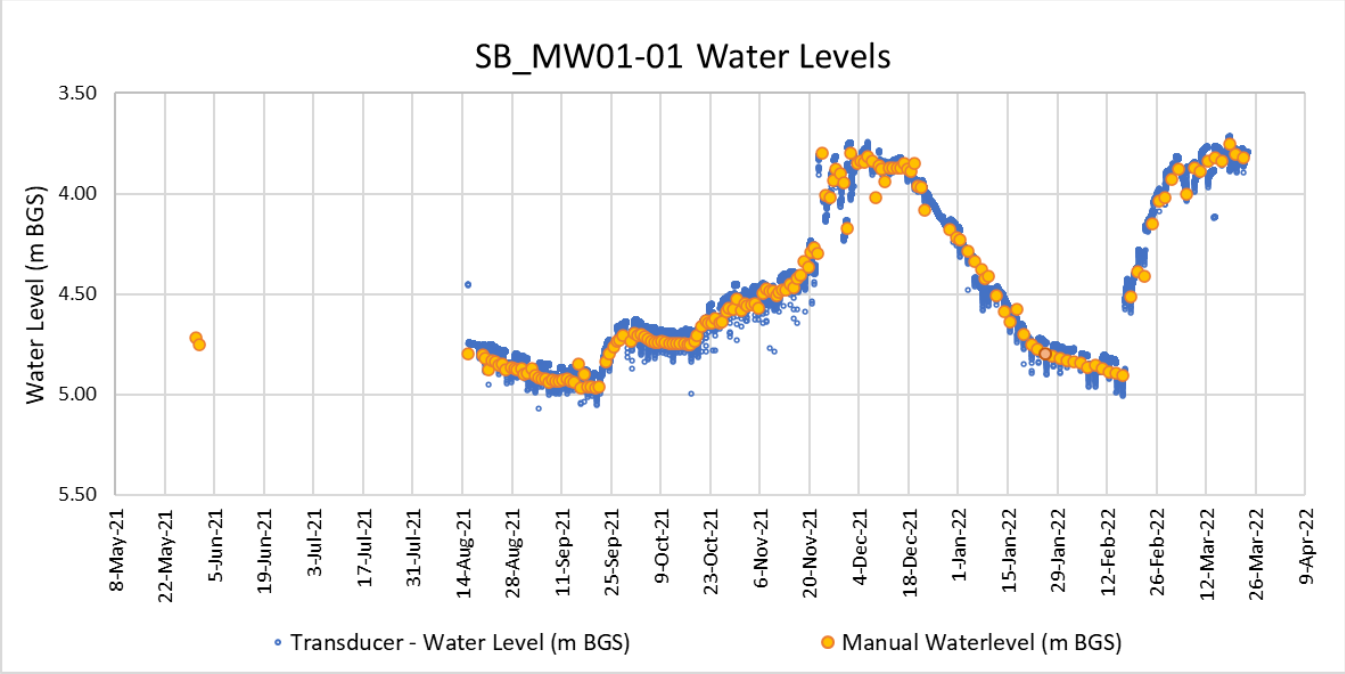


Figure 3: Water Levels, SB_MW01-01, Manual and Processed Transducer Measurements

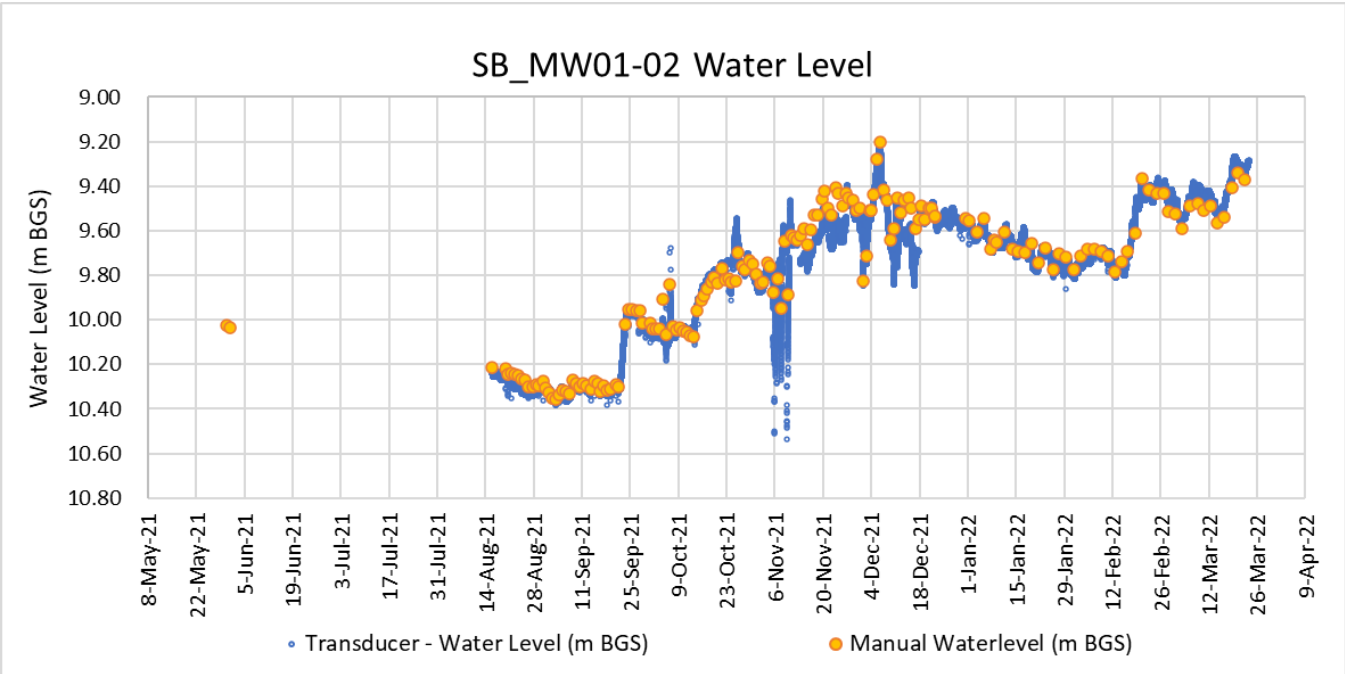


Figure 4: Water Levels, SB_MW01-02, Manual and Processed Transducer Measurements

3.2 Field Parameters and Fluorescein

Trends in field parameter and fluorescein measurements collected during drilling were compared to measurements collected prior to drilling to assess for potential impact on shallow groundwater quality near the SB_BH01 and SB_BH02 drill site.

Field parameter data from all three monitoring wells show no notable changes in groundwater chemistry during the SB_BH01 and SB_BH02 drilling programs. Fluorescein concentrations for water samples remained below the method detection limit of 0.4 ppb in both bedrock monitoring wells (MECP 1401064, SB_MW01-02) and were below or very close to the detection limit in SB_MW01-01.

The following subsections provide additional discussion of results for the field parameter and fluorescein measurements for each of the monitoring wells.

3.2.1 Monitoring Well MECP 1401064

Temperature, pH, electrical conductivity (EC), oxidation-reduction potential (ORP), and turbidity measurements collected from water samples from MECP 1401064 remained relatively constant for the duration of the monitoring program. All fluorescein concentrations in water samples from MECP 1401064 were below the method detection limit of 0.4 ppb (Figure 5).

Dissolved oxygen (DO) measurements from MECP 1401064 between August 2 to August 16, 2021, showed elevated concentrations relative to the expected range for this well based on the pre-drilling baseline testing (Figure 9). These elevated DO readings occurred after the pump was repaired on August 1, 2022, and are likely indicative of a small leak in the plumbing between the pump and the sampling discharge line. The leak was corrected, and all DO readings after August 18, 2021, were 0 mg/L.

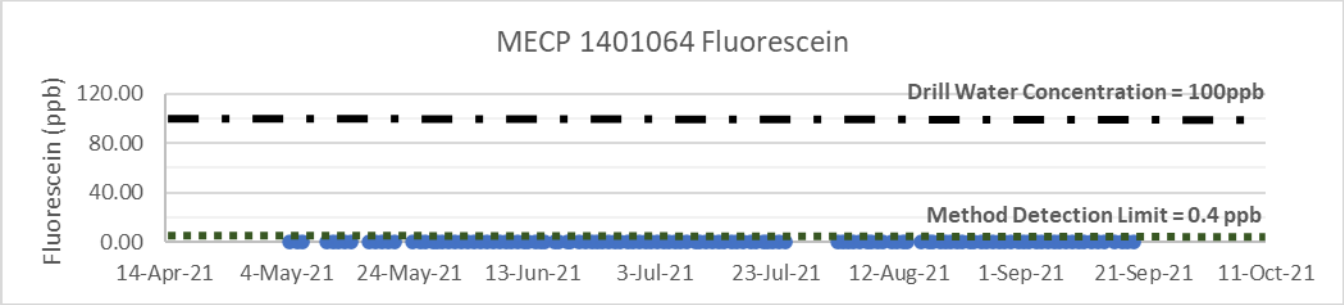


Figure 5: Fluorescein Measurements, MECP 1401064

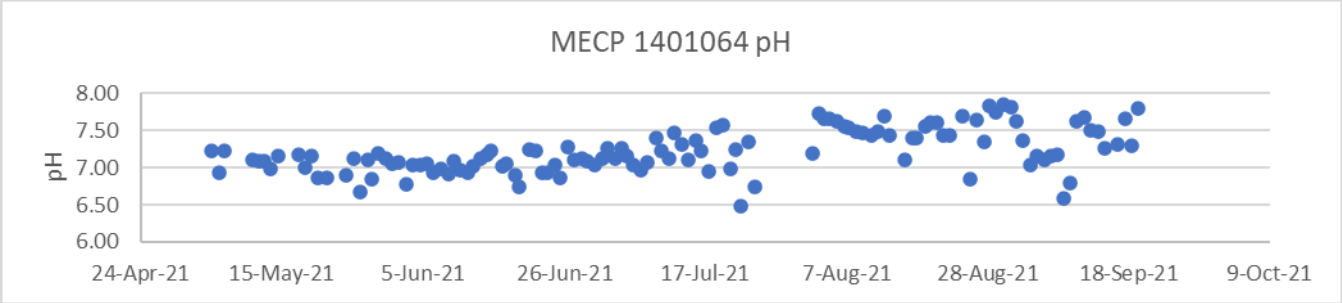


Figure 6: pH Measurements, MECP 1401064

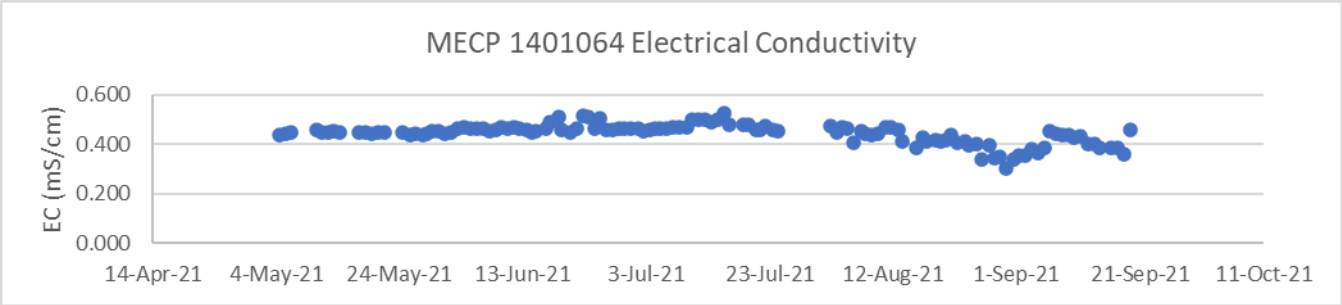


Figure 7: EC Measurements, MECP 1401064

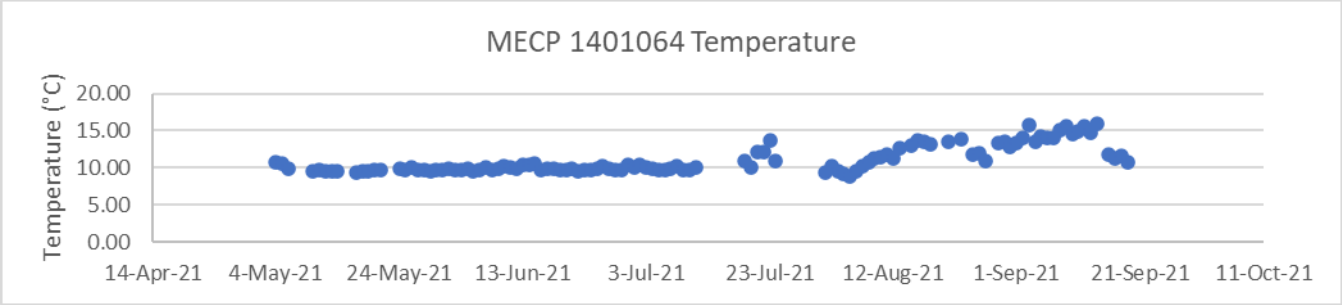


Figure 8: Temperature Measurements, MECP 1401064

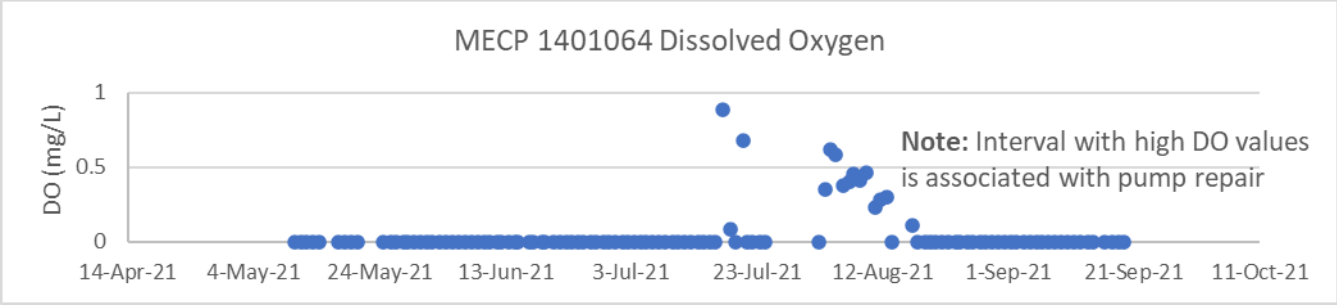


Figure 9: Dissolved Oxygen, MECP 1401064

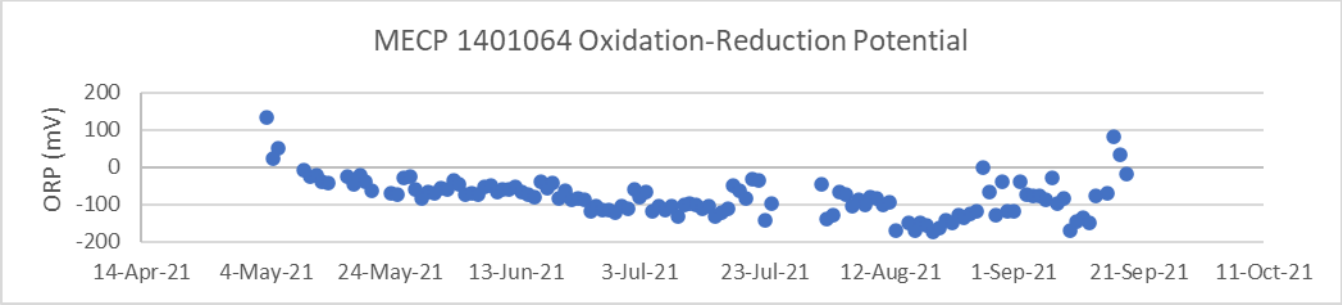


Figure 10: ORP Measurements, MECP 1401064

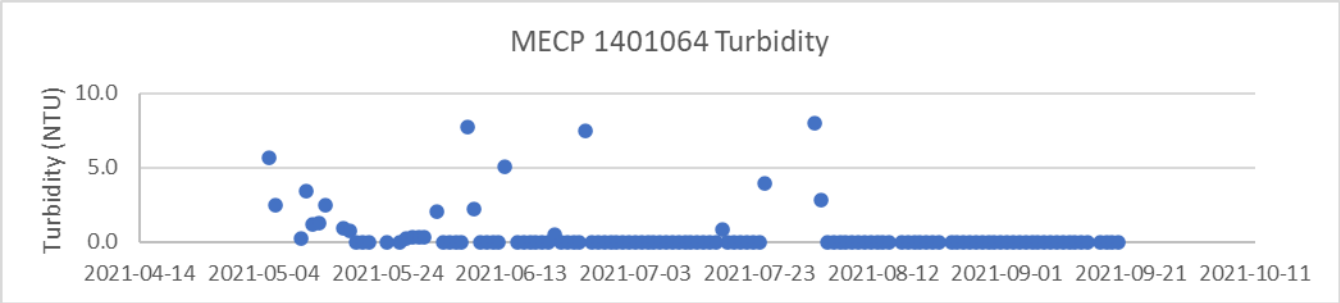


Figure 11: Turbidity Measurements, MECP 1401064

3.2.2 Monitoring Well SB_MW01-01

Temperature, pH, EC, ORP, and DO measurements from water samples from SB_MW01-01 remained relatively constant for the duration of the monitoring program. Fluorescein concentrations in water samples from SB_MW01-01 remained below or near the method detection limit of 0.4 ppb (Figure 12) throughout the monitoring program. Some fluorescein measurements at SB_MW01-01 were above the detection limit but were well below the 100ppb fluorescein tracer concentration that was maintained in the drill fluid throughout drilling operations at SB_BH02.

Of the few detections that occurred above the method detection limit (0.4ppb), all were below 0.8 ppb except for two measurements that were 1.2 and 2.0 ppb. These two detections were separated by several non-detects and the remaining detections were near the method detection limit. If the source of fluorescein was groundwater impacted by drilling fluid from SB_BH02, fluorescein concentrations would be expected to increase over time towards the drill fluid concentration and samples collected in sequence would be expected to show a consistent trend, not be separated by non-detects.

The measured groundwater turbidity in SB_MW01-01 was high due to abundant fine-grained suspended sediment and was typically above the detection limit of the Horiba (>1000 NTU). Over the duration of the monitoring program, turbidity measurements for water samples from SB_MW01-01 decreased to within the method detection limit (<1000 NTU), but were still generally high.

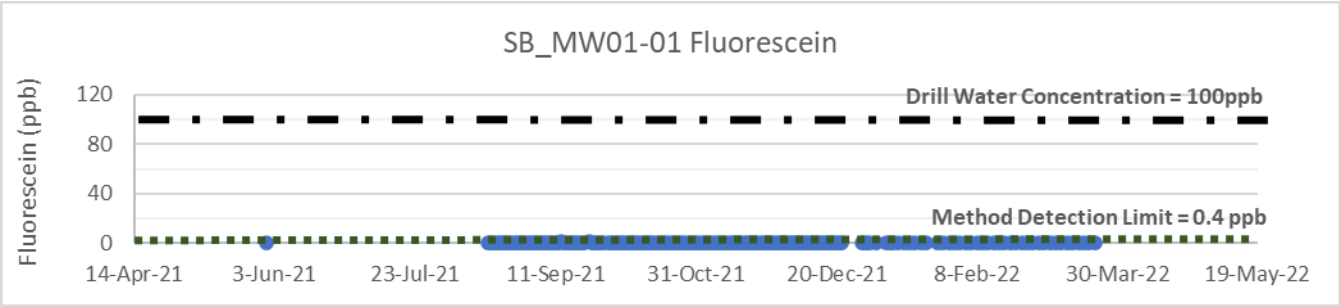


Figure 12: Fluorescein Measurements, SB_MW01-01

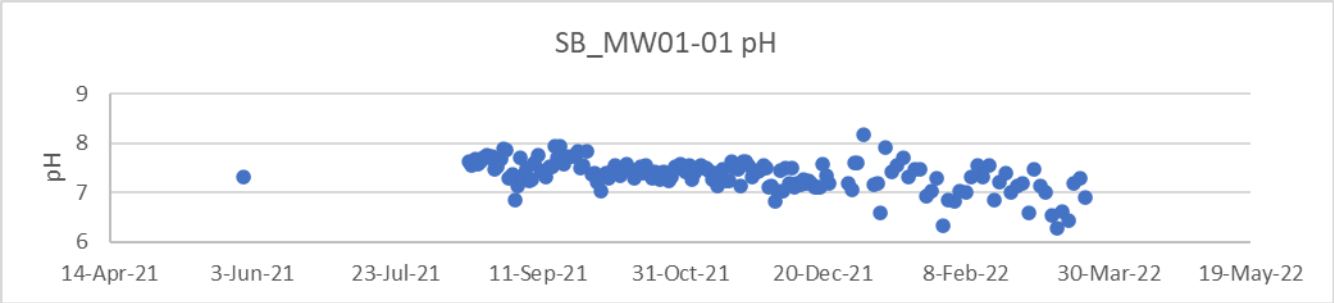


Figure 13: pH Measurements, SB_MW01-01

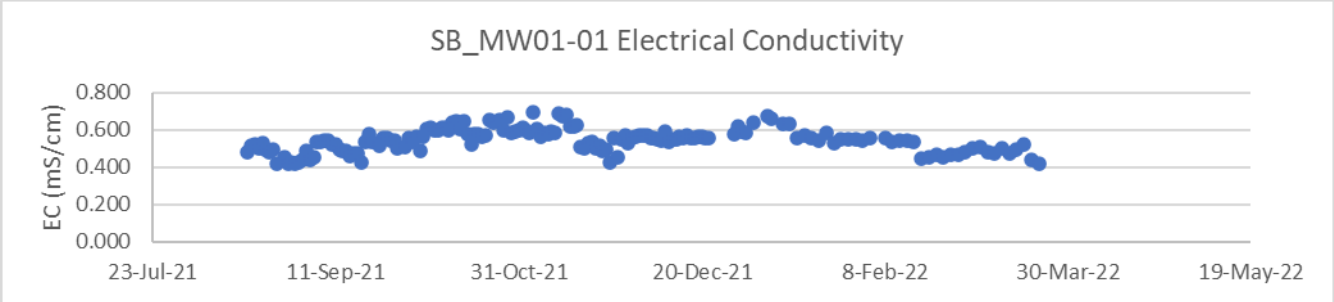


Figure 14: EC Measurements, SB_MW01-01

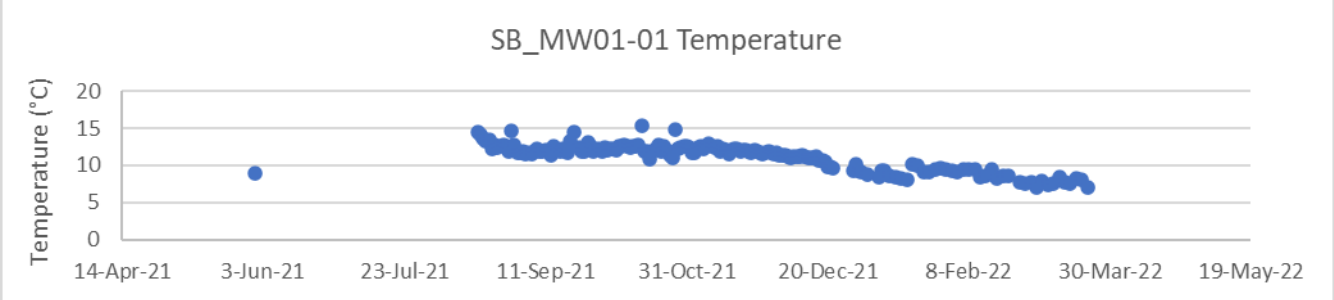


Figure 15: Temperature Measurements, SB_MW01-01

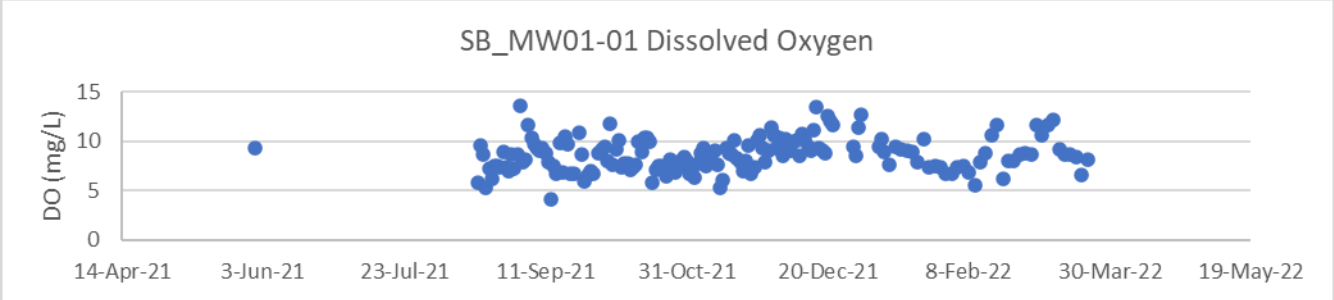


Figure 16: Dissolved Oxygen, SB_MW01-01

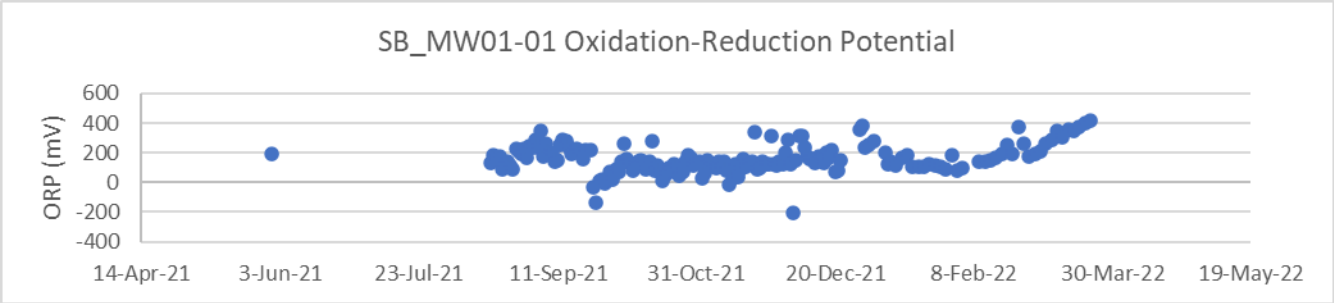


Figure 17: ORP Measurements, SB_MW01-01

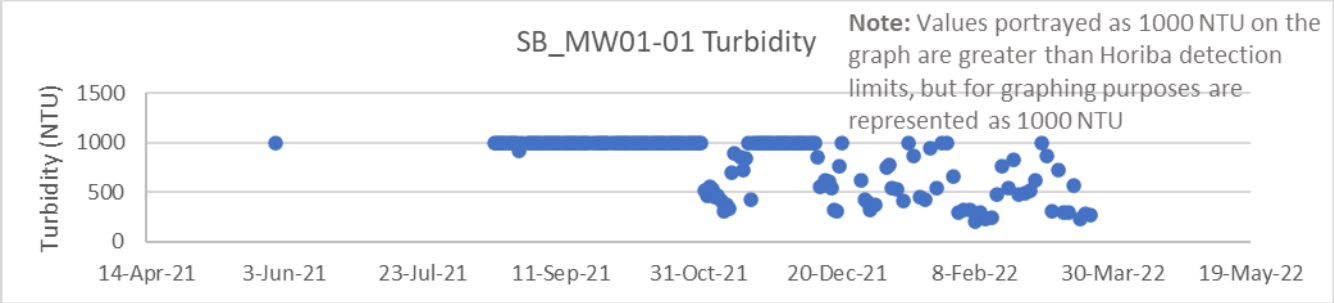


Figure 18: Turbidity Measurements, SB_MW01-01

3.2.3 Monitoring Well SB_MW01-02

Electrical conductivity (EC), pH, oxidation-reduction potential (ORP), and turbidity measurements collected from water samples from SB_MW01-02 remained relatively constant for the duration of the monitoring program. All fluorescein concentrations in water samples from SB_MW01-02 were below the method detection limit of 0.4 ppb (Figure 19).

Dissolved oxygen and temperature readings showed anomalous values from December 20, 2021, to February 02, 2022. The timing of these anomalous values occur when a rented multiparameter probe was in use and are therefore not expected to be representative of a change in water quality during this time period.

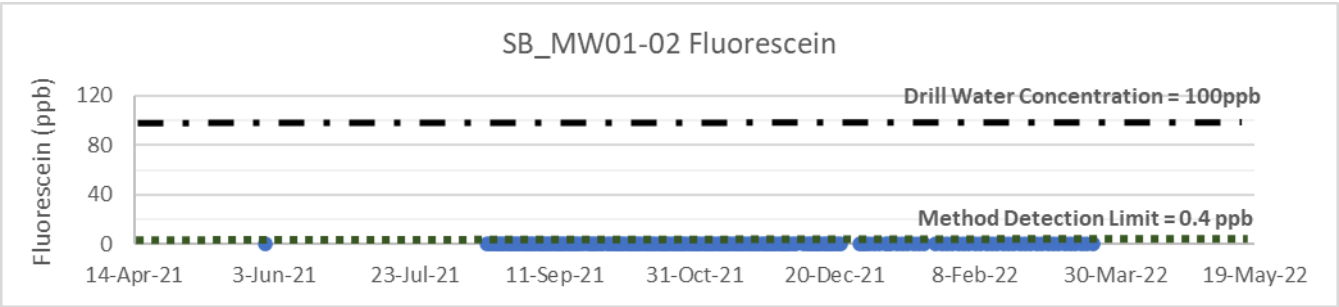


Figure 19: Fluorescein Measurements, SB_MW01-02

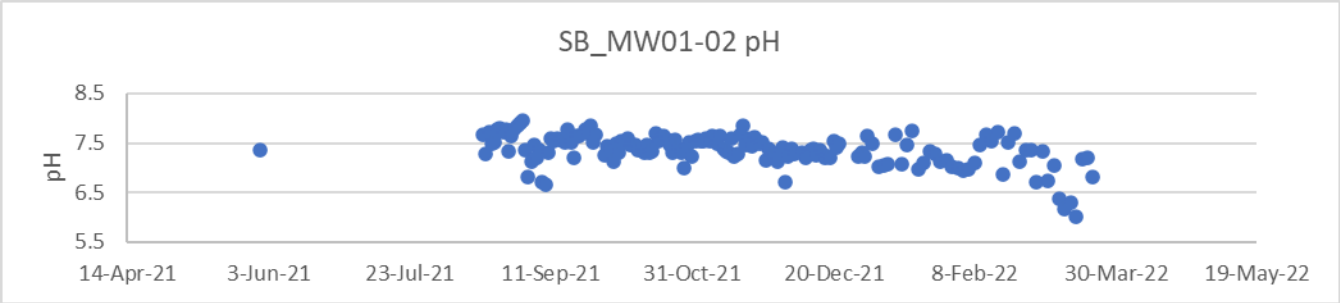


Figure 20: pH Measurements, SB_MW01-02

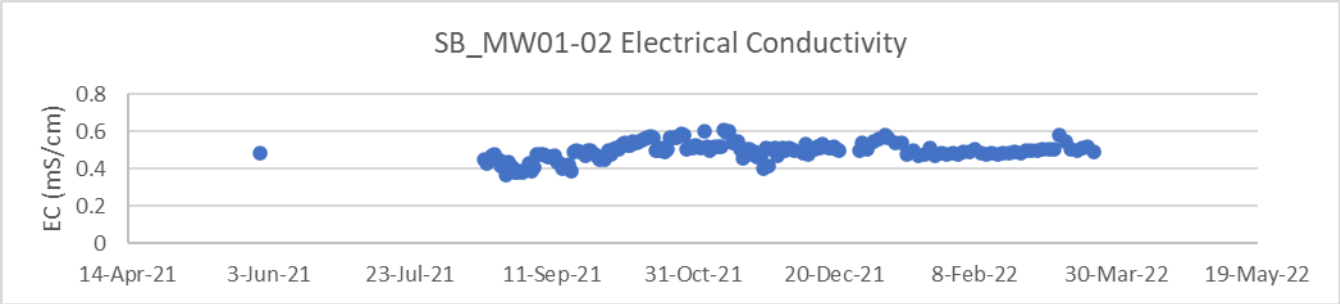


Figure 21: EC Measurements, SB_MW01-02

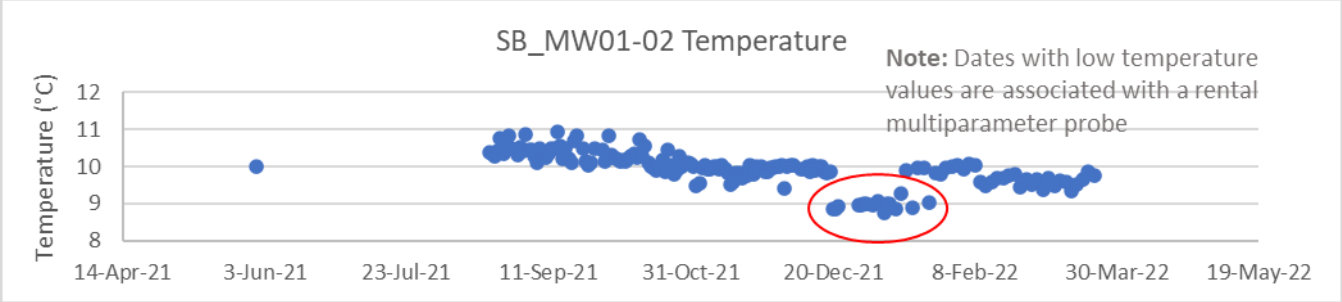


Figure 22: Temperature Measurements, SB_MW01-02

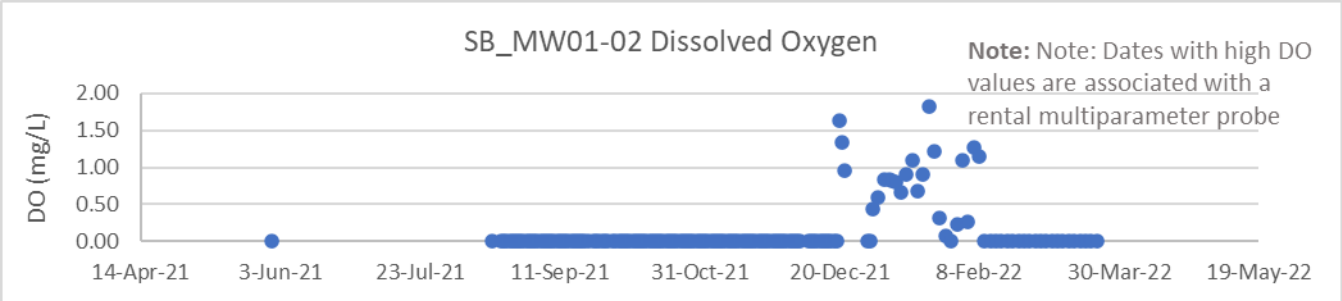


Figure 23: Dissolved Oxygen, SB_MW01-02

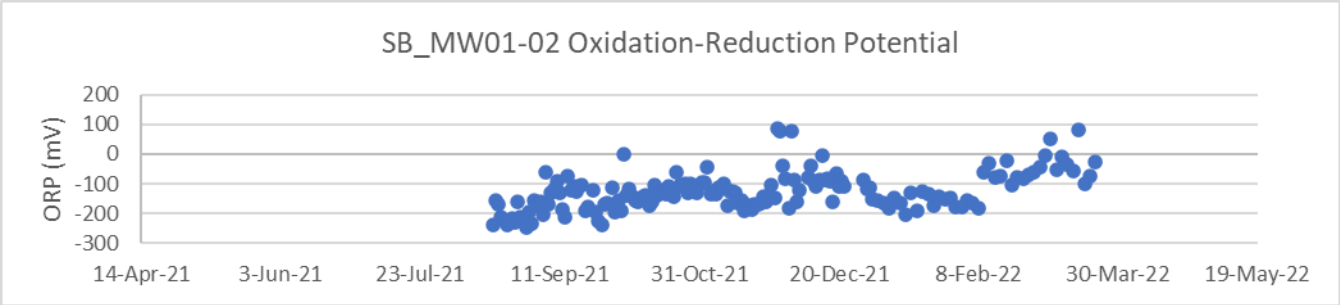


Figure 24: ORP Measurements, SB_MW01-02

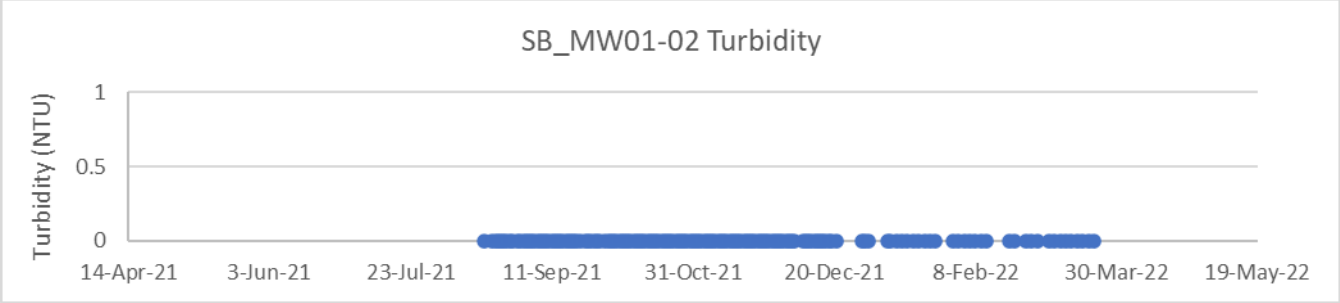


Figure 25: Turbidity Measurements, SB_MW01-02

4 DATA QUALITY ASSURANCE AND QUALITY CONTROL

Several data quality assurance and quality control (QA/QC) measures were implemented by Geofirma staff during the field program and subsequent analysis and reporting. Verification of results was completed following acceptance criteria and verification procedures outlined the Water Well Testing Test Plan and the Geofirma Project Quality Plan. All data acquisition and analysis were reviewed, verified, dated, and signed by a second Geofirma technical staff member who was not directly involved in the work being reviewed.

5 HEALTH, SAFETY AND ENVIRONMENT

All field activities were completed in accordance with the requirements outlined in the accompanying project-specific Health, Safety and Environment Plan (HSEP) prepared by Geofirma and approved by the NWMO. Pre-job briefings were conducted at the beginning of every field day onsite to discuss the daily plan, health and safety concerns, and any relevant changes to procedures.

6 CONCLUSIONS

Geofirma Engineering Ltd. (Geofirma) was retained by NWMO complete a monitoring program at three monitoring wells near the deep boreholes SB_BH01 and SB_BH02. The monitoring program was implemented to monitor for potential impacts on water levels and groundwater chemistry in the shallow aquifers during the SB_BH01 and SB_BH02 drilling programs. Field activities associated with the monitoring well monitoring were completed by Geofirma between May 4, 2021 and March 22, 2022.

Three monitoring wells were monitored during drilling of SB_BH01 and SB_BH02. A domestic well, MECP 1401064 was monitored near SB_BH01 from May 4 to September 19, 2021, and a cluster of two wells (SB_MW01-01 & SB_MW01-02) were monitored near SB_BH02 from August 19, 2021, to March 20, 2022. Manual water level and field parameter measurements were collected daily from the monitoring wells during coring until the production casing was cemented into Salina F-Unit at each deep borehole. After installation of the production casing, the frequency of manual water level and field parameter measurements decreased to every other day. Semi-continuous (5-minute frequency) records of water level were also recorded using downhole pressure transducers in each monitoring well.

Results from the monitoring well monitoring program do not indicate any notable impact from drilling activities on the shallow groundwater system during drilling of boreholes SB_BH01 and SB_BH02:

- Considering seasonal water table fluctuations, both the processed pressure transducer data and the manual measurements show negligible changes in water levels throughout the duration of the SB_BH01 and SB_BH02 drilling programs.

- Fluorescein tracer concentrations for water samples from the monitoring wells remained below the method detection limit of 0.4 ppb in both bedrock monitoring wells (MECP 1401064, SB_MW01-02). Some fluorescein measurements at SB_MW01-01 were above the detection limit (up to 1.7 ppb) but were well below the 100 ppb fluorescein tracer concentration that was maintained in the drill fluid throughout drilling operations at SB_BH01 and SB_BH02. The low and sporadic detections of fluorescein near the method detection limit at SB_MW01-01 are not consistent with trends that would be expected for groundwater impacted by fluorescein-traced drill water.

- Comparison of other field parameter measurements for water samples from the monitoring wells with pre-drilling measurements from these wells show no notable changes in groundwater chemistry during the SB_BH01 and SB_BH02 drilling programs.

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7 REFERENCES

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