2022

December

Water Management Plan

Document Details

Document Number: NTR-ENV-WMP-2023

Version 03

Revision A

Title: Water Management Plan 2023

Issue date: January 2023

Authorisation

Version	Author	Changes	Reviewed By	Approval Date	Approved By
00	Natasha Rodwell	Annual review and update	Andrew Tong	26 Apr 18	Andrew Tong
01	Bruce Blunden	Review and update	Greg Molloy	Oct 2020	Greg Molloy
02	Bruce Blunden	Review and update	Greg Molloy	Oct 2022	Greg Molloy
03	Bruce Blunden	WLD177-10 new limits	Greg Molloy	Jan 2023	Greg Molloy

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Acronyms

Acronym	Full name
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
BSS	Black Shale Stockpile (previously named Intermediate Stockpile)
DITT	Department of Industry, Tourism and Trade
DPIR	Department of Primary Industry and Resources (now DITT)
EBFR	East Branch of the Finniss River
EFDC	East Finniss Diversion Channel
EPA	Northern Territory Environmental Protection Authority
mbgl	Meters below ground level
MAP	Mean Annual Precipitation
MMP	Mining Management Plan
PAF	Potentially Acid Forming Stockpile
RGC	Robertson GeoConsultants Inc.
SP3	Stockpile 3 (previously named Low Grade Stockpile)
SRO	Site Run Off Pond (previously named Small Sed Dam)
WDL	Waste Discharge Licence
WMP	Water Management Plan
WRD	Waste Rock Dump
WTP	Water Treatment Plant

1. INTRODUCTION

1.1 Purpose

The purpose of this Water Management Plan (WMP) is to address water management for the Browns Project (the Project). The WMP documents the Project site's environmental performance as it relates to water management and has been produced in adherence to the requirements set out in guidelines provided by the Northern Territory Government's Department of Industry, Tourism and Trade (DITT) dated August 2013.

In accordance with Section 36 of the *Mining Management Act* a Mining Management Plan (MMP) is required to attain and maintain mine Authorisation. The MMP contains a summary of the Project, associated activities and design of infrastructure. The WMP forms part of the MMP requirements.

This WMP provides an overview of the Project site's environmental performance as it relates to water management. The site is operating under a car and maintenance regime. No mining activities are planned.

The objectives and targets of the WMP are:

- Provide a comprehensive description of surface water and groundwater conditions.
- Provide a comprehensive of groundwater model.
- Provide a water balance with representation of flows and volumes.
- Identify hazards that could result from activities related to the operation
- Outline how potential hazards/ impact associated with surface and groundwater at the Project will be managed.
- Support the approval process for the MMP by resolving water-related issues in a consistent framework.
- Detail relevant legislation, codes of practice, standards and guidelines applicable to the Project site.
- Address the legislative requirements of the mining authorisation and waste discharge licences; and
- Provide an indicative Water Account.
- Present any improvement projects

1.2 Term of Plan

This WMP will be valid for the period of the MMP. It will be updated and re-submitted on a needs basis, as part of the MMP, but may be reviewed in response to incidents or any significant change to operation which will require Northern Territories Resources Pty Ltd (NTR) to submit a formal amendment to the Department of Industry, Tourism and Trade (DITT).

1.3 Guidelines

The WMP has been developed with reference to the DITT, Northern Territory Environmental Protection Authority (EPA) and the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines including:

- Template for the Preparation of a Mining Management Plan.
- Waste Discharge Licence 177-10;

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a);
- Australian Guidelines for Water Quality Monitoring & Reporting (ANZECC/ARMCANZ, 2000b);
- Australian Drinking Water Guidelines (NHMRC/ARMCANZ) (2004); and
- Guidelines for Groundwater Protection in Australia (ANZECC/ARMCANZ, 2013).

1.4 Location

The Project is located 7 km northwest of Batchelor, approximately 105 km by road (Stuart Highway, Batchelor Road and Rum Jungle Road) south of Darwin in the Northern Territory. It is located to the north-east of Litchfield National Park and within the upper catchment of the Finniss River.
To the immediate east, and upstream, of the site is the former Rum Jungle Mine, which contains former mine workings including flooded open pits and waste rock dumps/stockpiles.

1.5 Brief History

Mining and construction of the TSF began in July 2007 with the commissioning of the plant in May 2008. Mining began in 2008 with approximately 700,000 tonnes of oxide ore mined from the Browns Pit. In August 2008 the site commenced copper production and also began discharging tailings and liquor to the Tailings Storage Facility (TSF). Mining ceased in January 2009 when Compass Resources (the owner at the time) entered Voluntary Administration (VA). The Project site has been in care and maintenance since.

1.6 Technical Assistance

Robertson GeoConsultants Inc. (RGC) were engaged to undertake an assessment of surface and groundwater quality data. The scope of this report incorporated reporting requirements for the then WDL 177-06 Monitoring Report as well as technical support for the production of the 2018 WMP. RGC were selected due to their local expertise, having worked extensively on the water related issues on the Rum Jungle project.

The Water Quality Review and Load Balance, with more recent information provided by NTR include the following;

- Present all monitoring data in tabulated format required as a condition of WDL177, i.e. groundwater and surface water quality data up to 2022. Monitoring has continued in accordance with WDL177 and no substantial departure from the analysis presented in the 2018 MMP has occurred. No non-compliances with the discharge limits prescribed by WLD177 have occurred in 2019-2022 period.
- Conduct a long-term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available). Where relevant, contemporary data has been added to the 2022 WMP to further assist understanding of the site environmental performance.
- Estimate of the volume of contaminated groundwater leaving the mine lease, including estimates of individual contaminant volumes, e.g. metal and metalloids.
- Create spatial images of contaminated groundwater (i.e. contaminant plumes) generated by activities on the mine lease at differing depths/aquifer.

- Identify potential contaminant sources to groundwater and the extent of groundwater quality impacts near the TSF and ore stockpiles.
- Characterize AMD impacts to groundwater and runoff at the Browns site and estimate contaminant loads to groundwater and the water treatment system.
- Develop a site water balance and Water Account for the care and maintenance MMP.
- Evaluate surface water quality impacts during a 1 in 100 year, 72-hour rainfall event.
- Document trigger value exceedances at the compliance point for boundary discharge (Site 5) and discussion of potential environmental implications.
- Discuss potential surface water quality impacts during a 1 in 100-year, 72-hour rainfall event.
- Recommend a routine groundwater monitoring program that is commensurate with current water quality impacts on site and future remediation objectives.

At some future time, it is recommended that a detailed scope for the hydrogeology drilling program be implemented in support of an interim (Phase I) remediation strategy for groundwater near the TSF.

2. PHYSICAL SETTING

2.1 Climate

The Browns site is characterized by a tropical wet-dry monsoonal climate. Mean annual rainfall is 1422 mm (all of which occurs as rainfall). More than 90% of MAP occurs during the Wet Season from November to April **(Figure 2-1**). The Dry Season is from May to October. Mean monthly maximum temperatures at the Batchelor Airport range from 31°C in June (Dry Season) to 37°C in October during the 'build up' to the Wet Season.

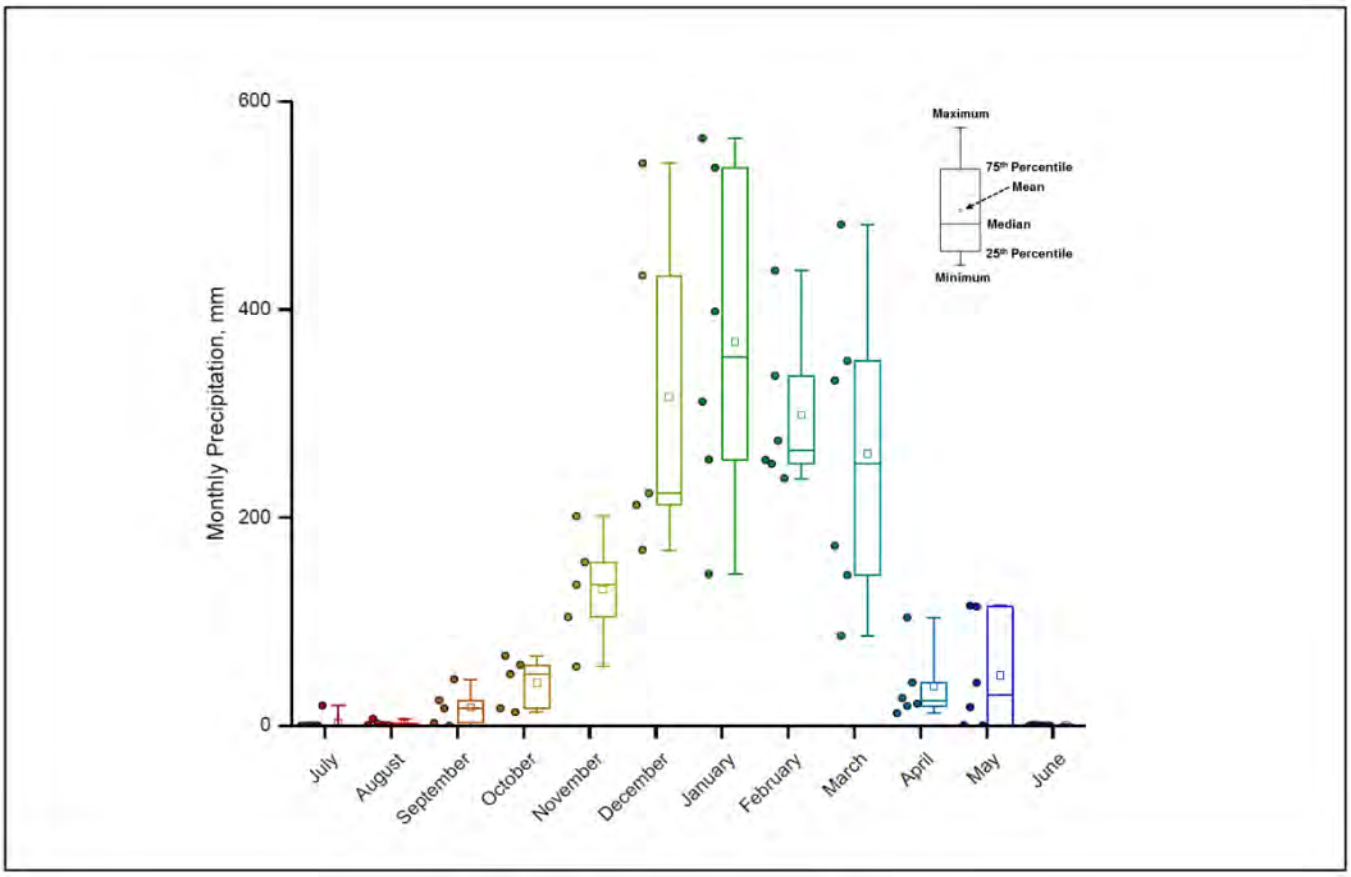

Figure 2-1- Box Plots of Monthly Rainfall 2012 to 2017 (RGC, 2018)

Evaporation is greatest in October (during the build up to the Wet Season). Annual average evaporation is 2,445.5mm with average monthly evaporation ranging from 159.6mm in February and to 244.9mm in October.

The 1 in 100-year, 72-hour rainfall event in the 2016 WMP was 489 mm. This was obtained from the Intensity Frequency Duration (IFD) curve specified by Australian Bureau of Meteorology (BOM) for the coordinates of the Browns site (13º S and 131º E). In 2016, the BOM prepared a new set of IFD curves for the country and this resulted in a reduction in the estimated 100-year, 72-hour rainfall at the mine to 453 mm (**Figure 2-2**).

Figure 2-2- IFD Rainfall Depth (mm)

Duration	Return Period (Years)				
	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 2000
24 Hour	293	340	404	459	518
48 Hour	391	445	526	593	667
72 Hour	**453**	512	597	667	740
96 Hour	492	553	639	708	779
120 Hour	516	577	662	729	799
144 Hour	528	590	673	738	809
168 Hour	531	594	675	738	811

Source: BOM IFD 2016 Tool, Issued 8 February 2018

2.2 Local and Regional Hydrology

The Project site is located in the headwaters of the East Branch of the Finniss River (EBFR). The watercourses within the region of the Project are ephemeral, base flow is generally not established in the East Finniss River until sustained monsoonal rains arrive in January. The EBFR and the West Branch of the Finniss River are the major tributaries of the Finniss River. The EBFR flows through the former Rum Jungle mine site to the east (**Figure 2-3**). Flows in the EBFR are monitored at gauge stations GS8150200, GS8150327, and GS8150097 by the DITT. Peak flows in the EBFR usually occur in January, February, or March. No appreciable flow is observed during the Dry Season due to minimal rainfall.

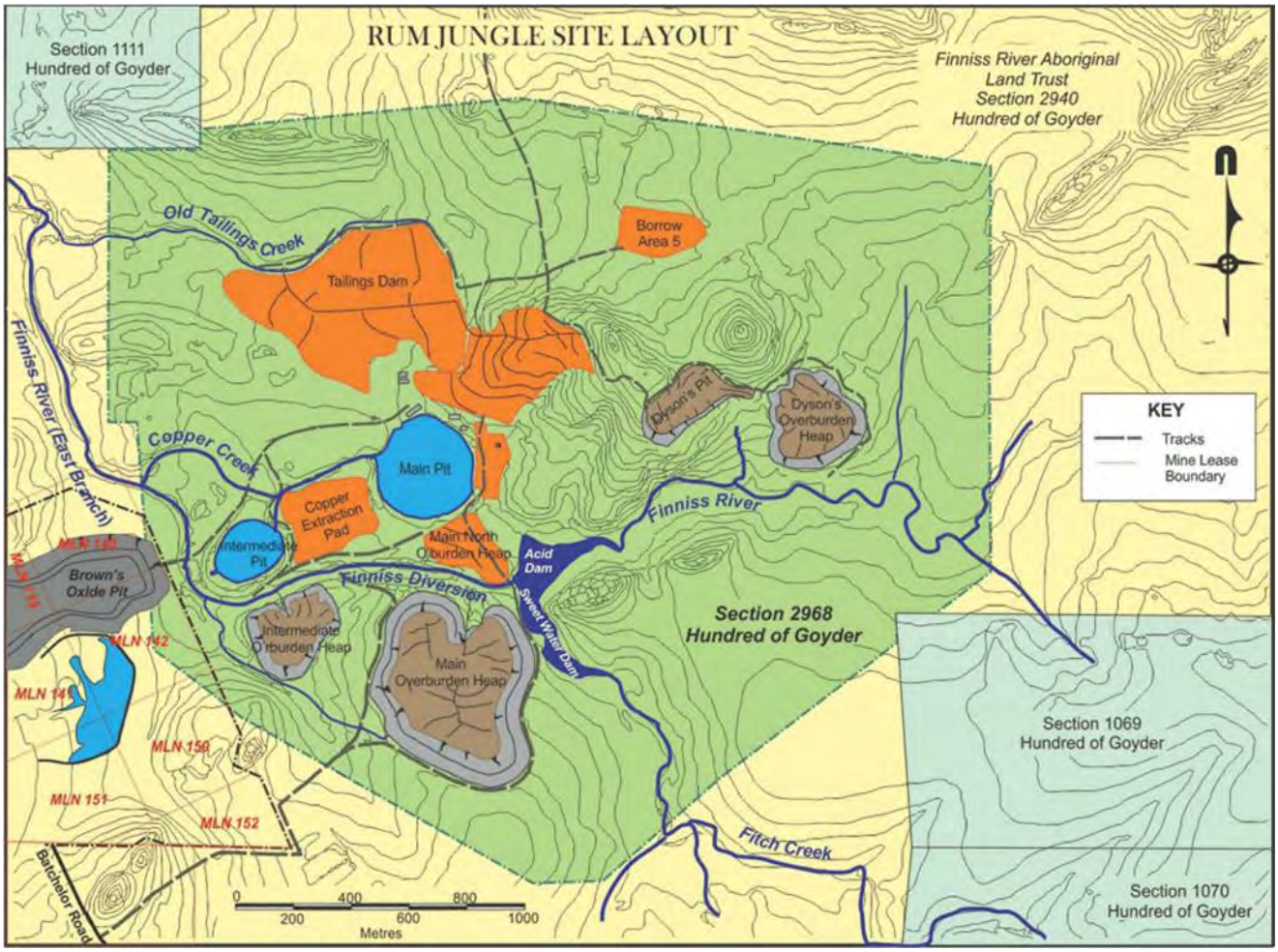

Figure 2-3 - Rum Jungle Site Layout (DME, 2016b)

There are two non-perennial (ephemeral) creeks near the Browns Site: Middlebrook Creek and Wandering Creek. Middlebrook Creek flows to a low-lying wetland near the eastern boundary of the Browns site (**Figure 2-4**). The wetland also receives flows during controlled discharge events from the Sediment Dam. Water from the wetland then discharges to the EBFR upstream of station GS8150200 via Middlebrook Creek. Upstream flows from Middlebrook Creek and controlled discharge from the Sediment Dam flow through Site 5, the compliance point for WDL177-10 (**Section 15**). Wandering Creek flows through the former Rum Jungle mine site and discharges to the EBFR downstream of SITE5.

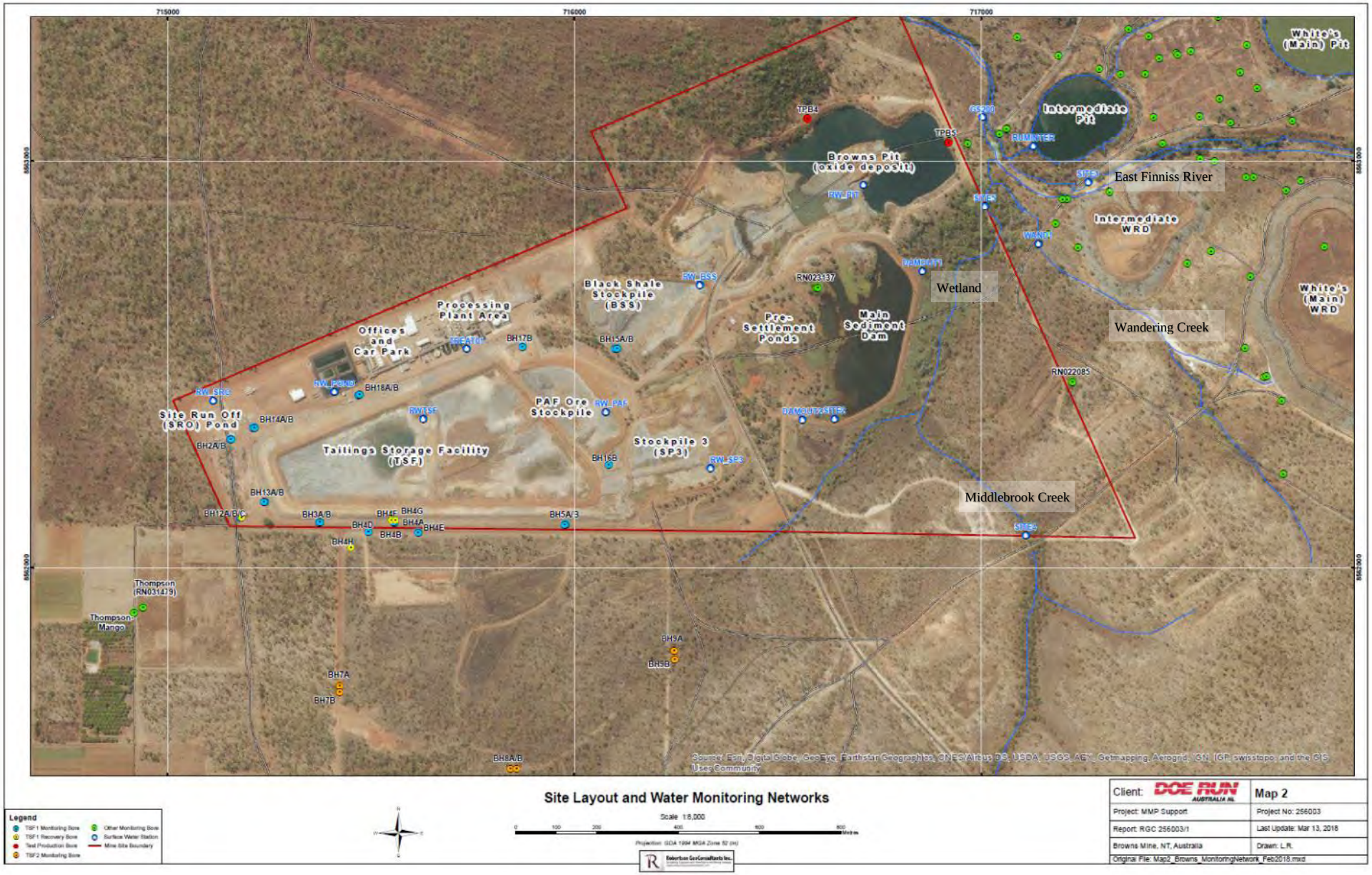

Figure 2-4– Brown Project Site Layout and Water Monitoring Networks.

2.3 Hydrogeology

The hydrogeology of the Browns site is not well-characterized. URS (2010) provides an overview of groundwater conditions on site, including a summary of aquifer properties and water quality impacts. Few details are provided in that report and a comprehensive review of water quality impacts is not provided.

The physical hydrogeology of the Browns site is similar to the former Rum Jungle mine site where RGC has worked since 2010 and some general observations from that site are summarised below (RGC, 2018):

- The Coomalie Dolostone and Whites Formation are the key formations near the western boundary of the former Rum Jungle mine site and at the Browns site. The Coomalie Dolostone and Whites Formation both have a relatively high permeability, i.e. hydraulic conductivity (K) = 10^{-6} to 10^{-4} m/s (see RGC, 2016b). Higher K values (>10^{-4} m/s) can occur locally in both formations where bedrock is fractured or where karst occurs in the Coomalie Dolostone, and/or in areas where bedrock is highly-weathered. These factors increase the bulk permeability of bedrock and may thereby cause preferential flow and/or accelerated contaminant transport to occur in areas where there is a strong enough hydraulic gradient.
- Several systems of cavities have been identified in the Coomalie Dolostone at the former Rum Jungle mine site, including a linear system that provides a direct hydraulic connection between the Main Pit (Rum Jungle) and the East Finniss Diversion Channel (EFDC) over several hundred meters. Cavities have also been identified during drilling investigations in the central mining area (RGC, 2011) and in the Old Tailings Dam area (RGC, 2015) and during geophysical investigations of the site (RGC, 2016c). Individual bore yields for the Coomalie Dolostone and Whites Formation typically range from 1 L/s to 50 L/s in bores that intersect cavities and/or fracture zones or historic production bores.
- Groundwater levels typically fluctuate by 5 to 10 m. The lowest groundwater levels occur during the late Dry Season and the highest groundwater levels occur in March or April during the Wet Season. Rainfall is the main source of recharge to groundwater. Most recharge occurs in undisturbed land areas but the WRDs represent preferential recharge areas. The flooded pits at the former Rum Jungle mine site act as a source of recharge to groundwater during the Dry Season when groundwater levels decrease below the pit water level. Groundwater discharges to the pits in the Wet Season when groundwater levels are higher than pit water levels.
- Groundwater flow directions usually follow surface topography, meaning groundwater flows from higher elevation areas towards Fitch Creek and the EBFR in the central mining area. There is more elevation change at the former Rum Jungle mine site than at the Browns site, but the same trend appears to apply to the Browns site (see RGC, 2017, and Section 5.3). Groundwater at the Browns site likely flows to the Browns Pit or moves beyond the northern property boundary towards the EBFR.
- The EBFR is a regional groundwater discharge zone. It receives substantial flows of groundwater in the Wet Season and pools of water are often maintained by groundwater discharge during the Dry Season. Ephemeral creeks, such as Wandering Creek, are not major discharge zones for groundwater.

2.4 Environmental Values

2.4.1 East Finniss River

The area surrounding the Project has been subject to several investigations as part of the rehabilitation of the adjacent Rum Jungle Mine Site. Investigations have been undertaken by National Partnership Agreement (NPA), an agreement between the Commonwealth and Northern Territory Government to rehabilitate the site.

As part of the NPA, an investigation and designation of environmental values of the East Finniss River was undertaken. The study determined the application of ANZECC 80% species protection trigger values for the adjacent and downstream section of the East Finniss River. A summary of the environmental values determined through stakeholder consultation by the DPIR are provided in **Table 2-1**.

Table 2-1 - Environmental Values of the East Finniss River (Sources: Hydrobiology, 2013a)

Zones		Distance (km)	Environmental Values						
Commence	Terminate		ANZECC	Cultural / Spiritual	Wildlife Habitat	Human Consumer	Primary Recreation	Secondary Recreation	Visual Recreation
Zone 1 – Upstream									
Upstream East Finniss River (EFR)		-	SMD	X					
Zone 2 – Adjacent to Rum Jungle									
Rum Jungle site boundary (east of Main WRD)	East Finniss River and Old Tailings Creek confluence.	3	H-80%	X					
Zone 3 – Downstream									
East Finniss River and Old Tailings Creek confluence.	Hannah Spring	5	H-80%	X					
Zone 4 – Downstream									
Hannah Spring	East Finniss River and Finniss River confluence.	2	H-90%	X	X	X	X	X	X

Note: SMD indicates value assigned for classification of Slightly-Moderately Disturbed ecosystems; and H-x%PC indicates value assigned for classification of Highly Disturbed ecosystem with an x% protective concentration recommended.

2.4.2 Water Quality Objectives

The current surface water management strategy aims at preventing poor quality water entering the Sediment Dam. NTR holds a Waste Discharge Licence (WDL177-10) which under particular conditions enable them to discharge water from the Sediment Dam at Site 5 to the EBFR (via Middlebrook Creek). The WDL issued by the Northern Territory Environmental Protection Authority (EPA) stipulates trigger vales which are listed below (**Table 2-2**) and are applied to SITE5 monitoring location.

Table 2-2 – WDL177-10 Trigger Values for Site 5

Parameter	Abbreviation	Units	Trigger Value (WDL 177-10)
pH	pH	-	6.5-8.5
Electrical conductivity	EC	µS/cm	700
Aluminium	Al	µg/L	80[a]
Cadmium	Cd	µg/L	0.4
Chromium	Cr	µg/L	6
Cobalt	Co	µg/L	13
Copper	Cu	µg/L	2.5
Lead	Pb	µg/L	6.6
Manganese	Mn	µg/L	2500[a]
Nickel	Ni	µg/L	13
Zinc	Zn	µg/L	15[a]

Note: trigger values apply to filtered samples and are to be modified to account for hardness

A previous licence (WDL177-04 to 8) had four groundwater sites that were included in the sampling regime. These were removed in 2016. As such there are no trigger values currently exist for groundwater.

3. SURFACE WATER

The Project area is currently under care and maintenance. However, water management activities continue to be conducted on site and include:

- Routine surface and groundwater monitoring.
- Water treatment of contact water.
- Licenced discharge when required as per the requirements of WDL (177-10), and
- Recovery of seepage from TSF1.

The surface water management strategy aims at preventing poor quality water entering the Sediment Dam.

3.1 Site Features and Layout

Water management infrastructure was predominantly built following the Project entering care and maintenance. The current infrastructure consists of the following:

- Storm water drainage systems comprising open channels and underground drains, including diversion channels that were installed in 2018 that directed overflow from the stockpile bunds to the open mine pit.
- Containment bunds to capture contact water from ore stockpiles. In 2018, overflow pipes were installed in the stockpile bunds to provide wet weather overflow capacity to prevent overtopping and damage to the bunds.
- A pit, which is not being mined, acts as a water collection point where pumps are stationed to direct water to the Water Treatment Plant (WTP).
- Rainfall catchment ponds and sumps with dedicated pumps to direct water to the WTP.
- Diversion channels to direct rainwater runoff around the site were implemented in 2018/19.
- Several dedicated pumps to direct water collected from the pit and stockpile bunds to the WTP for treatment.
- Dedicated pipework to direct treated water from the WTP to the Sediment Dam.
- Pre-settlement ponds to naturally filtrate water as it flows to the Sediment Dam.
- A Sediment Dam to collect treated water.
- Discharge outlet to facilitate the controlled release of water from the Sediment Dam to the East Finniss River (via Middlebrook Creek) under Waste Discharge Licence WDL177-10.
- Groundwater abstraction bores located along the TSF southern boundary to collect seepage water. Only one pump is currently operational.

Water containment areas are described in the section below with a summary of their respective holding capacity provided in **Table 3-1**.

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Table 3-1- Water Containment Volumes

Storage	Approximate Storage Capacity (m^3)
Water Treatment Plant (WTP)	3,354
Black Shale Stockpile (BSS)	9,000
PAF Stockpile (PAF)	8,000
Stockpile 3 (SP3)	14,000
Site Run Off Pond (SRO)	14,000
Sediment Dam (including settling ponds)	125,000
Tailings Storage Facility (TSF)	970,054
Open Pit (PIT) at 57m AHD	609,000

3.1.1 Oxide Open Pit

The oxide open pit is located in the northeast corner of the project area and is not being actively mined. The height of the eastern wall (pit safety berm) was raised in 2011 following the flooding of the pit by overflow from the East Finniss River during Cyclone Carlos.
The water level in the open pit was previously held at a level between 55 and 60 m AHD. Assessments in 2011 indicated that the water level in the oxide open pit should be maintained at a level not higher than 55.8 m AHD (at a level slightly below the bed of the East Finniss River) to inhibit seepage from the pit.
Historically the water treatment program finishes at the end of the wet season and pit water only being pumped when required to supply the plant with process water. Currently NTR runs the water treatment plant periodically throughout the dry season to replenish the site's fire and process water ponds as well as topping up the Sediment Dam as treated water evaporates. At the end of the dry season the pit level is approximately 54.5 AHD ready for the oncoming wet season.

3.1.2 Tailings Storage Facility

TSF 1 is located in the western area of the site and comprises the following:

- Internal lining of compacted clayey soil;
- Earth rockfill for the external embankment;
- Clay bund forming the external embankment for the potentially acid forming (PAF) waste storage area; and
- 0.5 m thick protective layer of rockfill placed loose over the face of the embankment.

The TSF was constructed in 2005 to contain tailings from mining Copper, Nickel and Cobalt from an open cut mine. The TSF is about 600 m long (from east to west) and 300 m across. In August 2008, 200,000 t of tailings and 530 ML of acidic, metal-laden liquor from the processing plant were discharged to the TSF. No tailings have been deposited in the facility since the Project went into care and maintenance. The only material that enters the facility are:

- Direct precipitation,
- Small quantities of seepage water pumped from recovery bores,
- Storm water runoff pumped from the SRO pond during extreme rain events; and
- Precipitate (sludge) pumped from the WTP when settling tanks are cleaned out.

The TSF has a storage volume of 970,000m^3 however the TSF is not used as a water storage facility and is considered a closed system with no additional stormwater runoff directed to the

facility. In an emergency wet weather event, water can be pumped from the SRO to the TSF to prevent uncontrolled off-site discharge.

3.1.3 Sediment Dam

The Sediment Dam is located to the south of the open pit and receives flows of treated water from the WTP, direct rainfall, and rainfall runoff from a portion of the site via the Pre-Settlement Ponds. The Sediment Dam has a storage capacity of 125,000m^3, with a maximum storage depth of 4 m at the deepest point. Water from the Sediment Dam is discharged to the EBFR via Middlebrook Creek during high flow periods in accordance with WDL177-10.

3.1.4 Site Run Off Pond (SRO)

The Site Run Off Pond (previously known as the Small Sed Dam) (**Figure 3-1**) is located in the north-west corner of the site, and collects run-off from roads and water which falls onto the TSF embankments. It is approximately 13 m by 21 m with a maximum holding capacity of 11,000m^3. There are two (2) pumps located at the SRO. One pumps water to the WTP and in the case of extreme rainfall, both pumps can be directed to the TSF to prevent water running off the property.

Figure 3-1 - The SRO Pond prepared after Sediment Cleaned Out – Dry Season Maintenance Program

3.1.5 PAF Stockpile (PAF)

The PAF Storage area (Figure 3.2) is used to store potentially acid forming material. This area is bunded and contact water from the containment area is pumped directly to the WTP using a dedicated pump. NTR constructed diversion channel in 2018 to direct water to the pit during times of extreme rainfall. This is discussed in more detail in **Section 3.4.3**.

Figure 3-2 – PAF Catchment Pond – looking west to the TSF wall

3.1.6 Stockpile 3 (SP3)

Stockpile 3 containment area (previously referred to as the low-grade stockpile) contains both intermediate and low-grade stockpiles (**Figures 3-3 and 3-4**). This area is bunded and a dedicated pump directs water to the WTP. In response to an overflow incident in January 2018, an emergency spillway and diversion channel was constructed so that overflow water is directed to the pit (**Section 3.4.3**).

Figure 3-3 – SP3 Catchment Pond – The Dry Season

Figure 3-4 - SP3 Catchment Pond – The Wet Season

3.2 Water Treatment Plant (WTP)

The Browns Project site has a small network of open and underground drains, bunded containment areas and concrete sumps to collect contact water. This contact water is pumped from the containment areas to the water treatment circuit (or 'WTP') within the plant facility (**Figure 3-5**). Contact water is captured and pumped to the feed pump box in the WTP. The pipe configuration allows for the feed water input lines to be operated individually or at the same time depending on site requirements. The pit water only slightly exceeds the WDL trigger values and is used as the main feed source to the WTP and is used to blend the stockpile contact water.
In March 2017, the DPIR approved a change from sodium carbonate to hydrated lime as the key reagent for the precipitation of dissolved metals. In October 2017, NTR began reconfiguring the processing plant to facilitate this transition and the new circuit was commissioned in December 2017.

Figure 3-5 – Processing Plant – Refurbished for Treatment of Contact Water (looking southwest)

Figure 3-6 illustrates the process flow for the WTP. Feed water enters the treatment system via Tank #1 and then flows by gravity through Tank #3, Tank #5 and then Tank #7. These three tanks have agitators in place to facilitate the circulation of the lime through the water column. Flocculant is introduced into Tank #7 via a distribution pipeline at a constant flow rate. The flocculant aggregates the precipitated metal particles while gently agitating the water to keep the particles in suspension. This water is then gravity fed into CCD1 and LTT Tanks concurrently. These tanks provide no agitation. This enables the metal precipitate to settle to the bottom of the tanks where it collects as a metal precipitate slurry.

Treated water flows over the launders at the top of the tanks where it collects in each of the respective overflow tanks. From these overflow tanks the water is then pumped to the CCD2 Tank. This tank represents the 'clean' (treated) water which is then piped via the underflow pump to the Pre-Settlement Ponds within the Sediment Dam facility. There is a water quality sampling point (TREAT1) under CCD2 Tank. This sampling point is a WDL 177-09 monitoring site and is sampled weekly during discharge events.

Water released from the Pre-Settlement Ponds meanders through a series of vegetated ponds connected via vegetated channels that facilitate the natural filtration of the water. Water from the Sediment Dam is discharged by a valve-controlled pipeline to a naturally vegetated wetland area that also receives unimpacted flows from Middlebrook Creek. The compliance point (SITE5) for WDL177-10 is about 200 m downstream of the wetland near the fence line that separates the Browns Site from the former Rum Jungle mine site (**Figure 2-4**).

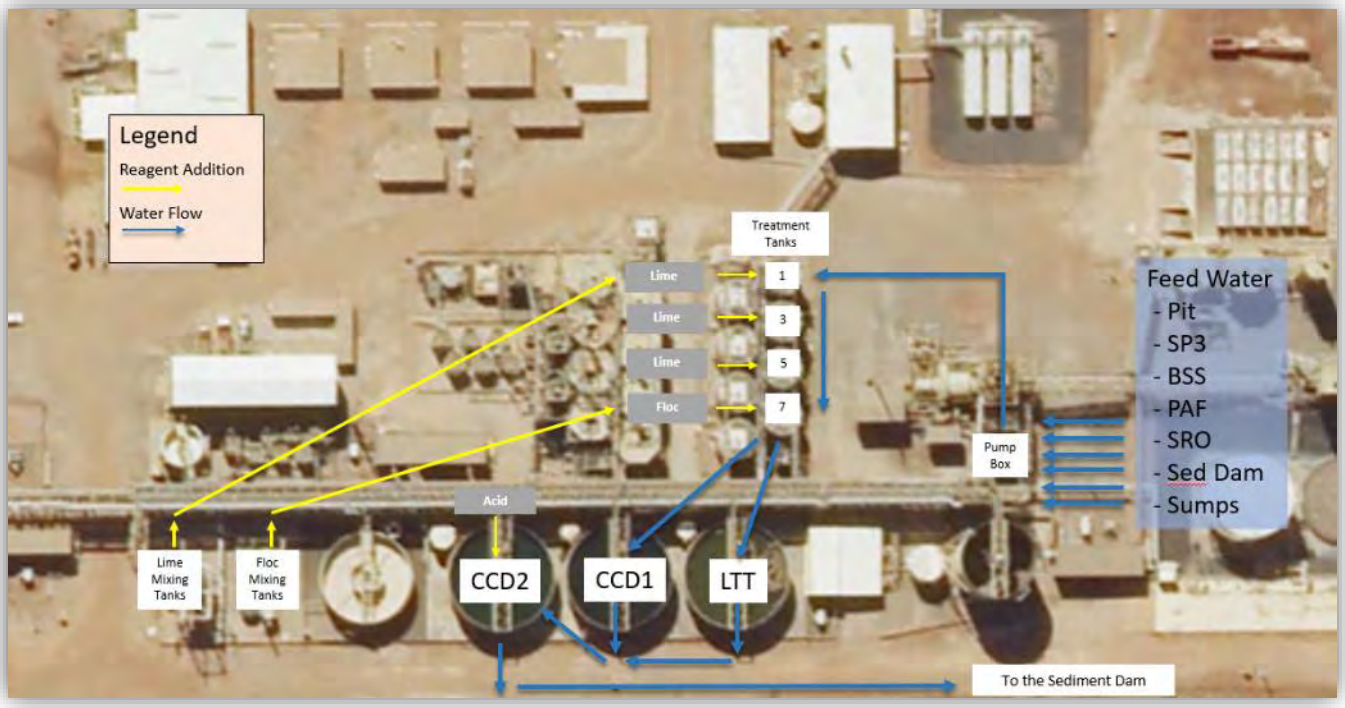


Figure 3-6 – Water Treatment Plant Process Flow

3.3 Controlled Discharge

Water from the Sediment Dam is discharged by a valve-controlled pipeline to a naturally vegetated wetland area that also receives unimpacted flows from Middlebrook Creek. The compliance point (SITE5) for WDL177-10 is about 200 m downstream of the wetland near the fence line that separates the Browns Site from the former Rum Jungle mine site.
WDL177-10 authorises wastewater discharge to the EBFR via Middlebrook Creek. Wastewater is defined as water containing a contaminant or waste, e.g. dissolved metals. Wastewater released from the site is a mixture of storm water (rainfall runoff) from the site that reports to the Sediment Dam and treated effluent from the water treatment system. Wastewater discharge is only authorised by WDL177-10 when the following criteria are satisfied:

- The river height at the gauge board adjacent to station GS8150200 is 1.50 m or higher.
- The pH of wastewater in the Sediment Dam at Site 2 is between pH 6.5 and pH 8.5.

Figure 3-7 – DAMOUT1 – Licenced Discharge Event

Figure 3-8 – GS200 Gauging Station East Finniss River

The 1.50 m river height on the gauge board equates to a flow rate of 1 m^3/s in the EBFR at station GS8150200 (**Figure 3-9**). Station GS8150200 is located downstream of the bridge at the former Rum Jungle mine site (**Figure 3-8**). It records the combined flow from the East Finniss Diversion Channel (EFDC) and EBFR flows through the Rum Jungle (RJ) Main Pit and RJ Intermediate Pit. Together, these flows comprise the total flow in the EBFR downstream of the central mining area at the former Rum Jungle mine site. Water quality in the EFDC is routinely monitored at SITE1 as part of WDL177-10.

Water released when the stream flow in the EBFR exceeds 1 m^3/s is referred to as a 'controlled discharge event'. An hourly flow-duration curve for EBFR at Station GS8150200 is provided in **Figure 9-4.** There are normally several controlled discharge events each Wet Season, although the number depends on the amount of rainfall that the EBFR catchment receives.

Uncontrolled discharge may enter Middlebrook Creek via an emergency spillway at the southwest corner of the Sediment Dam located at sample point DAMOUT2. Uncontrolled discharge can occur during periods of intense rainfall when the water level in the Sediment Dam exceeds 5 m depth (or 66.3 m AHD). The spillway is located upstream of SITE5.

The controlled discharge enters Middlebrook Creek via a hand-controlled siphon (**Figure 3-7**). Middlebrook Creek and the discharge enters a densely vegetated wetland and flows through WDL Site 5. The wetland is expected to assist in water treatment to a limited extent. Wandering Creek is situated to the east of Middlebrook Creek (located off the mining lease) and is impacted by seepages from Rum Jungle's Overburden Waste Rock Dump (WRD) and Rum Jungles Intermediate Overburden WRD. Wandering Creek enters Middlebrook Creek downstream of SITE5 and then flows to the EBFR.

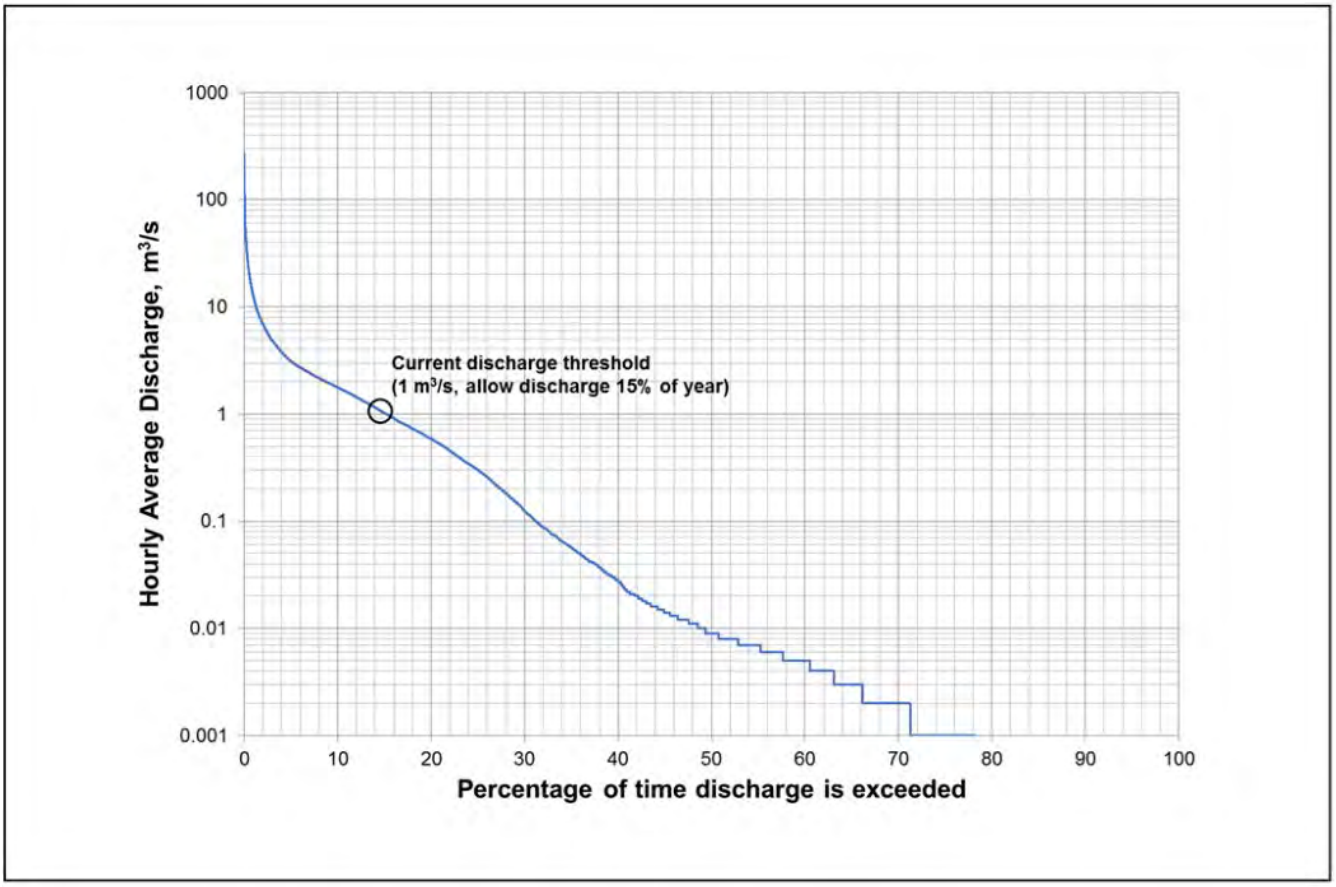


Figure 3-9 – Hourly Flow-Duration for EBFR at Station GS8150200 (RGC, 2018)

3.4 Stormwater Management

3.4.1 Rain Water Catchment Areas

There are several rainwater catchments within the Project site. These are presented in **Figure 3-10** and described in **Table 3-2.**

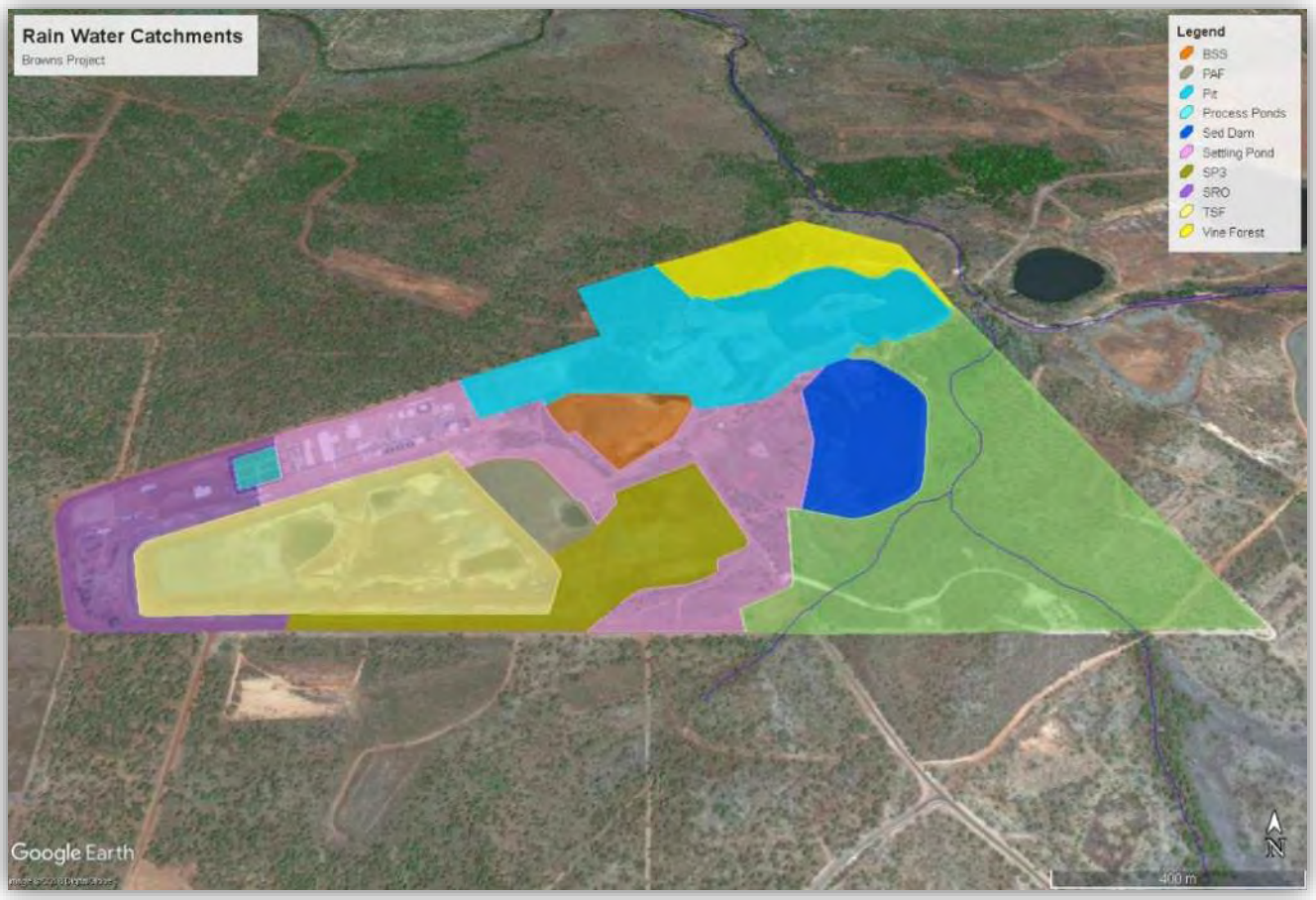


Figure 3-10 – Current Rain Water Catchments – Browns Project

The table below describes the current site configuration highlighting proposed improvement projects planned for the upcoming reporting period.

Table 3-2 – Rain Water Catchment Area Description

Catchment Name	Approximate Area (ha)	Water Quality	Water Management Strategy
Site Run Off (SRO)	10	Collects contact water from the western TSF wall and run off from the site laydown area and roads.	This water is pumped to the WTP for treatment. Pipework is configured to enable water to be redirected to the TSF in times of extreme rainfall where the SRO level is increasing rapidly. There is also a 2nd pump installed to reduce the risk of water overflowing off the property.
Process Water Ponds	0.8	The two southern most ponds hold water pumped from the WTP. One pond is used for process water throughout the plant and buildings while the other is a reservoir for fire suppression systems.	The southern pond is treated water from the plant and is the sites raw water supply (fire systems etc). Middle ponds are empty or collect rainfall. The northern pond is now collection from the TSF recovery bores and sent to the WTP.

Catchment Name	Approximate Area (ha)	Water Quality	Water Management Strategy
Settling Pond	27.4	This catchment receives run off from the processing plant (including a small section of the TSF wall and the roadway from the plant to the settling pond.	Currently this water collects in open channels which discharge into the settling ponds.
Pit	31.4	This catchment is the largest reservoir on site and collects the water that falls directly within the pit boundary, water from the old ROM pad and parts of the Vine Forest to the north west of the pit.	This water is pumped to the WTP for treatment. Two pumps service this catchment. This is the main feed water for the WTP and other waters are blended with it as the pit water pH is usually around neutral mark. A diversion drain and emergency spillways were constructed in 2018 to reduce the risk of untreated runoff entering the sediment dam.
Black Shale Stockpile (BSS)	4.7	This catchment collects contact water that falls on the Black Shale and Dolomite stockpiles located in within this area.	This is pumped to the WTP and blended with Pit water.
TSF	22.8	This is a closed basin and collects rainfall that falls directly within this area. Residue from the WTP is pumped to the TSF when tanks are cleaned and water from the SRO may be pumped here during times of extreme rainfall if there is a risk of the SRO overflowing.	This water is left in-situ to evaporate. A new recovery bore was installed in 2018 and seepage water is captured, stored in the PLS Ponds and directed to the WTP for treatment.
PAF Stockpile (PAF)	3.6	This catchment collects contact water that falls on the PAF stockpile adjacent to the TSF.	This is pumped to the WTP and blended with Pit water.
Stockpile 3 (SP3)	10.4	This catchment collects contact water that falls on the Low-Grade stockpiles located in within this area.	This is pumped to the WTP and blended with Pit water.

Catchment Name	Approximate Area (ha)	Water Quality	Water Management Strategy
Sediment Dam	10.3	This catchment collects the treated water from the WTP and any run off that passes through the Settlement Ponds.	This water is discharged to the Wetland Catchment when conditions of the WDL177-10 are met.
Wetland	41.7	Water enters the site via Middlebrook Creek and another ephemeral creek which enters the site from the southern site boundary and flows off site via Site 5 on the north-eastern site boundary.	This water mixes with discharge water from the Sediment Dam flowing through a natural wetland system which polishes the water before flowing off site via monitoring SITE5.
Vine Forest	11.0	This catchment is relatively undisturbed and is unimpacted by the site operations.	The pit is protected from water ingress by a 1.5 – 2m safety berm. The water from this catchment flows off site onto the EBFR floodplain.

Improvements to the collection of site contact water are presented in Section 3.4.3 and include an updated Catchment map (**Figure 3-13**)

3.4.2 Dedicated Pumps

There are several mobile diesel pumps dedicated to the water treatment on the Project site (**Table 3-3**). There are eight water storage catchments, five of which require water to be pumped to the WTP for treatment. All pumps are set up at five of these locations, with two (2) located at SRO and two (2) located at the open mine pit.
Stainless steel pumps are designated to catchment ponds that are characterised by low pH and the cast iron pumps are allocated to either the Pit, SRO or SP3 catchment ponds.

Water is pumped using 200mm polyethylene pipes from the catchment areas to the WTP. There are several smaller pumps that are used for evacuating water from WTP sumps and bunded areas. This water is also sent to the WTP for processing. Preventative maintenance (PM) is performed per manufacturers recommendations on all fixed and mobile plant.

Table 3-3 – Dedicated Water Management Pumps

Equipment ID	MODEL #	Water Pump Type/Size	Water Pump Material	Approximate Flow Rate (l/s)
Kubota pump set	V2203-ES01	6 x 4 DURCO Pump	Stainless Steel	40- 50
Cummins set # 1 Series B33	4BTA3-9-C	Davey Pump 150x125x315	Cast iron	50- 60
Cummins set # 2 Series B33	4BTA3-9-C130	Davey Pump 150x125x315	Cast iron	50- 60
Cummins set # 3 Series B33	150/125/400	Davey Pump 150x125x400	Cast iron	50- 60
Cummins set # 4 Series B33	QSB3.3	F.P.S Pump 125x100x315	Stainless Steel	30- 40
Cummins set # 5 Series B33	QSB3.3	F.P.S Pump 125x100x315	Stainless Steel	30- 40
Cummins set # 6 Series B33	QSB3.3	F.P.S Pump 125x100x315	Stainless Steel	30- 40

3.4.3 Diversion Drain and Emergency Spillways

The 2018 MMP proposed a few improvements to the water management infrastructure which included;

1. The installation of a diversion channel to direct water to the pit, and
2. The installation of emergency spillways to direct water from SP3, BSS and PAF catchments to the pit.

These improvements have been installed and are now operational.
The map below (**Figure 3-11**) illustrates the location of the new infrastructure. There are several benefits to this proposal including;

- Reduced risk of untreated water being able to enter the Sediment Dam.
- Emergency spillways will prevent stockpile catchments from breaching their bund walls and protects the integrity of the bund walls during extreme rain events.
- Improved efficiency of pumping efforts during extreme rain events. Emergency spillways will enable pumping effort to be focused on the pit, if required, where two pumps are stationed as this area has the greatest storage capacity.

The existing open drain is still utilised and new works key into the main drainage line. There are three spillways with the SP3 spillway. The dimensions are listed below and illustrated in **Figure** 3-12.
The Diversion Drain and the SP3 Emergency Spillway have been constructed to the same specifications as each other, which replicate the dimensions of the existing drainage channels. The existing drainage channels were built prior to the stockpile catchments being constructed and were built with sufficient capacity to manage the flows from these areas.
Each drain is 3m wide at the base and 1.8m in depth with the walls battered on a 2:1 gradient. Safety Berms have been constructed along the edge of each drain to a height of 1.2m, maintaining the 2:1 gradient.

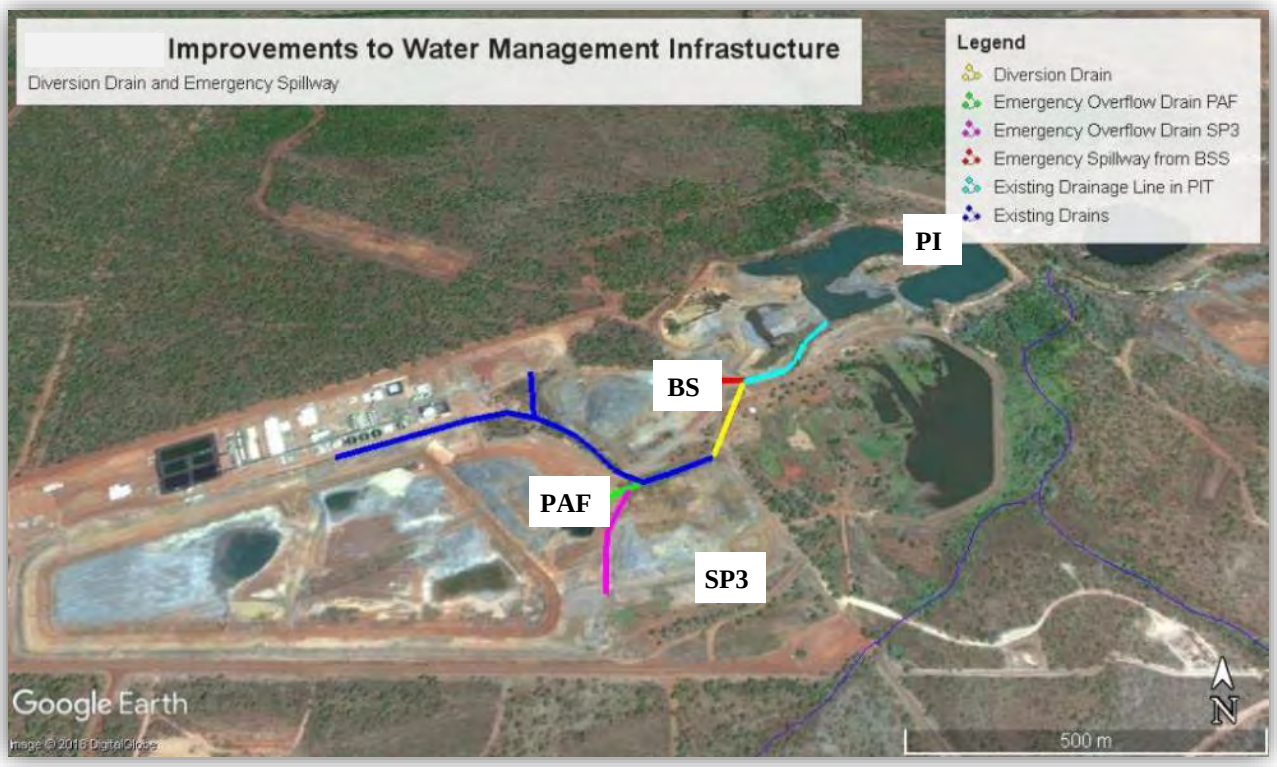


Figure 3-11 –Changes to Water Management Infrastructure

3.4.3.1 Diversion Drain

The Diversion Drain keys into the end of the existing drainage channel prior where it currently discharges into the open mine pit. The drain diverts water away from the Sediment Dam and directs water into the open pit. This Diversion Drain (will ensure all stormwater from the Processing Plant and a small section from the TSF wall discharges into the open pit. This Diversion Drain also captures and directs all water from the emergency spillways from SP3 and PAF to the open pit.
The Diversion Drain (**Figure 3-14**) was excavated to a 0.5% gradient and dug in a north, north east direction for ~200m, where it terminates in the open pit via a disused ramp.
The western wall of the spillway will have storm water entry points every 40m along the berm and any areas where there is potential for water to pool. The eastern safety berm is continuous and prevents any contaminated water entering the Pre-Settlement Ponds.
The drain is open along its full length except for one road crossing where culverts are installed (**Figure 3-15**). The juncture where the drain intercepts the ramp has rock armouring and whoa boys to slow water down and mitigate any erosion of the ramp.

3.4.3.2 SP3 Catchment Emergency Spillway

The SP3 Emergency Spillway was excavated within the existing catchment area and follows natural contours of the land. The opening of the spillway keys in at the western end of the existing pond which is located within the catchment area and not on the boundary wall. The height of the spillway has been surveyed to allow an 700mm freeboard along the boundary bund walls of the pond. This will protect the integrity of the bund walls and removes the need for any changes to the existing pump location.

The spillway was excavated to a 0.5% gradient in a north, northeast direction for 210m, where it keys into the existing open drainage channel. The western wall of the spillway has storm water

entry points every 40m along the berm and any areas where there is potential for water to pool. The eastern safety berm is continuous and will redirect any water that falls on the stockpiles back down to the catchment pond. An all-weather access track has been constructed adjacent to the drain and facilitate all weather access to the pumping station. The confluence of the spillway and the existing drain was constructed with rock armouring to prevent erosion.

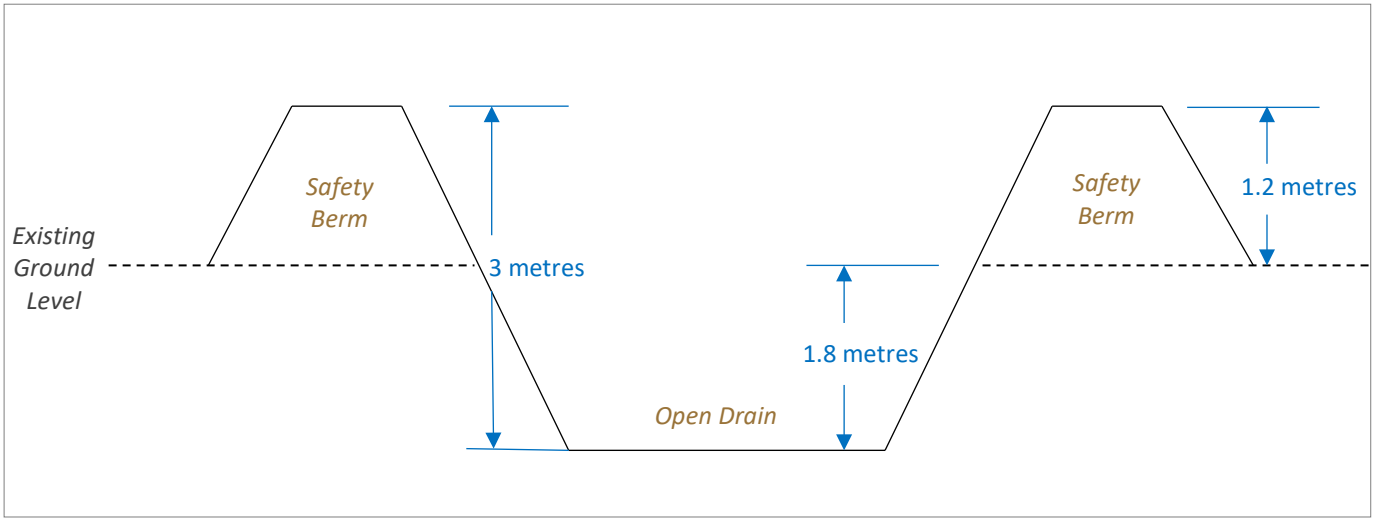


Figure 3-12 – Drain Cross-sectional Profile

3.4.3.3 PAF Emergency Spillway

This catchment area is significantly smaller than SP3 and does not require the excavation of a drainage channel. The emergency spillway for this catchment pond involved the installation of an overflow point along the PAF bund wall, directly adjacent to the existing drainage channel. Buried pipes will transport the overflow water ~65m where it will discharge into the existing drain.

3.4.3.4 BSS Emergency Spillway

This catchment is located only ~50m from the termination of the Diversion Drain. As such the emergency spillway was constructed along the same principle as PAF. An overflow point will be installed along the BSS bund wall and water was channelled via buried overflow pipes which will discharge at the same point at the Diversion Drain.
The new catchment areas are displayed in **Figure 3-13**.

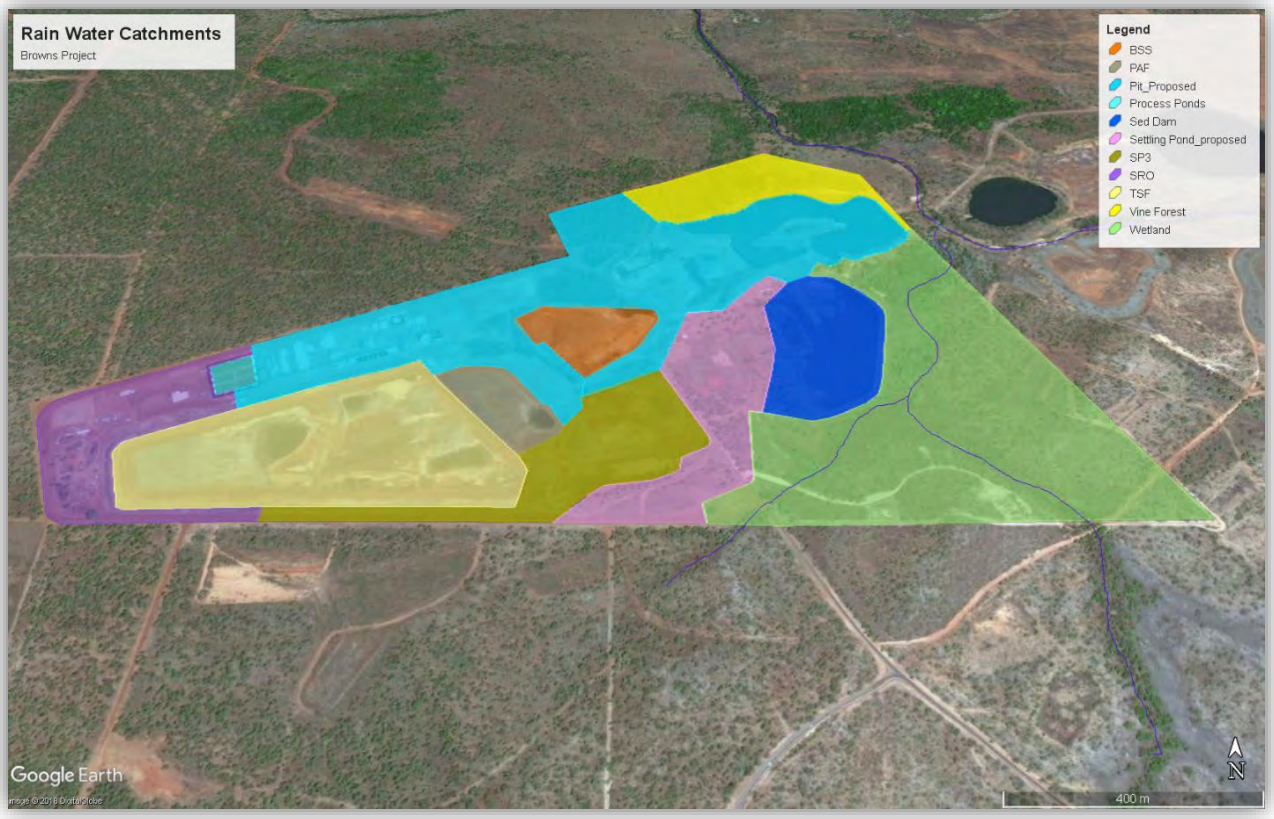


Figure 3-13 – Updated Catchment Map with Changes Associated with the Installation of the Diversion Drain

Figure 3-14 –Diversion Drain to Open Pit

Figure 3-15 –Road crossing (with pipes) along the Diversion Drain

4. SURFACE WATER DATA ANALYSIS

A surface water quality review was completed by RGC in February 2018 and this full report is available in **Appendix 1**. Below is an extract from the main report with a statistical summary of surface water quality available in Appendix E of the RGC (2018) report and surface water quality time trends in Appendix F of RGC (2018). Surface water monitoring continues in accordance with WDL-09.

4.1 Surface Water Flows

4.1.1 EBFR Flows (RGC, 2018)

Hourly flows in the EBFR from 2009 to 2017 are shown in **Figure 4-1**and a statistical summary of monthly flows is provided in **Table 4-1.** The table provides mean, minimum, and maximum monthly flows in the EBFR and the number of months for which there are data available.

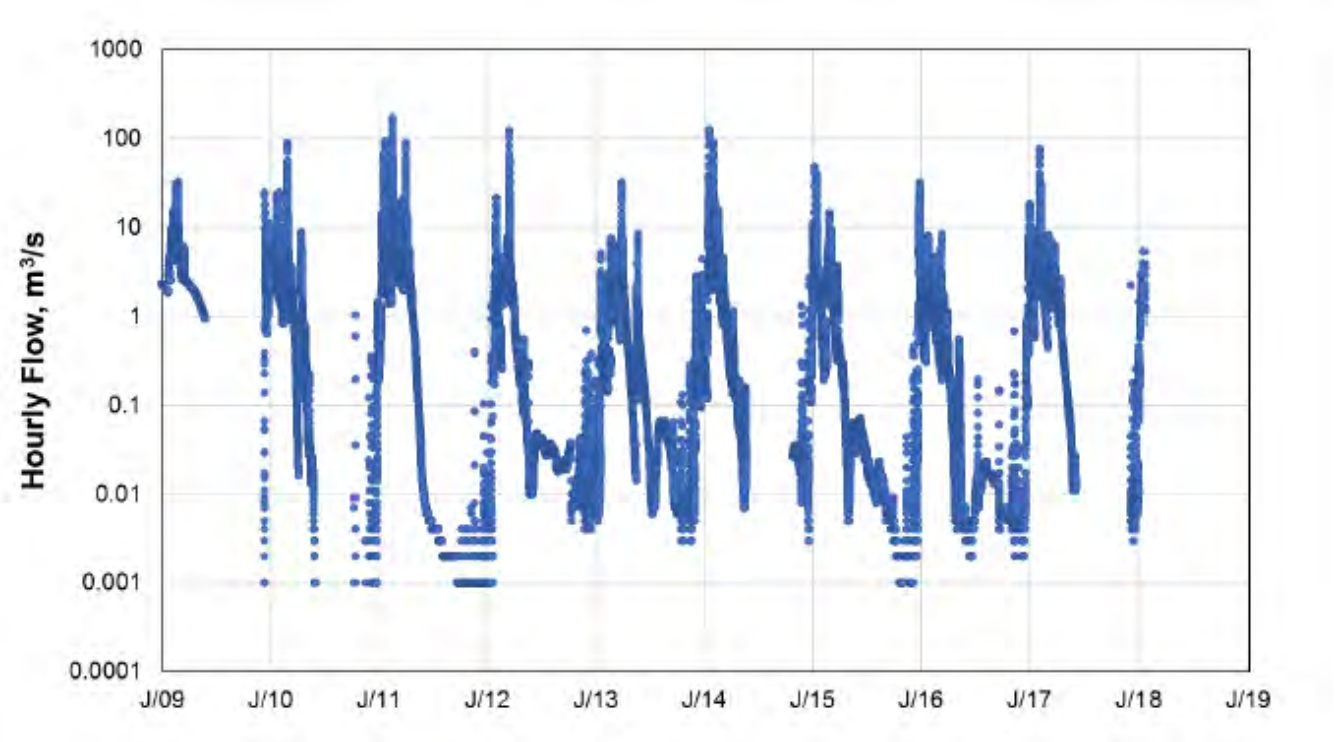


Figure 4-1 – Hourly Flows at GS8150200, 2009 to 2018

On average, EBFR flows exceed the 1 m^3/s threshold for controlled discharge about 55 days per year or about 15% of the time. The historic flow record for gauging station GS8150200 indicates that the number of days when flow exceeds 1 m^3/s varies substantially from year to year. In 2010/2011, which included Cyclone Carlos, the flow was greater than 1 m^3/s for 109 days or almost 30% of the year. In the extreme drought recorded in 1985/1986, the river's flow was greater than 1 m^3/s for only 14 days or less than 4% of the year.

Table 4-1 - Summary of EBFR Flow, 2009 to 2017 (RGC, 2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean flow, m^3/s	2.7	4.6	2.5	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6
Minimum flow, m^3/s	0.2	0.9	0.6	0.1	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Year recorded	2013	2013	2016	2016	2015	Multiple	Multiple	Multiple	Multiple	Multiple	2017	Multiple	2016
Maximum flow, m^3/s	5.7	11.8	5.9	5.2	0.4	0.2	0.03	0.05	0.02	0.02	0.03	2.2	0.7
Year recorded	2011	2011	2012	2011	2013	2013	2012	2013	2012	2012	2014	2015	2015
No. of months	8	9	9	9	7	6	6	6	6	6	7	6	4

4.1.2 Controlled (Licenced) Discharge Events

Table 4-2 summarises the licensed discharge events for the 2016/2017, 2017/2018, 2018/2019, 2019/2020, 2020/21 and 2021/22 Wet Season.

Table 4-2 - Licenced Discharges for the Wet Seasons since 2016/17

2016/17 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
30-Dec-16	10:02	06-Jan-17	8:00	166	53.6*
13-Jan-17	7:50	14-Jan-17	23:35	39.55	12.8*
24-Jan-17	10:38	27-Jan-17	7:08	70	23.9*
31-Jan-17	10:40	31-Jan-17	18:20	7.66	22.1*
02-Feb-17	7:20	02-Feb-17	18:12	11	2.5*
05-Feb-17	8:48	11-Feb-17	11:00	146.5	3.5*
16-Feb-17	11:20	17-Feb-17	22:00	32.5	47.2
22-Feb-17	10:20	22-Feb-17	18:50	8.5	27.10
05-Mar-17	7:40	09-Mar-17	18:10	82.5	7.40
12-Mar-17	7:15	25-Mar-17	8:10	312	73.10
11-Apr-17	13:10	13-Apr-17	18:05	77	83.20
18-Apr-17	7:40	21-Apr-17	7:15	96	49.50
			Total	1099.2	469.6
2017/18 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
18-Jan-18	16:55	20-Jan-18	7:20	37.5	32
22-Jan-18	0:32	22-Feb-18	18:25	755	443
5-Mar-18	8:30	8-Mar-18	6:30	70	44
18-Mar-18	2:25	20-Mar-18	6:57	57.5	48
19-Apr-18	7:21	21-Apr-18	4:55	45.5	44
			Total	965.5	611

2018/19 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
26-Jan-2019	15:12	13-Feb-2019	14:05	431	128
19-Mar-2019	23:15	21-Mar-2019	07:00	31	28
23-Mar-2019	07:32	25-Mar-2020	11:32	11	46
3-May-2019	11:20	6-May-2019	23:59	84	77
			Total	557	281

2019/20 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
27-Feb-2020	12:34	19-Mar-2020	20:49	513	270
11-Apr-2020	7:09	21-Apr-2020	0:46	223	129
			Total	736	399

2020/21 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
23-Dec-2020	08:25	31-Dec-2020	17:10	200	266
25-Jan-2021	08:24	31-Jan-2021	16:40	152	106
12-Feb-2021	05:40	22-Feb-2021	07:40	290	184
3-Mar-2021	10:10	11-Mar-2021	08:00	190	110
22-Mar-2021	11:35	4-Apr-2021	08:20	308	186
			Total	1,140	852

2021/22 Wet Season					
Valve Opened		Valve Closed		Duration	Volume Discharged
Date	Time	Date	Time	hours	ML
6-Jan-2022	09:37	7-Jan-2022	13:00	27	26
12-Jan-2022	11:25	24-Jan-2022	14:00	290	128
31-Jan-2022	09:30	7-Feb-2022	07:40	166	94
19-Feb-2022	08:25	1-Mar-2022	07:50	238	162
10-Mar-2022	08:50	12-Mar-2022	04:50	44	39
			Total	765	449

In 2016/17, there were 11 licensed discharge events and a total of 470 ML of water was discharged from the Sediment Dam. There was five licensed discharge events during the 2017/18 Wet Season. A total of 611ML was discharged during the 2017/18 season while an ungauged volume of water flowed over the emergency spillway for two days in January. The volume was very small and only overflowed for less than two days and never reached over 0.20m in depth. In 2018/19, there were four discharge events and a total of 281ML was discharged from the Sediment Dam. In 2019/20, there were two discharge events and a total of 399ML was discharged from the Sediment Dam. In 2020/21, there were five discharge events and a total of 852ML was discharged from the Sediment Dam. In 2021/22, there were five discharge events and a total of 449ML was discharged from the Sediment Dam.

4.2 Surface Water Quality

4.2.1 Water Quality Trends (RGC, 2018)

Surface water quality monitoring data collected from 2007 to January 19th, 2018, are provided in Appendix E of the RGC 2018 report (**Appendix 1**). Time trends for Site 5 are provided in **Figure 4-2 to Figure 4-6.** Time trends for SITE1, SITE2, SITE4, DAMOUT1, and DAMOUT2 are provided in Appendix F of the RGC (2018) report. The stations are ordered from upstream to downstream for ease of reference.
Selected surface water quality data for the WDL177-06 stations and others, i.e. the Rainwater Collection Ponds (RW) stations, are summarised in **Table 4-3** and shown in **Figure 4-7**. The data provided had the lowest Relative Percent Difference (RPD) (**Section 15.4.1**)values of any samples collected in 2017 and are considered reasonably representative of Wet Season conditions on site.

Table 4-3 - Selected Water Quality Water Results 2017 (RGC, 2018)

Location Code	Sampling Date	Field pH	Field EC	SO_4	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
Monitoring sites for WDL177-06 (upstream to downstream)															
TREAT1	27/04/17	9.6	810	140	<50	<0.2	3	3	<50	<5	5	2	<5	<5	15%
SITE2	22/02/17	7.7	326	98	<50	0.3	89	30	<50	97	43	1	<5	38	19%
DAMOUT1	22/02/17	7.1	317	98	<50	0.2	11	15	<50	90	31	1	<5	18	1%
SITE4	14/04/17	7.2	41	<2	<50	<0.2	<1	<1	<50	6	<1	<1	<5	<5	4%
SITE5	15/06/17	6.7	643	75	<50	<0.2	<1	20	<50	730	6	<1	<5	<5	6%
SITE1	29/05/17	4.6	2,392	1,800	4,000	13	2,000	4,400	17,000	7,800	3,600	<1	38	11,000	13%
Other surface water monitoring sites (pits, creeks, and effluent)															
RW_PIT	31/07/17	7.6	644	240	<50	0	10	75	50	290	67	4	<5	45	0.1%
RUMWHITE	12/01/17	6.1	157	48	<50	0	33	37	-	230	34	<1	<5	8	1%
RUMINTER	12/01/17	6.3	158	49	<50	0	55	35	-	240	36	<1	<5	10	7%
Rainwater collection ponds															
RW_TSF	27/04/17	4.6	703	280	3,700	2	13,000	2,100	<50	990	1,500	590	<50	530	14%
RW_SRO	27/04/17	6.3	42	8	<50	<0.2	45	19	<50	130	11	70	5	22	8%
RW_PAF	27/04/17	3.8	670	330	18,000	23	66,000	8,800	260	7,800	7,400	3,200	92	7,200	6%
RW_SP3	27/04/17	5.59	479	170	340	5	8,600	1,500	<50	3,200	1,000	1,400	6	1,300	3%
RW_BSS	27/04/17	4.1	545	110	4,000	3	55,000	5,300	110	4,100	2,700	2,300	150	990	63%
RW_POND	31/07/17	7.2	7	240	<50	0	19	51	<50	210	64	6	<5	36	1%

All raw data has been provided to the DPIR in digital format and compatible with ESDat software.

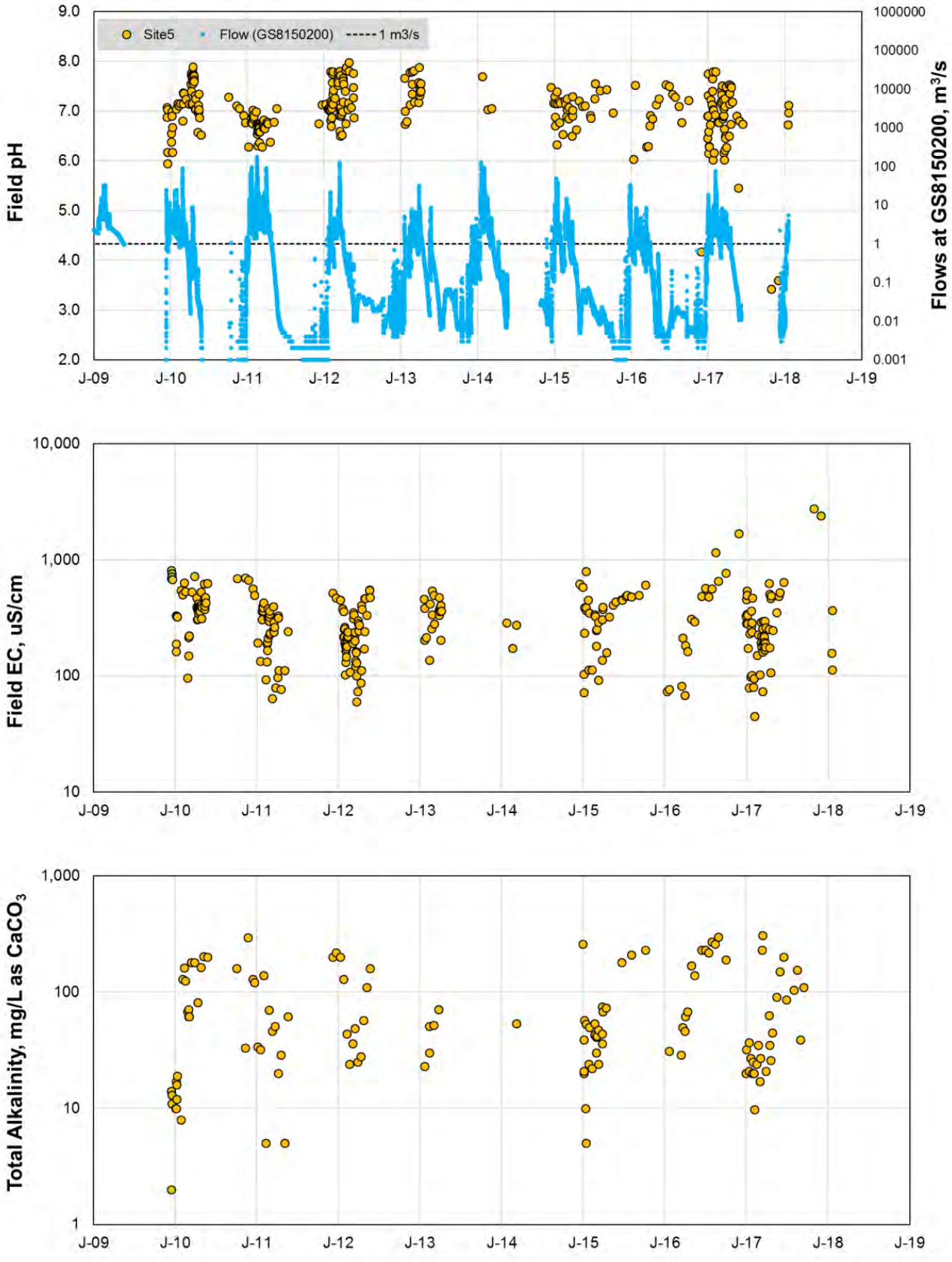


Figure 4-2 – Field pH, Field EC and Alkalinity at Site 5, 2009 to 2018 (RGC, 2018)

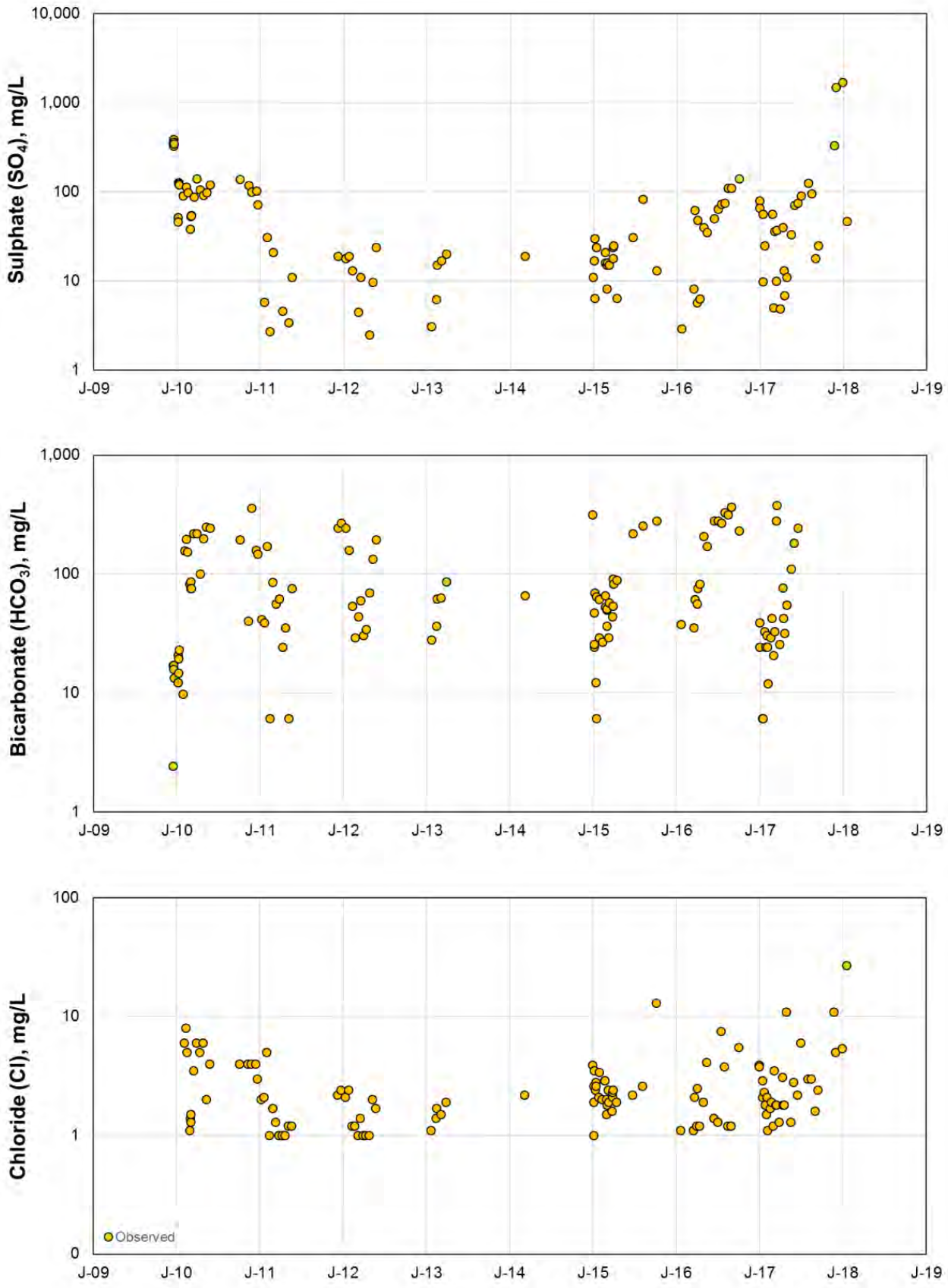


Figure 4-3 – Sulphate (SO_4), Bicarbonate (HCO_3) and Chloride (Cl) at Site 5. 2009 to 2018 (RGC, 2018)

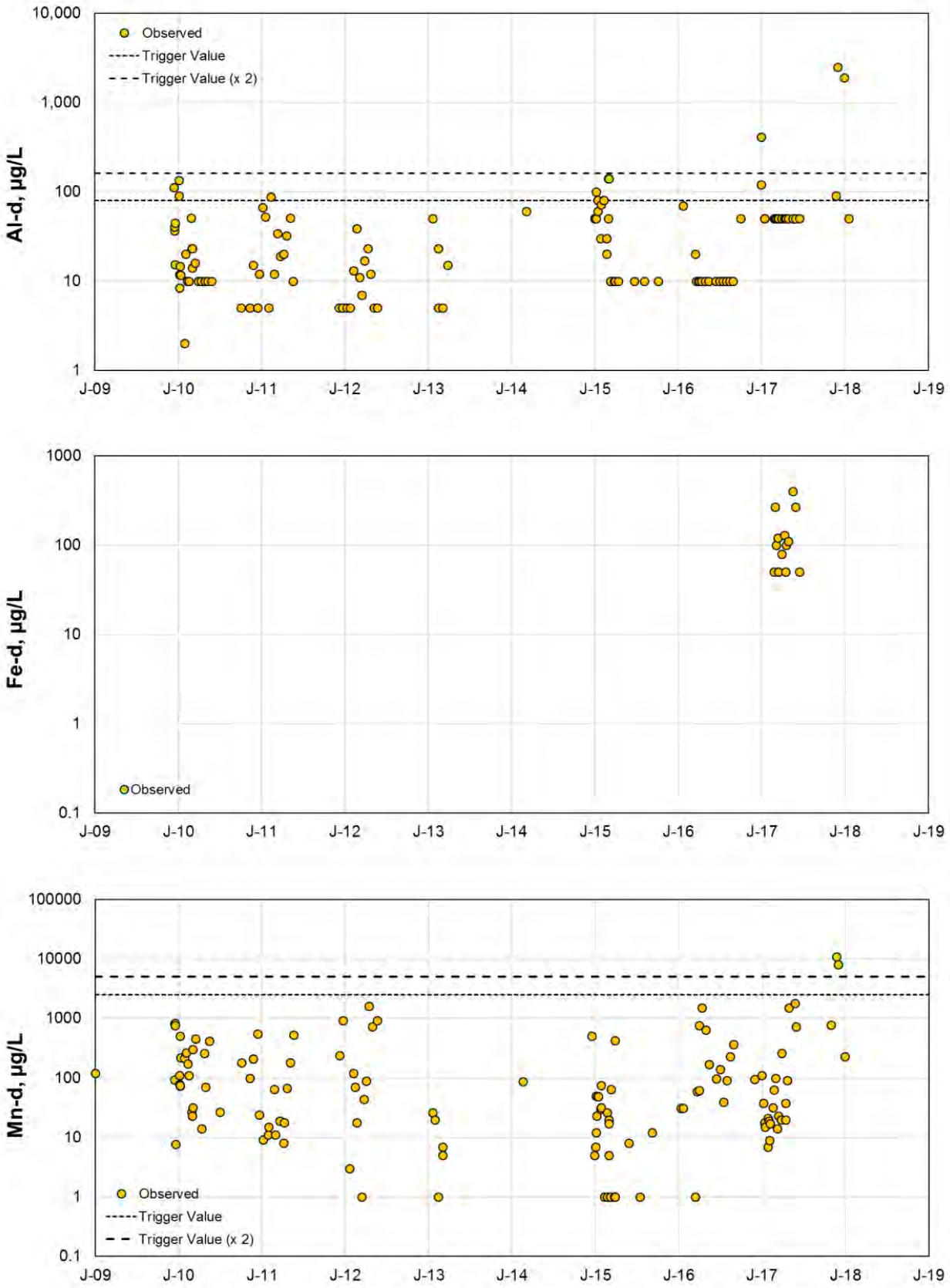


Figure 4-4 - Aluminium (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

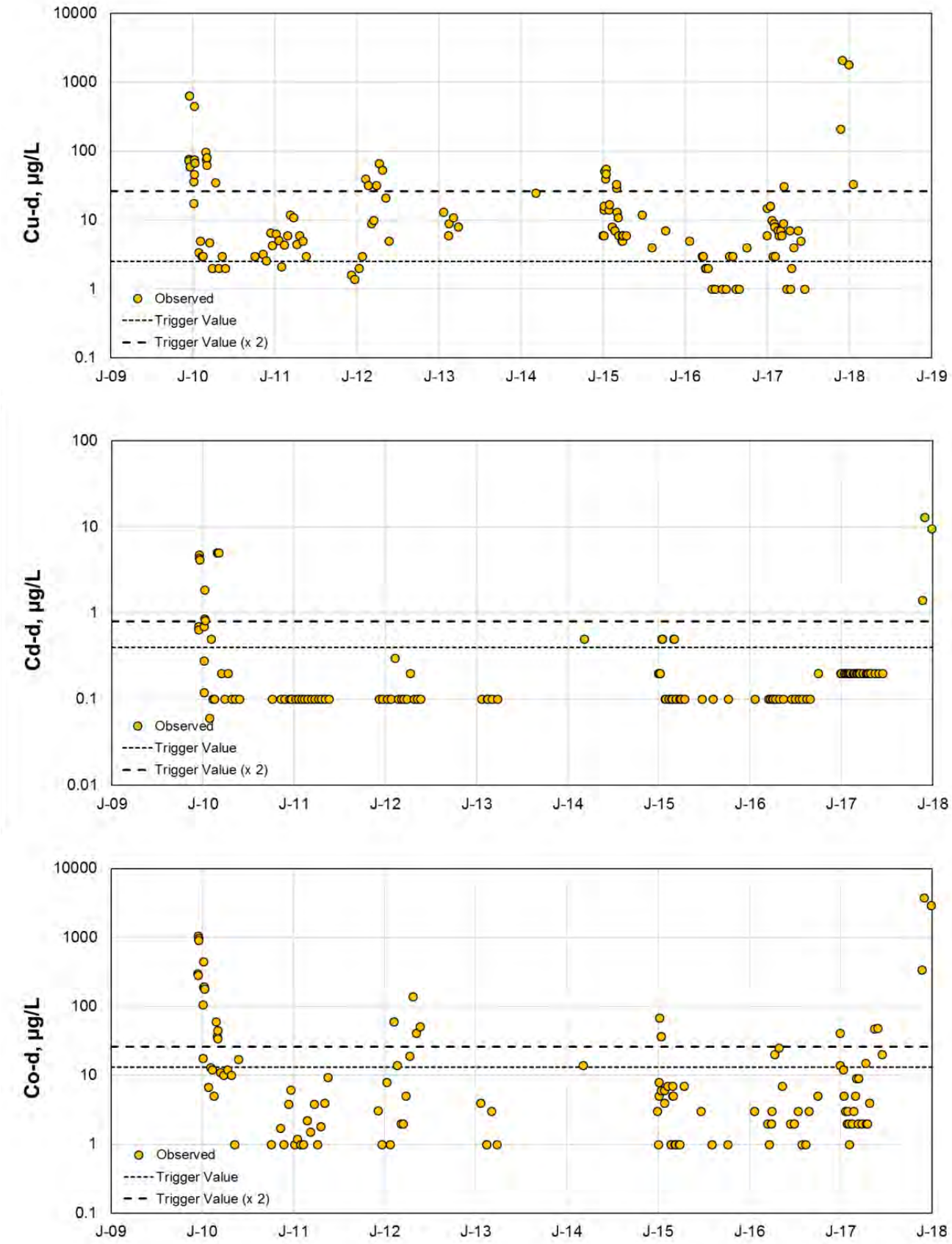


Figure 4-5 - Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

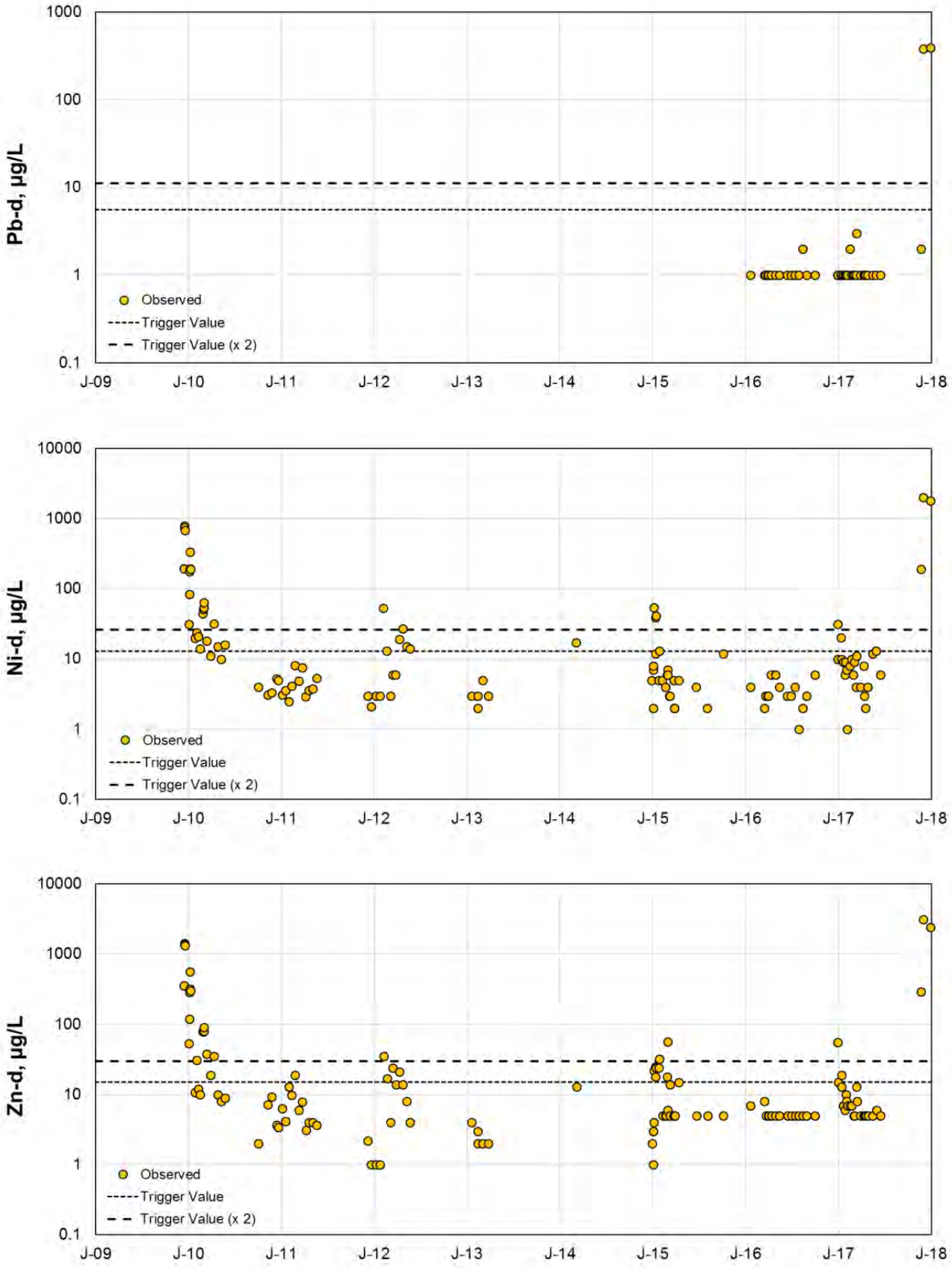


Figure 4-6 - Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

4.2.2 Key Observations of Surface Water Quality Data, (RGC, 2018)

Key observations noted by RGC (2018), are summarised below. Selected water quality has also been mapped in **Figure 4-7.**

Treated effluent at TREAT01

- Treated effluent released to the Sediment Dam from the water treatment system is typically alkaline (pH 9.6) and characterized by elevated bicarbonate and carbonate alkalinity. Effluent is characterized by elevated SO_4 and low metal concentrations, i.e. 3µg/L Cu, 3 µg/L Co, and non-detectable Zn concentrations in April 2017.

Sediment Dam at SITE2

- The pH of water in the Sediment Dam is typically neutral to slightly alkaline due to inflows of alkaline effluent from the processing plant (pH 9 to 10).
- Water contains some alkalinity and elevated SO_4, e.g. 98 mg/L in February 2017.
- Cu, Co, and Zn concentrations are often elevated, whereas other metals are near or below detection limits.

Controlled discharge from the Sediment Dam at DAMOUT1

- Controlled discharge water quality from the Sediment Dam is comparable to water quality at SITE2, except Cu, Co, and Zn concentrations are noticeably lower at DAMOUT1. DAMOUT1 is across the pond from SITE2, so the lower concentrations are likely related to the precipitation of metals within the pond as the concentration of SO_4 (which behaves conservatively) are identical at both stations.

Middlebrook Creek at SITE4 (upstream of boundary discharge)

- Unimpacted surface water flows at SITE4 are characterized by near neutral pH values, low alkalinity and EC, and non-detectable concentrations of SO_4 and most dissolved metals, i.e. all except Manganese.

Middlebrook Creek at SITE5 (downstream of boundary discharge)

- Boundary discharge from the site, wastewater is characterized by circum-neutral to slightly acidic pH, elevated EC and alkalinity, and metal concentrations that can exceed trigger values under some circumstances (see Section 4.2.3 for further discussion of SITE5).

EFDC at SITE1 (upstream of SITE5 at the former Rum Jungle mine site)

- Water samples collected from the EFDC at SITE1 are acidic (pH 3 to 5, depending on the time of year) and characterized by no appreciable alkalinity. SO_4 and dissolved metal concentrations are high, i.e. 2000 µg/L Cu in May 2017, due to ARD from the Intermediate WRD (immediately upstream of SITE1) and additional flows of seepage and ARD impacted groundwater from the Main WRD, Dyson's WRD, and Dyson's (backfilled) Pit.
- Downstream of SITE1 and SITE5, relatively clean flows from the Intermediate Pit (Rum Jungle) report to the EFDC during the Wet Season when the water level in the pit is 57.53 m AHD or higher. Water quality at gauge GS8150200 reflects the combined impact to the EBFR from the majority of the former Rum Jungle mine site and outflow from the Browns site. Flows from the former Rum Jungle mine site account for more than 99% of the SO_4 and metals in the EBFR.

A few key observations from other surface water monitoring stations are summarised here:

TSF Pond at RW_TSF

- TSF pond water is acidic and characterized by elevated metal concentrations. This water is a mixture of rainfall to the TSF, water from the SRO pond during high rainfall periods, and groundwater. Recovery bores BH4G and BH24 currently pump to PLS ponds for treating. (see Section 7.3.1 for further discussion).

Browns Pit at RW_PIT

- Pit water from the Browns Pit is slightly alkaline and characterized by appreciable alkalinity and low metal concentrations. The sample included in Table 4-3 was collected in July 2017 (Dry Season) and likely represents an intra-annual maximum due to evapo-concentration.
- Metal concentrations in the Browns Pit are lower than observed in the Main Pit (Rum Jungle) and the Intermediate Pit at the former Rum Jungle mine site during the Wet Season when EBFR flows through the pits and dilutes shallow pit water.

Rainfall runoff from the existing ore stockpiles (RWSP3, RWPAF, and RWBSS)

- Rainfall runoff from the existing stockpiles is often acidic (pH 3 to 4) and characterized by no appreciable alkalinity. SO_4 concentrations are elevated, i.e., 100 to 400 mg/L SO_4, and up to 66,000 µg/L Cu is observed in some samples. Metal concentrations are highest in runoff from the PAF (RW_PAF) ore stockpile and the Black Shale Stockpile (RW_BSS).

Further discussion of surface water flows and impacts and simulated loads to the water treatment system and the EBFR is provided in **Section 9.**

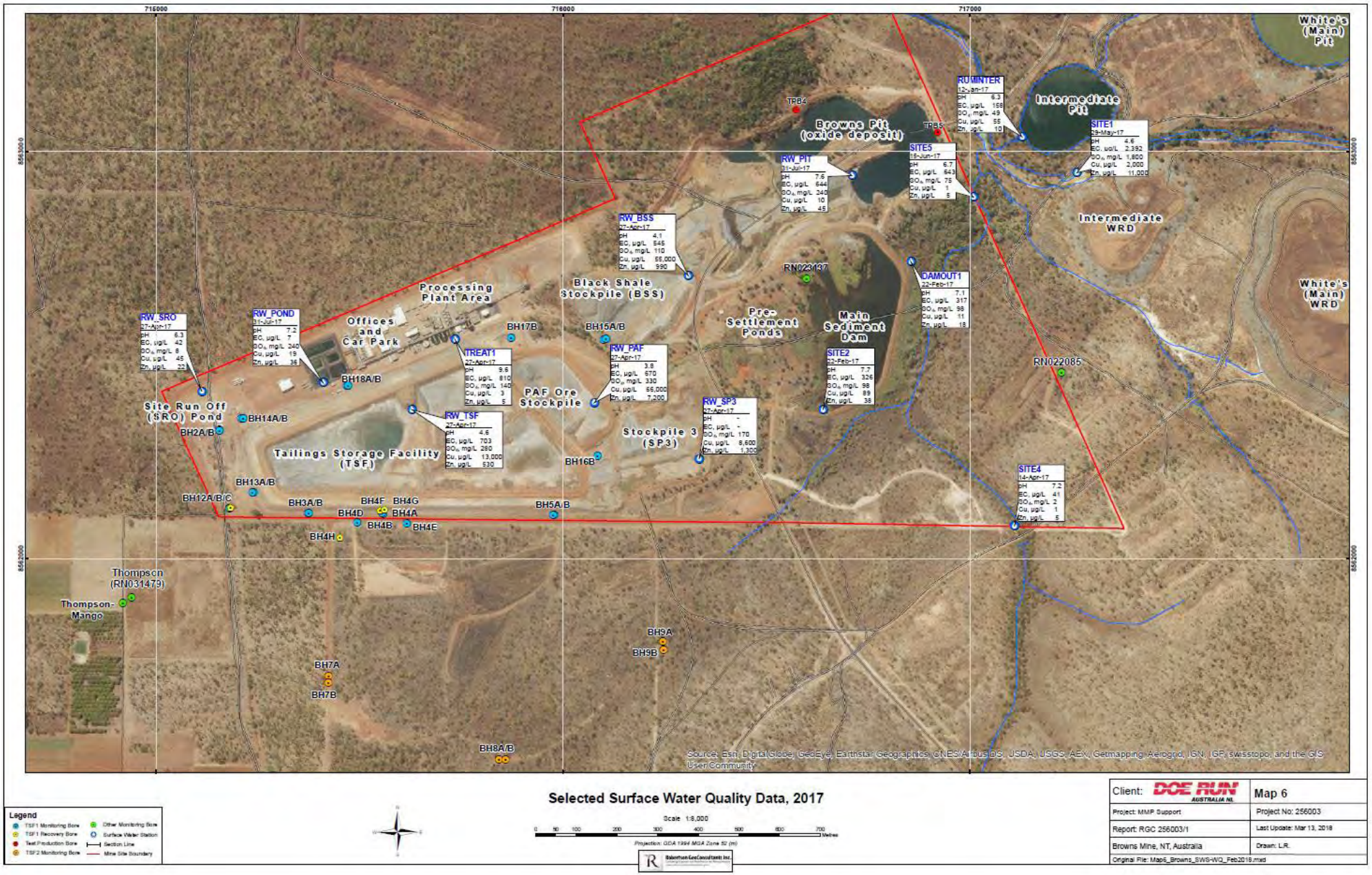


Figure 4-7 – Map of Selected Water Quality Data, 2017 (RGC, 2018)

4.2.3 Boundary Discharge Exceedances at SITE5 (RGC, 2018)

Table 4-4 summarises trigger value exceedances at SITE5 for the 2016/17 and the 2017/18 wet seasons. Consistent with Condition 38 of the then WDL177-06, which is in italics below, NTR has to notify NT EPA based on exceedances of the trigger value. WDL177-06 does not define such exceedances as non-compliance events.

"Condition 38 The licensee must as soon as practicable (and in any case within 24 hours) after becoming aware, notify the Administering Agency:

38.1 when a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions,

38.2 when a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value."

There were 25 instances in the 15 months from December 2016 to March 2018 when the trigger value (2.5µg/L) for Cu was exceeded on three consecutive occasions. Cu, Co and Zn are the three metals that exceeded their respective trigger values most frequently. The Cu concentration at SITE5 was higher than 5µg/L, i.e. twice the trigger value, on 28 separate occasions (or 77% of the sampling events).

In November and December, the highest metal concentrations on record were observed at SITE5, i.e. up to 2100µg/L Cu (**Table 4-4**). The exceedances on November 22nd, 2017, occurred after the first substantial (73mm) rain event of the 2017/2018 Wet Season. An additional 42 mm of rain occurred between November 22nd and the second exceedance event on November 30th. These rainfall events may have caused a pulse of existing contaminants to be flushed to the wetland (RGC, 2018).

This may occur each year, but in November 2017, samples from SITE5 were collected during the first flush. This has not been done in the past and likely explains the elevated metal concentrations observed (RGC, 2018). Further discussion of potential causes and the environmental implications of the exceedances in the context of contaminant loads in the EBFR is provided in **Section 4.3.2**.

Exceedances of the WDL177-06 trigger values for this period and previous monitoring periods are shown in to **Figure 4-8** to **Figure 4-10.** It should be noted that prior to 2014 that SSTV were in place for Copper and Cobalt at 37µg/L and 47 µg/L. However the trigger values illustrated on the graphs in **Figure 4-9** are displayed as the WDL177-06 trigger values.

Table 4-4 - Trigger Value Exceedances at SITE5, December 2016 to February 2018

Sample Date	pH	EC	Temp	Hardness as CaCO3	Al (filtered)	Cd (filtered)	Co (filtered)	Cu (filtered)	Mn (filtered)	Ni (filtered)	Pb (filtered)	Zn (filtered)
	-	uS/cm	oC	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WDL177-06_SW Trigger Values					80	0.4	13	2.5	2,500	13	5.6	15
29/12/2016	6.46	328	26	88	410	0.2	41	15	96	31	1	56
30/12/2016	6.9	285	25.3	95	120	<0.2	14	6	110	10	<1	15
12/01/2017	6.73	79.3	29.9	88	<50	<0.2	12	16	38	20	<1	19
13/01/2017	7.23	231	28	29	<50	<0.2	5	16	18	10	<1	13
20/01/2017	7.23	355	28.7	49	ND	<0.2	3	10	15	9	<1	7
26/01/2017	7.02	471	26.2	32	ND	<0.2	2	3	7	6	<1	6
2/02/2017	6.93	95	27.8	29	ND	<0.2	2	8	19	7	<1	8
5/02/2017	7.8	44.8	24.9	8.9	ND	<0.2	<1	3	9	1	1	7
16/02/2017	6.78	151.2	29.4	49	ND	<0.2	2	7	17	8	2	7
22/02/2017	6.77	227.3	30.1	570	<50	<0.2	3	6	32	10	<1	7
1/03/2017	7.17	103	27.3	27	<50	<0.2	5	7	63	6	<1	5
5/03/2017	7.2	194	25.3	63	<50	<0.2	9	6	100	9	<1	<5
12/03/2017	6.85	73.5	26.5	26	<50	<0.2	2	9	14	4	1	13
14/03/2017	6.89	161.7	29.6	65	<50	<0.2	9	31	23	11	3	8
28/03/2017	6.27	261	27.4	26	<50	<0.2	2	<1	20	4	<1	<5
11/04/2017	6.5	253	23.4	88	<50	<0.2	15	7	260	8	<1	5
14/04/2017	7.14	175	26.3	47	<50	<0.2	2	1	38	3	<1	<5
18/04/2017	6.74	107	25.8	31	<50	<0.2	2	2	20	2	<1	<5
27/04/2017	7.19	246	24.7	46	<50	<0.2	4	4	92	4	<1	<5
16/05/2017	6.9	351	25.2	140	<50	<0.2	47	7	1,500	12	<1	5
30/05/2017	6.81	525	23.2	220	<50	<0.2	48	5	1,800	13	<1	6
15/06/2017	6.74	643	19	250	<50	<0.2	20	<1	730	6	<1	<5
22/11/2017	6.42	691	24.7	320	90	1.4	340	210	780	190	2	290
30/11/2017	3.6	2,396	27.7	1,600	2,500	13	3,800	2,100	11,000	2,000	380	3,100
29/12/2017	3.42	2,755	31.3	1,900	1,900	9.5	2,900	1,800	8,100	1,800	390	2,400
17/01/2018	6.73	156.7	28.10	61	<50	0.3	61	33	230	52	<1	70
18/01/2018	6.73	156.7	28.1	37	<50	<0.2	9	8	81	7	<1	15
22/01/2018	6.87	128.6	27	41	70	<0.2	11	16	49	15	<1	23
29/01/2018	6.81	70	24.7	87	50	<0.2	<1	8	<5	4	2	6
31/01/2018	6.81	91.3	27.2	35	70	<0.2	2	5	6	5	2	7
14/02/2018	7.46	248	25.6	48	<50	<0.2	1	6	14	6	<1	8
28/02/2018	6.74	79.90	28.30	26	<50	<0.2	5	8	58	4	1	6
5/03/2018	6.92	85	28.3	36	<50	<0.2	6	6	81	3	<1	<5
15/03/2018	6.91	97	28.7	35	<50	<0.2	8	6	130	5	<1	<5
18/03/2018	7.2	109.4	26.3	35	60	<0.2	7	6	96	5	<1	6
28/03/2018	6.74	135.4	27.4	54	<50	<0.2	18	4	360	7	<1	16

* ND = No data available, **Blue Number** = exceeds trigger value, **Orange Number =** Equal to or double the trigger value

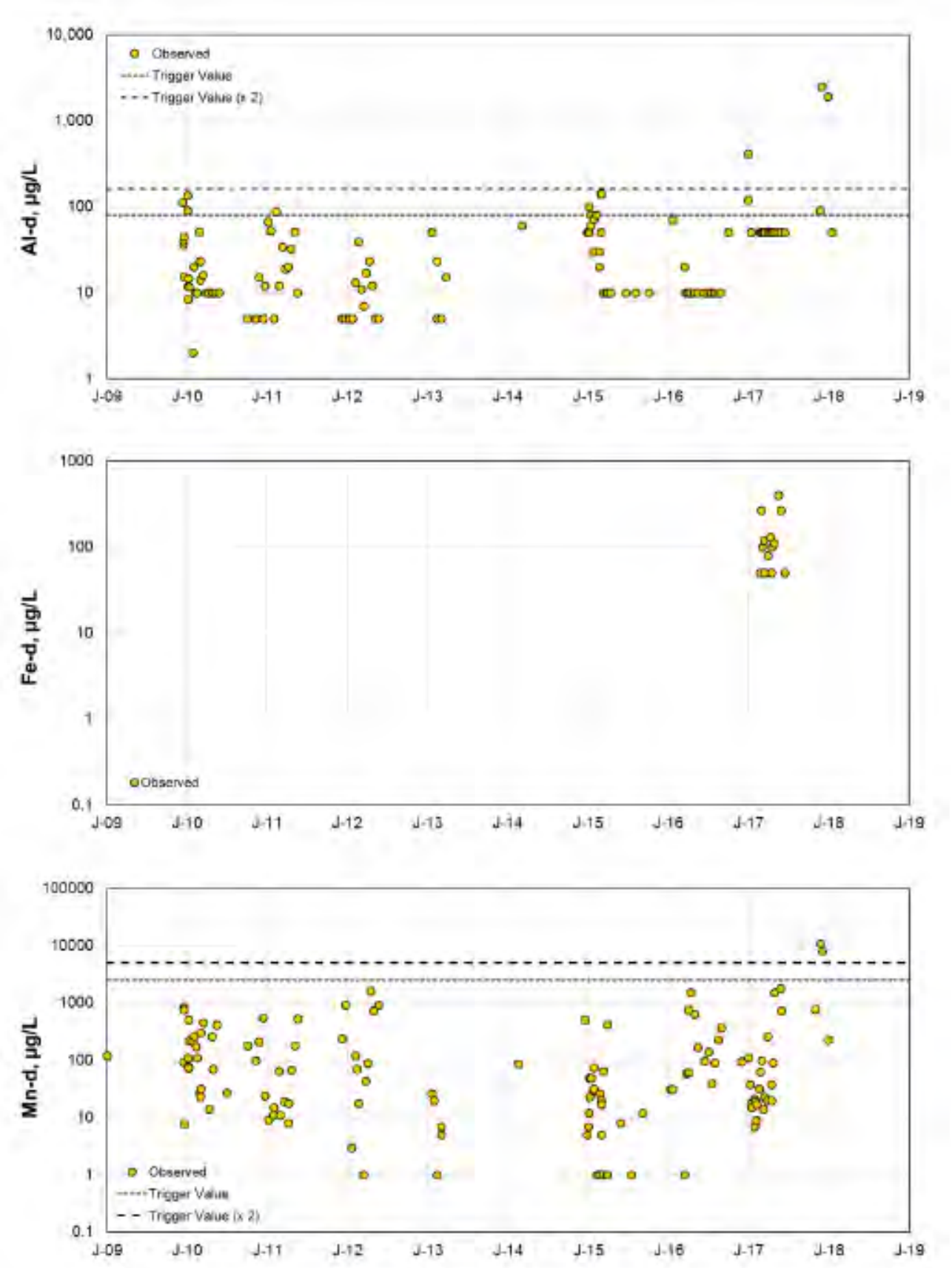


Figure 4-8 - Aluminium (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

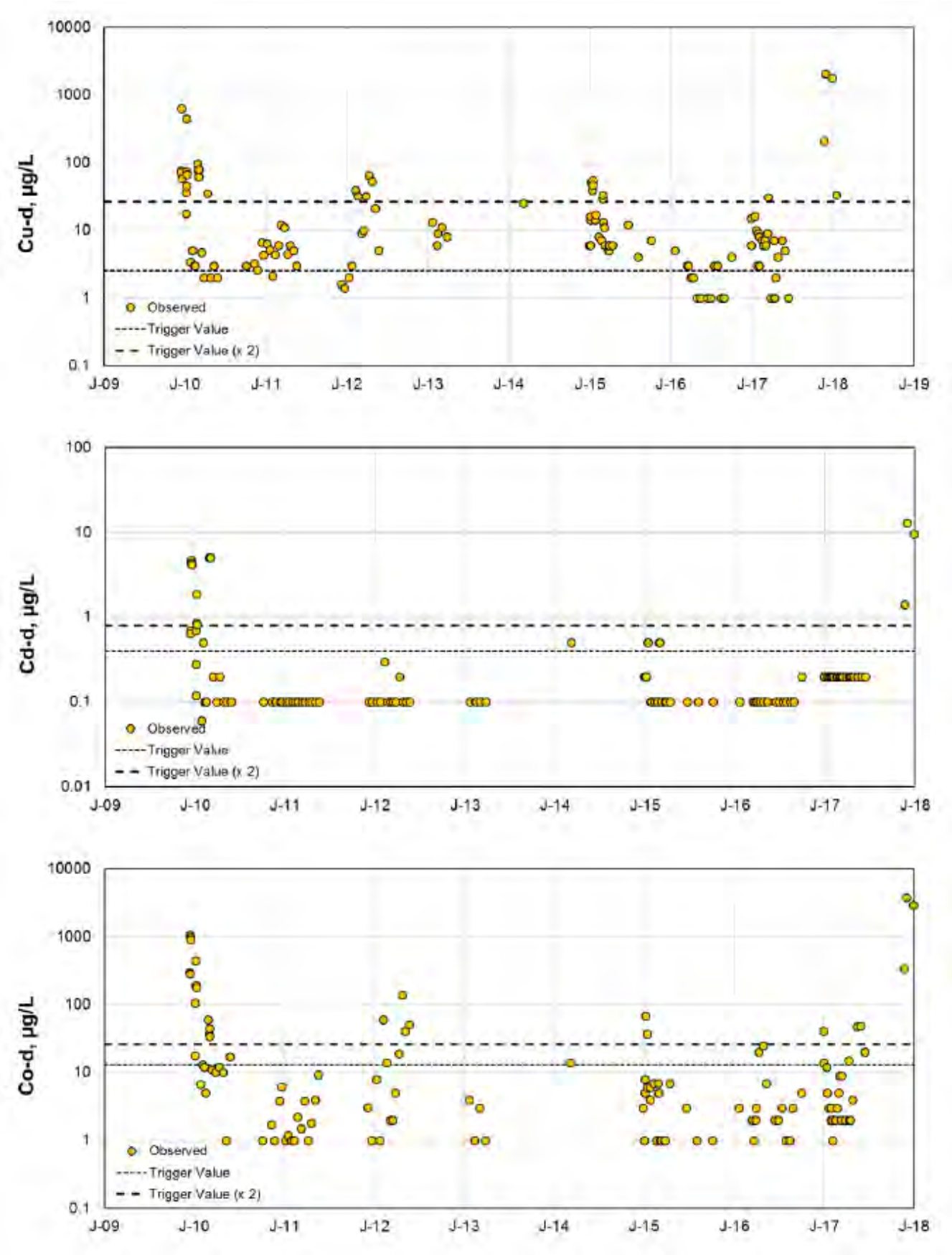


Figure 4-9 - Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

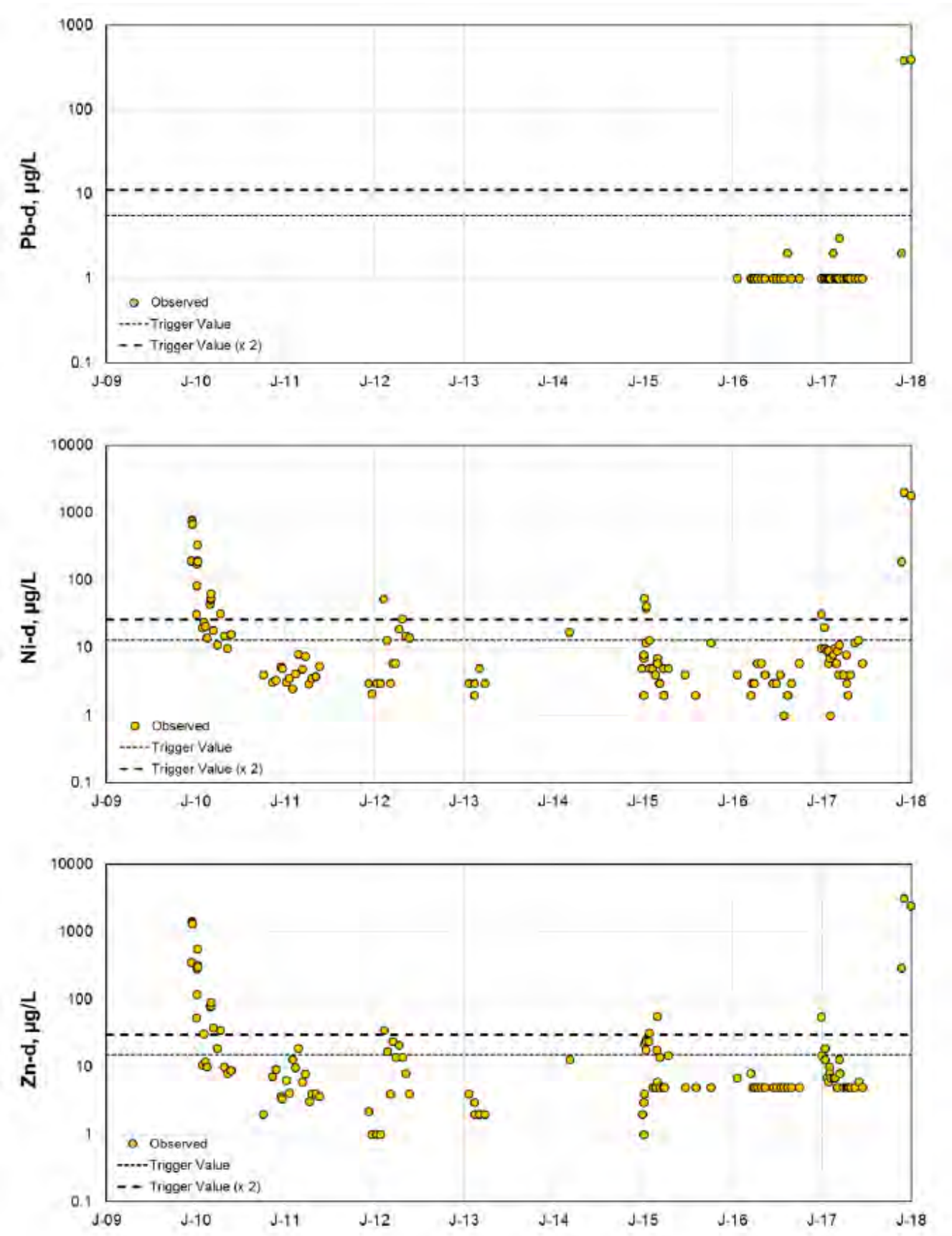


Figure 4-10 - Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 5, 2009 to 2018 (RGC, 2018)

4.2.4 Additional surface water quality results 2019 to 2022

The NT EPA issued WDL177-08 on 24 December 2019 and WDL177-09 on 19 December 2020. WDL177-10 came into effect on 20 December 2022. Trigger values for pH between 6.5 and 8.5 and Electrical Conductivity up to 700 µS/cm are prescribed for the discharge point at Site 5. pH and EC results for Site 5 from 1 January 2018 to 1 September 2022 are shown in Figure 4-11. pH is generally within the range 6.5-8, with only a few isolated instances of pH results below 6.5 during periods where no discharge was occurring. Similarly, EC is generally below 700 µS/cm, with only a few isolated instances of EC results greater that 700 µS/cm during periods where no discharge was occurring during periods of relatively low flow. Occasional low pH was observed at Site 5 early in the wet season – this results is associated with first flush discharges from Rum Jungle.

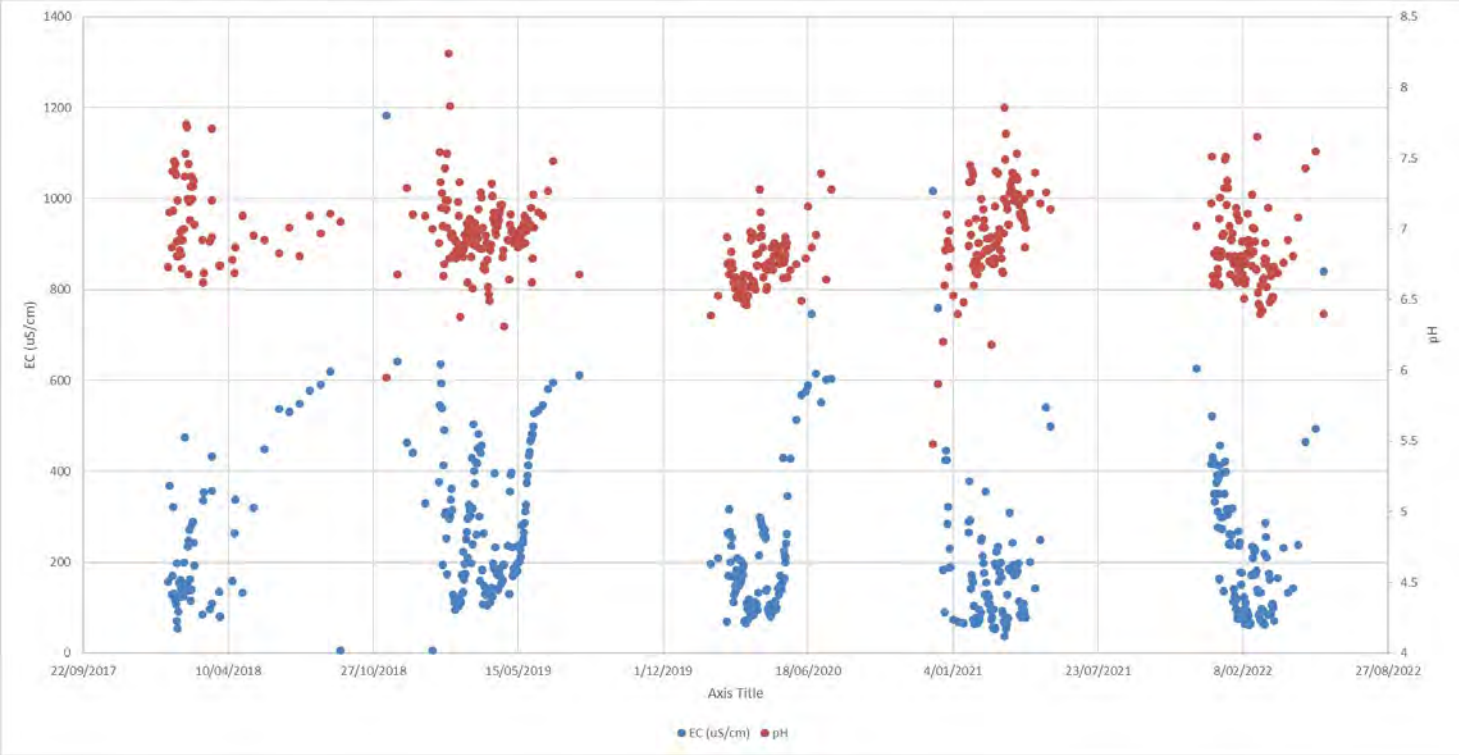


Figure 4-11 Site 5 pH and EC for 1 Jan 2018 – 1 September 2022

During the 2018-19 wet season the copper level was above the trigger value four times and cobalt levels two times. This was after adjusting the trigger values for hardness at GS8015200 as per Appendix 1 of the WDL. These exceedances have been quite low with a maximum of 12 µg/L for copper and 24 µg/L for cobalt, both occurring at the beginning of the wet season rains, and so can be associated with a first flush event. The improvements in the wet season of 2018-19 can be attributed to an improved method of comparing trigger values to results after taking water hardness at GS8015200 and the improvements made to the Water Treatment Plant itself by NT Resources.

Table 4-5 Trigger value criteria for WDL177-08 during 2019-2020

Blue Number = exceeds trigger value

Sample Date	Hardness as CaCO3 (filtered)	Al (filtered)	Cd (filtered)	Co (filtered)	Cu (filtered)	Mn (filtered)	Ni (filtered)	Pb (filtered)	Zn (filtered)
	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WDL177-08 Trigger Values		**150**	**1**	**13**	**3**	**3600**	**17**	**9**	**31**
WDL177-08 Hardness Adjusted Trigger Values			4		12		71	75	129
4/01/2019	200	<50	<0.2	**14**	6	340	11	<1	7
17/01/2019	200	<50	<0.2	13	30	270	12	<1	<5
26/01/2019	140	<50	<0.2	**24**	12	580	14	<1	7
30/01/2019	250	<50	<0.2	4	4	61	8	<1	<5
6/02/2019	110	<50	<0.2	3	8	26	4	<1	<5
14/02/2019	40	<50	<0.2	**16**	10	310	4	<1	<5
20/02/2019	31	110	<0.2	**18**	11	360	5	3	8
28/02/2019	51	<50	<0.2	12	3	280	4	<1	<5
6/03/2019	93	<50	<0.2	**27**	3	810	6	<1	<5
13/03/2019	110	<50	<0.2	**16**	<1	500	5	<1	6
20/03/2019	190	<50	<0.2	3	5	32	5	<1	<5
23/03/2019	48	<50	<0.2	2	5	28	3	<1	<5
26/03/2019	68	<50	<0.2	3	3	42	3	<1	<5
2/04/2019	32	<50	<0.2	2	5	29	2	<1	<5
9/04/2019	48	<50	<0.2	2	2	31	2	<1	<5
16/04/2019	45	<50	<0.2	3	<1	110	2	<1	<5
23/04/2019	62	<50	<0.2	8	<1	250	2	<1	<5
3/05/2019	40	<50	<0.2	2	5	40	2	<1	<5
3/05/2019	40	<50	<0.2	2	6	40	2	<1	<5
14/05/2019	64	<50	<0.2	3	1	53	3	<1	<5
22/05/2019	110	<50	<0.2	10	<1	330	4	<1	<5
29/05/2019	190	<50	<0.2	10	<1	450	5	<1	<5
4/06/2019	220	<50	<0.2	8	<1	360	4	<1	<5
3/07/2019	260	<50	<0.2	5	2	150	5	<1	<5
15/02/2020	81	<50	<0.2	**25**	2	380	7	<1	<5
15/02/2020	86	<50	<0.2	**25**	2	390	7	<1	6
27/02/2020	22	100	<0.2	1	4	11	<1	<1	<5
27/02/2020	22	80	<0.2	1	4	11	<1	<1	<5
5/03/2020	75	<50	<0.2	3	4	25		<1	7
5/03/2020	71	<50	<0.2	2	4	24		<1	7

13/03/2020	59	<50	<0.2	2	10	21	5	<1	9
13/03/2020	59	<50	<0.2	3	9	20	4	<1	8
3/04/2020	29	<50	<0.2	4	5	96	1	<1	9
3/04/2020	29	<50	<0.2	4	5	96	1	1	7
11/04/2020	79	<50	<0.2	1	7	11	4	1	7
11/04/2020	110	<50	<0.2	1	6	11	3	<1	6
27/04/2020	27	<50	<0.2	3	4	85	2	<1	5

Importantly, a significant revision to the method of determining the trigger levels for WDL177-08 was adopted, with alignment to the ANZECC (2000) method of adjusting dissolved metal concentrations for hardness in the receiving waters. During the 2019-20 wet season (see Table 4-5), no exceedances of the WDL177-08 trigger levels have been measured for the discharge at Site5 with the exception of a small exceedance for cobalt, noting however that no hardness adjustment for cobalt is set in the ANZECC (2000) guidelines (see Table 4-5) and no discharge from Site 5 was occurring at that time. If a nominal 3 x hardness adjustment was applied (as per previous WLD's) then no exceedance for cobalt would have been registered.

Table 4-6 shows the WDL metals water quality data at Site 5 during 2020 to 2022, with the purple exceedances being determined by the hardness modified trigger levels that were calculated for each individual sampling date. Some initial exceedances for copper were recorded, although there are generally not associated with period of discharge from Site 5 and reflect in-situ water quality in the East Finnis River.

Table 4-6 Trigger value exceedances for WDL177-09 during 2021-2022

Sample date	Hardness as CaCO3	Al (filtered)	Cd (filtered)	Cr (III+VI) filtered)	Co (filtered)	Cu (filtered)	Pb (filtered)	Mn (filtered)	Ni (filtered)	Zn (filtered)
WDL177-09 trigger levels		0.150	0.0008	0.0040	0.0013	0.0025	0.0094	0.0036	0.0017	0.0031
Date specific hardness modified trigger level exceedance										
Immediately before discharge										
During discharge										
6/07/2020	240	<0.05	<0.0002	<0.001	0.004	0.002	<0.001	0.076	0.005	0.006
13/07/2020	230	<0.05	<0.0002	<0.001	0.008	0.005	<0.001	0.12	0.007	0.006
13/07/2020	240	<0.05	<0.0002	<0.001	0.008	0.005	<0.001	0.12	0.008	0.008
20/07/2020	270	<0.05	<0.0002	<0.001	0.008	0.009	<0.001	0.073	0.007	0.005
20/07/2020	270	<0.05	<0.0002	<0.001	0.008	0.009	<0.001	0.073	0.007	0.005
21/12/2020	53	<0.05	<0.0002	<0.001	0.017	0.014	<0.001	0.14	0.008	0.018
21/12/2020	55	<0.05	<0.0002	<0.001	0.015	0.012	<0.001	0.12	0.007	0.015
23/12/2020	110	<0.05	<0.0002	<0.001	0.004	0.007	<0.001	0.025	0.006	0.01
23/12/2020	100	<0.05	<0.0002	<0.001	0.003	0.006	<0.001	0.018	0.002	0.005
23/12/2020	73	<0.05	<0.0002	<0.001	0.004	0.008	<0.001	0.025	0.006	0.012
28/12/2020	130	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.017	0.006	0.009
28/12/2020	130	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.017	0.006	0.012
4/01/2021	24	<0.05	<0.0002	<0.001	0.004	0.009	<0.001	0.044	0.003	0.005
4/01/2021	23	<0.05	<0.0002	<0.001	0.004	0.008	<0.001	0.043	0.003	0.005
7/01/2021	18	<0.05	<0.0002	<0.001	0.002	0.009	<0.001	0.019	0.002	0.005
7/01/2021	29	<0.05	<0.0002	<0.001	0.002	0.01	<0.001	0.017	0.002	0.005
10/01/2021	23	<0.05	<0.0002	<0.001	0.002	0.004	<0.001	0.021	0.002	0.005
10/01/2021	22	<0.05	<0.0002	<0.001	0.002	0.005	0.002	0.022	0.002	0.005
11/01/2021	22	<0.05	<0.0002	<0.001	0.003	0.007	<0.001	0.025	0.003	0.005
18/01/2021	54	0.06	<0.0002	<0.001	0.002	0.005	0.001	0.023	0.001	0.005
18/01/2021	15	0.07	<0.0002	<0.001	0.002	0.005	0.001	0.023	0.001	0.005
25/01/2021	91	<0.05	<0.0002	<0.001	0.001	0.011	<0.001	0.011	0.005	0.005
25/01/2021	32	<0.05	<0.0002	<0.001	0.001	0.004	<0.001	0.021	0.002	0.005
25/01/2021	120	<0.05	<0.0002	<0.001	0.001	0.009	<0.001	0.011	0.004	0.005
1/02/2021	28	<0.05	<0.0002	<0.001	0.001	0.005	<0.001	0.012	0.003	0.007
1/02/2021	31	<0.05	<0.0002	<0.001	0.002	0.004	<0.001	0.013	0.002	0.005
8/02/2021	29	<0.05	<0.0002	<0.001	0.001	0.003	0.002	0.009	0.002	0.005
8/02/2021	28	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.009	0.002	0.005
10/02/2021	28	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.01	0.001	0.005
10/02/2021	28	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.007	0.001	0.005
12/02/2021	110	<0.05	<0.0002	<0.001	0.002	0.005	<0.001	0.024	0.004	0.008
12/02/2021	100	<0.05	<0.0002	<0.001	0.002	0.005	<0.001	0.024	0.005	0.005
12/02/2021	26	<0.05	<0.0002	<0.001	0.002	0.004	<0.001	0.015	0.002	0.005
15/02/2021	85	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.012	0.003	0.005
15/02/2021	86	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.012	0.004	0.006
22/02/2021	43	<0.05	<0.0002	<0.001	0.001	0.004	<0.001	0.005	0.002	0.005
22/02/2021	42	<0.05	<0.0002	<0.001	0.001	0.005	<0.001	0.007	0.002	0.005
1/03/2021	13	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.017	0.001	0.005

1/03/2021	46	<0.05	<0.0002	0.003	0.001	0.002	<0.001	0.01	0.001	0.005
3/03/2021	83	<0.05	0.0002	<0.001	0.001	0.083	<0.001	0.2	0.062	0.078
3/03/2021	16	<0.05	<0.0002	0.001	0.001	0.003	<0.001	0.015	0.001	0.005
3/03/2021	17	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.015	0.001	0.005
6/03/2021	17	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	<0.005	0.001	0.005
6/03/2021	89	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.014	0.003	0.007
8/03/2021	66	<0.05	<0.0002	<0.001	0.002	0.002	<0.001	0.022	0.003	0.005
8/03/2021	39	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.022	0.003	0.005
15/03/2021	22	<0.05	<0.0002	<0.001	0.002	0.002	<0.001	0.042	0.001	0.005
15/03/2021	32	<0.05	<0.0002	<0.001	0.002	0.003	<0.001	0.039	0.001	0.005
18/03/2021	11	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	<0.005	0.001	0.005
18/03/2021	21	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	<0.005	0.001	0.005
21/03/2021	75	<0.05	<0.0002	<0.001	0.001	0.004	<0.001	<0.005	0.003	0.006
21/03/2021	89	<0.05	<0.0002	<0.001	0.001	0.006	<0.001	0.018	0.003	0.005
22/03/2021	19	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	0.009	0.001	0.005
22/03/2021	19	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	0.008	0.001	0.005
22/03/2021	19	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	0.008	0.001	0.005
29/03/2021	80	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	0.017	0.002	0.005
29/03/2021	72	<0.05	<0.0002	<0.001	0.001	0.001	<0.001	0.016	0.002	0.005
5/04/2021	35	<0.05	<0.0002	<0.001	0.005	0.011	<0.001	0.03	0.003	0.005
5/04/2021	19	<0.05	<0.0002	<0.001	0.005	0.011	<0.001	0.03	0.003	0.005
12/04/2021	46	<0.05	<0.0002	0.001	0.003	0.002	<0.001	0.067	0.002	0.005
12/04/2021	21	<0.05	<0.0002	<0.001	0.003	0.002	<0.001	0.065	0.002	0.005
12/04/2021	21	<0.05	<0.0002	<0.001	0.003	0.002	<0.001	0.07	0.002	0.005
14/04/2021	21	<0.05	<0.0002	<0.001	0.003	0.005	<0.001	0.078	0.002	0.005
12/04/2021	14	<0.05	<0.0002	<0.001	0.003	0.002	<0.001	0.07	0.002	0.005
14/04/2021	15	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.079	0.002	0.005
20/04/2021	23	<0.05	<0.0002	<0.001	0.001	0.004	<0.001	0.029	0.001	0.005
20/04/2021	25	<0.05	<0.0002	<0.001	0.001	0.008	<0.001	0.035	0.002	0.005
27/04/2021	40	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.14	0.002	0.006
27/04/2021	39	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.16	0.002	0.005
4/05/2021	100	<0.05	<0.0002	<0.001	0.009	0.002	0.001	0.4	0.005	0.007
4/05/2021	95	<0.05	<0.0002	<0.001	0.009	0.002	<0.001	0.43	0.005	0.006
12/05/2021	180	<0.05	<0.0002	<0.001	0.01	0.008	<0.001	0.35	0.006	0.005
12/05/2021	180	<0.05	<0.0002	<0.001	0.009	0.008	<0.001	0.34	0.006	0.005
18/05/2021	210	<0.05	<0.0002	<0.001	0.006	0.001	<0.001	0.25	0.005	
18/05/2021	200	<0.05	<0.0002	<0.001	0.007	0.001	<0.001	0.25	0.005	
6/12/2021	270	<0.05	0.0002	<0.001	0.004	0.011	0.001	0.062	0.008	0.008
13/12/2021	260	<0.05	0.0002	<0.001	0.001	0.006	0.001	0.045	0.005	0.005
13/12/2021	260	<0.05	0.0002	0.002	0.001	0.006	0.001	0.047	0.005	0.005
26/12/2021	200	<0.05	0.0002	<0.001	<0.001	0.008	0.001	<0.005	0.005	0.007
26/12/2021	180	<0.05	0.0002	<0.001	<0.001	0.008	0.001	<0.005	0.005	0.006
4/01/2022	120	<0.05	0.0002	<0.001	0.02	0.003	0.001	1.1	0.003	0.006
4/01/2022	110	<0.05	0.0002	<0.001	0.022	0.005	0.001	1.1	0.003	<0.005
5/01/2022	140	<0.05	0.0002	<0.001	0.015	0.002	0.001	0.8	0.005	<0.005
6/01/2022	200	<0.05	0.0002	<0.001	0.005	0.009	0.001	0.15	0.005	0.006

6/01/2022	180	<0.05	0.0002	<0.001	0.005	0.009	0.001	0.15	0.006	0.007
44567	61	<0.05	0.0002	<0.001	0.009	0.005	0.001	0.21	0.004	0.006
7/01/2022	230	<0.05	0.0002	<0.001	0.002	0.005	0.001	0.044	0.004	<0.005
7/01/2022	220	<0.05	0.0002	<0.001	0.002	0.004	0.001	0.044	0.004	<0.005
10/01/2022	110	<0.05	0.0002	<0.001	0.01	0.003	0.001	0.49	0.005	<0.005
10/01/2022	110	<0.05	0.0002	<0.001	0.01	0.003	0.001	0.48	0.005	0.008
12/01/2022	53	<0.05	0.0002	<0.001	0.002	0.003	0.001	0.029	0.002	0.005
12/01/2022	54	<0.05	0.0002	<0.001	0.002	0.003	0.001	0.029	0.002	0.006
19/01/2022	100	<0.05	0.0002	<0.001	0.001	0.005	0.001	0.018	0.002	0.05
19/01/2022	100	<0.05	0.0002	<0.001	0.001	0.005	0.001	0.018	0.002	0.005
22/01/2022	110	<0.05	0.0002	<0.001	<0.001	0.002	0.001	0.016	0.002	<0.005
22/01/2022	110	<0.05	0.0002	<0.001	<0.001	0.001	0.001	0.015	0.001	<0.005
25/01/2022	25	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.007	0.001	<0.005
25/01/2022	26	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.007	<0.001	<0.005
31/01/2022	30	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.008	0.001	<0.005
31/01/2022	30	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.011	0.001	<0.005
7/02/2022	29	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.017	0.001	<0.005
7/02/2022	28	<0.05	<0.0002	<0.001	0.002	0.004	<0.001	0.018	0.002	<0.005
10/02/2022	19	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.012	0.001	<0.005
10/02/2022	18	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.015	0.001	<0.005
14/02/2022	24	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.012	0.001	<0.005
14/02/2022	26	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.012	0.001	<0.005
17/02/2022	19	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.013	0.001	<0.005
17/02/2022	20	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.012	<0.001	<0.005
19/02/2022	100	<0.05	<0.0002	<0.001	0.001	0.004	<0.001	0.027	0.002	<0.005
19/02/2022	44	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.011	<0.001	<0.005
19/02/2022	26	<0.05	<0.0002	<0.001	<0.001	0.002	0.001	0.009	0.001	<0.005
22/02/2022	93	<0.05	<0.0002	<0.001	<0.001	0.003	<0.001	0.015	0.002	<0.005
22/02/2022	96	<0.05	<0.0002	<0.001	<0.001	0.004	<0.001	0.015	0.001	<0.005
28/02/2022	49	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.01	0.001	<0.005
28/02/2022	49	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.011	0.001	<0.005
8/03/2022	26	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.015	<0.001	<0.005
8/03/2022	28	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.015	<0.001	<0.005
10/03/2022	25	<0.05	<0.0002	<0.001	<0.001	0.001	<0.001	0.015	<0.001	<0.005
10/03/2022	85	<0.05	<0.0002	<0.001	0.002	0.005	<0.001	0.056	0.002	<0.005
10/03/2022	100	<0.05	<0.0002	<0.001	0.001	0.005	<0.001	0.055	0.002	<0.005
15/03/2022	24	<0.05	<0.0002	<0.001	<0.001	0.001	<0.001	0.012	<0.001	<0.005
19/03/2022	26	<0.05	<0.0002	<0.001	<0.001	0.001	<0.001	0.023	<0.001	<0.005
19/03/2022	25	<0.05	<0.0002	<0.001	<0.001	0.001	<0.001	0.024	0.003	<0.005
23/03/2022	25	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.024	<0.001	<0.005
23/03/2022	26	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.025	<0.001	<0.005
28/03/2022	32	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.017	<0.001	<0.005
28/03/2022	29	<0.05	<0.0002	<0.001	<0.001	0.002	<0.001	0.019	<0.001	<0.005
4/04/2022	27	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.047	<0.001	<0.005
4/04/2022	27	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.047	<0.001	<0.005
11/04/2022	49	<0.05	<0.0002	<0.001	0.002	0.002	<0.001	0.12	0.001	<0.005
11/04/2022	39	<0.05	<0.0002	<0.001	0.002	0.002	<0.001	0.11	0.001	<0.005

18/04/2022	59	<0.05	<0.0002	<0.001	<0.001	0.001	<0.001	0.083	0.001	<0.005
18/04/2022	61	<0.05	<0.0002	<0.001	0.001	0.002	<0.001	0.08	0.001	0.006
25/04/2022	92	<0.05	<0.0002	<0.001	0.002	0.008	<0.001	0.19	0.002	0.005
25/04/2022	33	<0.05	<0.0002	<0.001	<0.001	0.004	<0.001	0.071	<0.001	0.006
5/05/2022	210	<0.05	<0.0002	<0.001	0.003	0.003	<0.001	0.64	0.002	<0.005
5/05/2022	210	<0.05	<0.0002	<0.001	0.003	0.004	<0.001	0.62	0.002	<0.005
19/05/2022	250	<0.05	<0.0002	<0.001	0.002	0.003	<0.001	0.12	0.003	<0.005
19/05/2022	250	<0.05	<0.0002	0.002	0.002	0.003	<0.001	0.12	0.003	<0.005
30/05/2022	290	<0.05	<0.0002	<0.001	0.002	0.003	<0.001	0.093	0.002	<0.005
30/05/2022	290	<0.05	<0.0002	<0.001	0.001	0.003	<0.001	0.095	0.002	<0.005

4.3 Surface Water Quality Impacts and Contaminant Loads

4.3.1 Contaminant Load Balance for Surface Water (RGC, 2018)

Table 4-7 summarises simulated annual loads of SO_4 and Cu in surface water. Loads were calculated by multiplying representative source term concentrations by simulated annual flows from the Water Balance Model (WBM). SO_4, Cu, and Zn concentrations in rainfall runoff and in the water released from the Sediment Dam (**Table 4-7**). For recovered groundwater, the average concentrations in groundwater from bores BH12C and BH4G in January 2018 were used.
The objective of the contaminant load balance model is to identify key sources to the WTP. A reduction in Cu and Zn loads within the WTP is represented by applying a solubility limit that simulates the removal of Cu and Zn prior to water release to the Sediment Dam. SO_4 is assumed to behave conservatively so no reduction in the WTP is simulated. A further reduction in loads within the Pre- Settlement Pond and/or the Sediment Dam is not represented.

Table 4-7 - Simulated SO_4 and Cu Loads in Surface Water

Source	Flow Rate			SO_4	Cu	Zn	SO_4 Load		Cu Load	
	L/s	ML/Year	Contribution	mg/L	mg/L	mg/L	t/year	Contribution	kg/year	Contribution
Flows and Loads to WTP										
From Browns Pit	8	252	62%	240	0	0	61	77%	3	0%
From TSF Pond	0	0	0%	280	13	0.50	0	0%	0	0.00%
SRO	1.8	56.0	14%	8	0.1	0.02	0.5	1.00%	3	0.00%
PAF Stockpile	0.8	24.0	6%	330	66	7.2	8	10%	1,591	38%
Black Shale Stockpile	0.9	28.0	7%	170	8.6	1.3	5	6%	244	6%
SP3	1.4	43	11%	110	55	1.0	5	6%	2,365	56%
TOTAL (IN):	**12.9**	**403**	**100%**	**-**	**-**	**-**	**79**	**100%**	**4,206**	**100%**
Removed by Water Treatment										
To PLS Ponds	9.4	296.0	136%	-	-	-				
Loads in the EBFR										
From Main Sediment Dam	15.8	497.0	2%	120	0.013	0.021	60	1.3%	6	0.2%
From upstream/ Rum Jungle	1010	31864	98%	140	0.128	0.172	4459	98.7%	4079	99.8%
TOTAL (OUT):	**1026**		**100%**	**-**	**-**	**-**	**4519**	**100%**	**4,085.0**	**100%**

The reduction in Cu and Zn loads by the WTP is simulated for completeness and does not represent the treatment process in a meaningful way. Annual Cu and Zn loads to the EBFR are also provided for completeness but the simulated loads are intended to be predictive of discharge consistent with the conservative requirements of WDL177-06 (Note: the trigger levels in WDL177-08/9 are generally higher).
RGC (2018) made some key observations from the SO_4 load balance for surface water are summarised here:

- 78 t/year SO_4 is simulated to report to the WTP. About 77% of this load is related to flows pumped from the Browns Pit and the other 23% is related to rainfall runoff from the SRO and ore stockpile ponds.
- The TSF is a closed system, meaning combined inflows from runoff and flows of recovered groundwater from bores BH4G and BH12C are balanced by losses by infiltration to groundwater

and evaporation. This implies that the TSF pond does not contribute a SO4 load (or a Cu or Zn load) to the water treatment system.

- SO_4 is assumed to behave conservatively, so 78 t/year reports to the Sediment Dam from the processing plant. About 24% of the SO_4 load to the Sediment Dam is assumed to enter the groundwater system beneath the pond due to seepage. The other 76% reports to the EBFR via controlled discharge.
- The SO_4 load that reports to the EBFR from the Sediment Dam represents about 1.5% of the SO_4 load to the EBFR from the portion of the former Rum Jungle mine site that affects the EFDC at Site 1, i.e. the entire site except for the Old Tailings Dam area.

RGC (2018) made some key observations from the Cu load balance for surface water and are listed below.

- ~4200 kg/year Cu is simulated to report to the WTP. 90% of this load is related to water pumped from PAF Ore Stockpile pond and the Black Shale Stockpile pond. The other 10% is from the Stockpile 3 pond. Other surface water flows, e.g. from SRO, do not contribute an appreciable Cu load.
- The simulated Cu load to the EBFR from the Sediment Dam for the 2016/2017 Wet Season is ~6 kg/year Cu. This load roughly corresponds to a concentration that is at or below the trigger value for Cu. To achieve this load, 99.9% of the Cu load that reports to the WTP is removed from wastewater.
- The annual Cu load to the EBFR from the Sediment Dam represents about 1.3% of the load to the EBFR from the former Rum Jungle mine site.

4.3.2 Environmental Implications of Contaminant Loads to the EBFR (RGC, 2018)

Water quality in the Sediment Dam often deteriorates after the first rainfall event each year. This is referred to as the ‘first flush’, as it reflects a flushing of oxidation products that likely accumulated during the later stages of the previous Wet Season and during the Dry Season. The first flush was particularly evident in November and December 2017, when concentrations that were several orders of magnitude higher than the trigger value for Cu were observed at SITE5 and comparable to Cu concentrations in the EFDC at Site 5 (**Figure 4-12, Figure 4-5** and **Figure 4-13**). This is an unusual occurrence, as concentrations at SITE1 are typically much higher than at SITE5 because of the much larger loads contributed to the EFDC by ARD from the former Rum Jungle mine site.

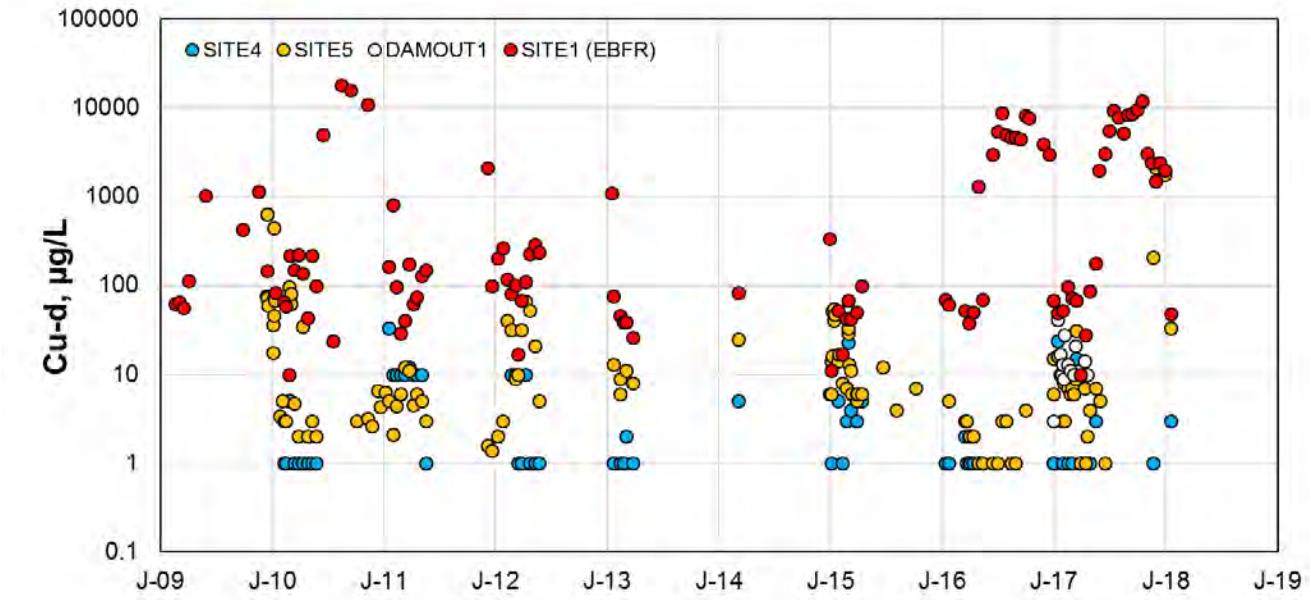


Figure 4-12 – Dissolved Cu Concentrations in Surface Water from Selected WDL177-06 Monitoring Stations. 2009 to Dec 31st 2017 (RGC, 2018)

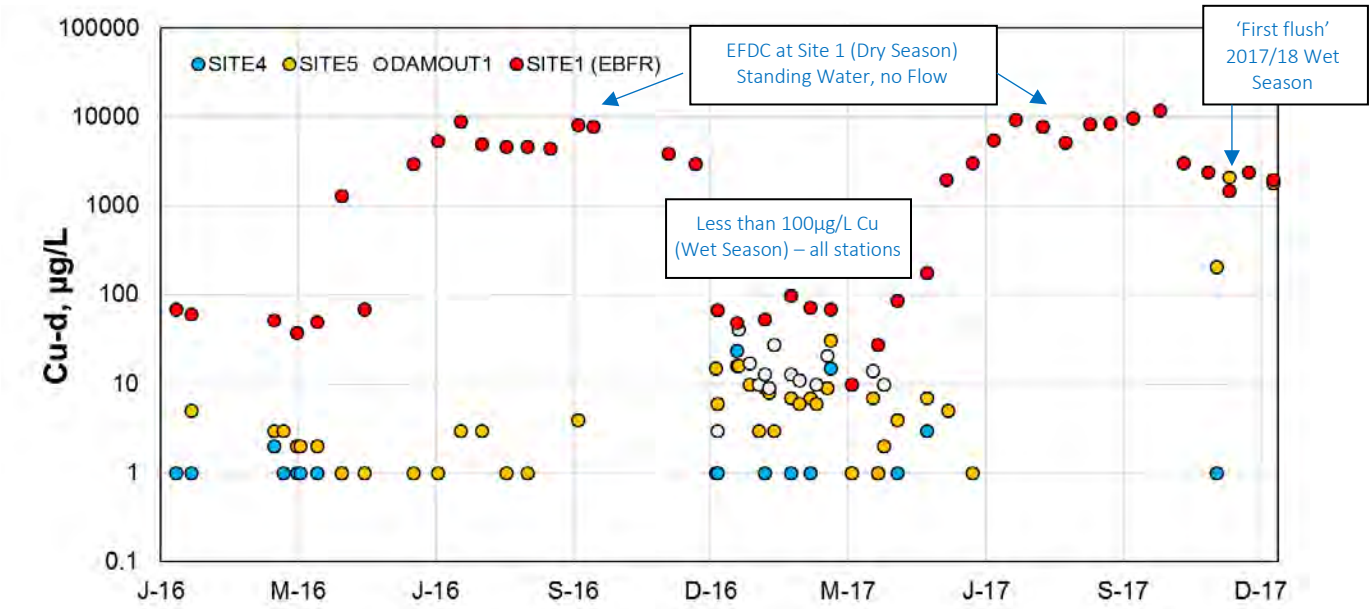


Figure 4-13 - Dissolved Cu Concentrations in Surface Water from Selected WDL177-06 Monitoring Stations. January 1st, 2016 to Dec 31st 2017 (RGC, 2018)

Samples from November 22nd, 2017, were collected within hours of a 73-mm rainfall event and an additional 43-mm was received by the site between November 22nd and November 30th, 2017, when the second set of samples were collected. According to the exceedance notification (RGC, 2018 - Appendix E), Middlebrook Creek began flowing around this time, contributing additional flows to the wetland. These flows are not associated with an appreciable load but may have contributed enough water to re-dissolve accumulated oxidation products. Water was not being discharged from the Sediment Dam at this time. Further discussion of these elevated concentrations is speculative without additional information about the conditions within the Sediment Dam prior to the flushing event. The environmental impact of the small loads to the EBFR from the Sediment Dam was likely relatively minor compared to impacts by the former Rum

Jungle mine site despite the unusually high concentrations of Cu and other metals in November and December 2017. This is consistent with findings from the surface water load balance, which suggests that controlled discharge from the Sediment Dam accounts for about 0.2% of the Cu load in the EBFR downstream of SITE5 and SITE1 at the former Rum Jungle Mine Site.

The analysis above has been further proven during subsequent monitoring (2020-2022) where elevated concentrations of metals in the EBFR have been recorded at Site 1 and GS200, compared to Site 5.

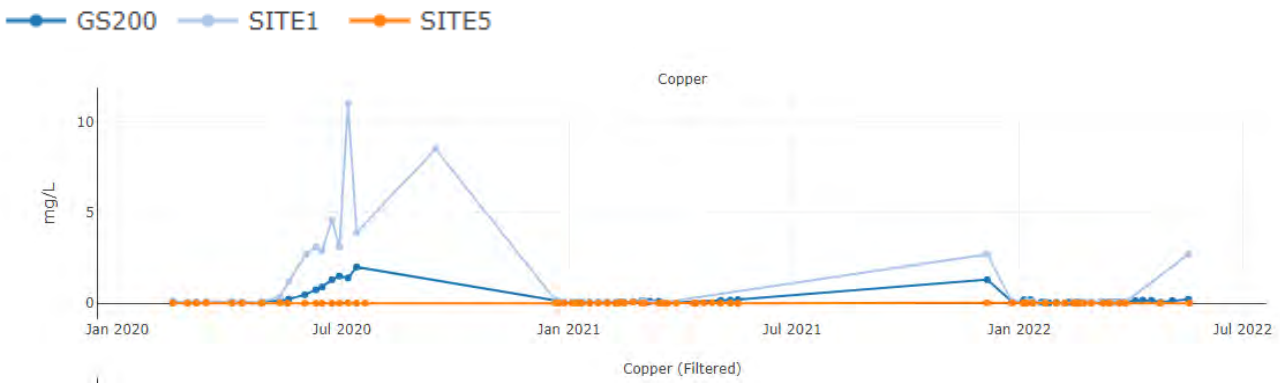


Figure 4-14 – Filtered Cu concentrations at Site 1, GS200 and Site 5 for 2020-2022

5. GROUNDWATER

5.1 Monitoring Bores (RGC, 2018)

Figure 2-4 illustrates the network of monitoring bores at the Browns site and several regional monitoring bores that are beyond the Browns mine lease. Bores at the former Rum Jungle mine site are shown on the map for reference but are not labelled. Construction details, i.e. depths, screened intervals, etc., for the TSF1 and TSF2 bores are provided in (**Appendix 1).** The TSF1 bores were installed by ATC Williams in 2005 as part of geotechnical investigations of TSF1 (ATC Williams, 2007) and the TSF2 bores were later installed around the proposed perimeter of TSF2 (ATC Williams, 2009).

The TSF1 and TSF2 bores were installed to characterize sub-surface (foundation) conditions beneath the proposed tailings facilities during the design phase. Hence the bores are not in strategic areas where groundwater quality is impacted by current contaminant sources to groundwater. Moreover, the screening intervals for the TSF2 bores were selected prescriptively without considering the material types encountered during drilling. This explains the identical screening intervals for the shallow bores (2.8 to 5.8 m/bgs) and most of the deeper bores.

The screening intervals for the TSF1 bores appear to have been selected with some consideration of lithology. There is no record of the TSF1 or TSF2 bores being developed (purged) after installation so the bores are often characterized by high turbidity and Total Suspended Solids (TSS). The TSF1 bores are screened in laterite/saprolite, Whites Formation shales, dolerite, or the Coomalie Dolostone, i.e. magnesite/dolomite. Bores BH4A and BH4B are located south of the TSF near the mine lease boundary. Bore BH4A is screened from 2.8 to 5.8 m/bgs in laterite and bore BH4B is screened from 11.0 to 20.0 m/bgs in black shale of the Whites Formation. These are the two bores where undiluted liquor was identified in 2008 (see **Section 7.3.1** for further details).

5.2 Seepage Recovery Bores (RGC, 2018)

There are four seepage recovery bores around the perimeter of the TSF: BH12C, BH4F, BH4G, and BH4H (**Figure 2-4**). Recovery bore BH4G has been operated since November 2009 and recovery bore BH12C was operated from March 2010 until December 2017 when there was a blockage and pump was subsequently removed. BH12C has been replaced with BH22. Groundwater pumped from bore BH12C is characterised by elevated SO_4 and non-detectable concentrations of most metals, e.g. less than 1 µg/L Cu. The rationale for pumping from this bore is unclear and RGC (2018) recommended that pumping be discontinued.

Together, recovery bores BH12C and BH4G have reportedly pumped ~120 ML/year (or 3.8 L/s) of impacted groundwater back to the TSF since 2009 (see GHD, 2016b). However, pumping records for these bores are unavailable, so the magnitude of flows from each bore cannot be differentiated.

Moreover, when RGC visited the Browns site in July 2017, less than 0.1 L/s from each of these bores was observed. The bores were operating normally at the time suggesting they were not performing as intended.

Recovery bores BH4F and BH4H were installed by URS in April 2009 and October 2009, respectively. According to URS (2009), recovery bore BH4F yielded 5 L/s during a 13-hour pumping test in April 2009 and a 200-m capture zone developed around the bore. A solar-powered Airwell pump was installed after this test and bore BH4F was pumped at 1.5 L/s until November 2009 when the pump was moved to bore BH4G (see URS, 2009). Recovery bore BH4H has not been pump-tested or operated since it was installed.

Recovery bores BH4F and BH4H are not currently operated because groundwater from each appears to be unimpacted by the TSF. Further details on current seepage management and the condition of recovered groundwater are provided in **Section 8.**

5.2.1 Groundwater and Pit Levels

Figure 5-1 summarises several site-wide groundwater level surveys completed in 2017 and 2018. The survey completed in November 2017 was used to infer a preliminary groundwater flow field for the site (see **Section 7.2**). Water levels in the Browns Pit are not routinely monitored.

5.3 Groundwater Level Time Trends (RGC, 2018)

Groundwater level time trends for each bore on site are provided in Figures 4-1 to 4-19 in RGC (2018) in **Appendix 1** and are referenced in the text below. Some key features of the time trends are summarised by RGC are listed below:

- Bores BH2A, BH13A and BH14A are typically dry and do not appear to have been installed properly or were not properly developed (purged) (see Figures 4-1, 4-13 and 4-14). The low geodetic water levels on the time trends correspond to the bottom elevation of the bore where some water likely accumulates between manual water level measurements. These water levels are provided here for completeness but they are erroneous and neither of these bores should be monitored in the future.
- Groundwater levels for most bores fluctuate seasonally by 5 to 10 m. The highest groundwater levels are typically observed in March or April before water levels recede to minimum levels in November or December immediately prior to the Wet Season. The largest fluctuations in groundwater levels occur to the south of the Browns site, i.e. up to 15 m at bores BH8A and BH8B (see Figure 4-8) and near the western end of the TSF at bores BH12A and BH12B (see Figure 4-12).
- Groundwater levels in bores BH2B, BH3A/B, and BH4A/B mounded by up to 6 m in 2008 and 2009 when there was standing water in the nearby TSF. Historic water level trends indicated a gradual recovery of this groundwater mounding over the next 2-5 years. Limited (and delayed) mounding was observed at bores BH5A and BH5B. At present, there is little evidence of mounding in the TSF area, except for some small inferred mounding near the southwestern portion of the TSF (**Figure 5-1** below).
- Groundwater levels near the TSF berm are not substantially affected by pumping from bores BH4G and BH12C because the flow rates for these recovery bores are too low. Groundwater levels observed at bore BH4G have gradually declined (Figure 4-5), possibly due to pumping directly from this bore since 2009. Groundwater levels from the shallower of two bores at the same location are often higher than the groundwater level in the deeper bore. This suggests a downward vertical gradient, i.e. from weathered laterite/saprolite to the bedrock aquifer.
- Groundwater levels at TPB5 are a proxy for the water level in the pit due to a strong hydraulic connection between the bore and the nearby pit. This is consistent with groundwater levels around 35 m AHD in 2008 when the pit was de-watered to allow the oxide deposit to be mined (see Figure 4-19).

Recent SWL measurements from 2020 (see Table 5-1) are consistent with these findings.

Table 5-1 Selected Groundwater Level Survey Data. 2017 /2018 (RGC, 2018) and 25 April 2020

Bore ID	TOC	Survey Date	DTW	GWL	Survey Date	DTW	GWL	Survey Date	DTW	GWL	Survey Date	DTW	GWL
	m AHD		m	mAHD		m	mAHD		m	m AHD		m	mAHD
TSF1 Bore													
BH2A	74.8	17-Aug-17	Dry	-	1-Nov-17	Dry	-	29-Dec-17	Dry	-	25-Apr-20	Dry	-
BH2B	75.4	17-Aug-17	15.15	60.2	1-Nov-17	15.15	60.2	29-Dec-17	Dry	-	25-Apr-20	9.6	65.8
BH3A	76.9	17-Aug-17	5.77	71.2	1-Nov-17	5.77	71.2	29-Dec-17	Dry	-	25-Apr-20	2.49	74.41
BH3B	77.4	17-Aug-17	6.23	71.1	1-Nov-17	6.23	71.1	29-Dec-17	8.69	68.7	25-Apr-20	2.82	74.58
BH4A	78.0	17-Aug-17	5.47	72.5	1-Nov-17	5.47	72.5	29-Dec-17	Dry	-	25-Apr-20	2.21	75.79
BH4B	78.4	17-Aug-17	6.50	71.9	1-Nov-17	6.50	71.9	29-Dec-17	8.82	69.6	25-Apr-20	2.67	75.73
BH4D	78.0	17-Aug-17	6.05	72.0	1-Nov-17	6.05	72.0	29-Dec-17	8.69	69.4	25-Apr-20	2.51	75.49
BH4E	74.7	17-Aug-17	5.67	69.1	1-Nov-17	5.67	69.1	29-Dec-17	7.77	67.0	25-Apr-20	2.37	72.33
BH4F*	78.3	17-Aug-17	6.03	72.3	1-Nov-17	6.03	72.3	29-Dec-17	8.29	70.0	25-Apr-20	3.02	75.28
BH4G**	78.8	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	10.72	-	25-Apr-20	4.01	74.79
BH4H*	78.0	17-Aug-17	5.97	72.0	1-Nov-17	5.97	72.0	29-Dec-17	8.22	69.7	25-Apr-20	2.54	75.46
BH5A	75.1	17-Aug-17	3.49	71.6	1-Nov-17	3.49	71.6	Buried in sediment		-			
BH5B	75.9	17-Aug-17	4.08	71.8	1-Nov-17	4.08	71.8	29-Dec-17	5.02	70.9	25-Apr-20	1.05	74.85
BH12A	75.6	17-Aug-17	9.05	66.6	1-Nov-17	-	-	29-Dec-17	Dry	-	25-Apr-20	4.64	70.96
BH12B	75.6	17-Aug-17	9.25	66.4	1-Nov-17	12.87	62.7	29-Dec-17	12.80	62.8	25-Apr-20	4.75	70.85
BH12C**	75.0	17-Aug-17	-	-	1-Nov-17	12.02	63.0	29-Dec-17	12.86	62.2	25-Apr-20	4.89	70.11
BH13A	75.1	17-Aug-17	Dry	-	Abandoned		-	Abandoned		-	25-Apr-20		75.1
BH13B	75.2	17-Aug-17	8.92	66.3	1-Nov-17	11.51	63.7	29-Dec-17	12.29	62.9	25-Apr-20		75.2
BH14A	74.8	17-Aug-17	10.97	63.9	Abandoned		-	Abandoned		-	25-Apr-20		74.8
BH14B	74.7	17-Aug-17	23.56	51.2	1-Nov-17	13.33	61.4	29-Dec-17	14.05	60.7	25-Apr-20	9.9	64.8
BH15A	74.8	17-Aug-17	9.63	65.2	1-Nov-17	10.86	63.9	29-Dec-17	10.20	64.6	25-Apr-20	7.8	67
BH15B	74.8	17-Aug-17	9.38	65.4	1-Nov-17	10.60	64.2	29-Dec-17	9.86	65.0	25-Apr-20	7.59	67.21
BH16B	76.3	17-Aug-17	6.15	70.1	1-Nov-17	8.00	68.3	29-Dec-17	7.92	68.4	25-Apr-20	3.17	73.13
BH17B	78.2	17-Aug-17	14.54	63.7	1-Nov-17	14.53	63.7	29-Dec-17	14.54	63.7	25-Apr-20	14.55	63.65
BH18A	77.6	17-Aug-17	13.44	64.2	1-Nov-17	15.19	62.4	29-Dec-17	15.19	62.4	25-Apr-20	11.62	65.98
BH18B	77.7	17-Aug-17	13.63	64.1	1-Nov-17	16.07	61.6	29-Dec-17	16.78	60.9	25-Apr-20	11.04	66.66
BH7A	80.8	17-Aug-17	7.66	73.2	1-Nov-17	-	-	29-Dec-17	Dry	-	25-Apr-20	3.97	76.83
BH7B	81.0	17-Aug-17	7.88	73.1	1-Nov-17	9.42	71.6	29-Dec-17	10.08	70.9	25-Apr-20	4.2	76.8
BH8A	75.0	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	Dry	-	25-Apr-20	3.42	71.58
BH8B	74.9	17-Aug-17	-	-	1-Nov-17	12.77	62.1	29-Dec-17	13.77	61.1	25-Apr-20	3.74	71.16
BH9A	73.6	17-Aug-17	4.52	69.1	1-Nov-17	6.30	67.3	29-Dec-17	6.70	66.9	25-Apr-20	1.31	72.29
BH9B	74.5	17-Aug-17	4.69	69.8	1-Nov-17	6.51	68.0	29-Dec-17	6.90	67.6	25-Apr-20	-	-
BH10	78.6	17-Aug-17	-	-	1-Nov-17	10.39	68.2	29-Dec-17	10.90	67.7	25-Apr-20	4.34	74.26
BH11	70.5	17-Aug-17	-	-	1-Nov-17	10.54	60.0	29-Dec-17	11.14	59.4	25-Apr-20	4.53	65.97
TPB4	61.5	17-Aug-17	5.55	56.0	1-Nov-17	5.61	55.9	29-Dec-17	5.99	55.6	25-Apr-20	5.64	55.86
TPB5	59.9	17-Aug-17	3.78	56.1	1-Nov-17	3.90	56.0	29-Dec-17	4.23	55.6	25-Apr-20	3.87	56.03
RN023137	66.0	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	3.78	62.2	25-Apr-20	3.3	62.7
RN022085	73.8	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	-	-	25-Apr-20	-	-

* = Recovery Bore, ** = Operational Recovery Bore

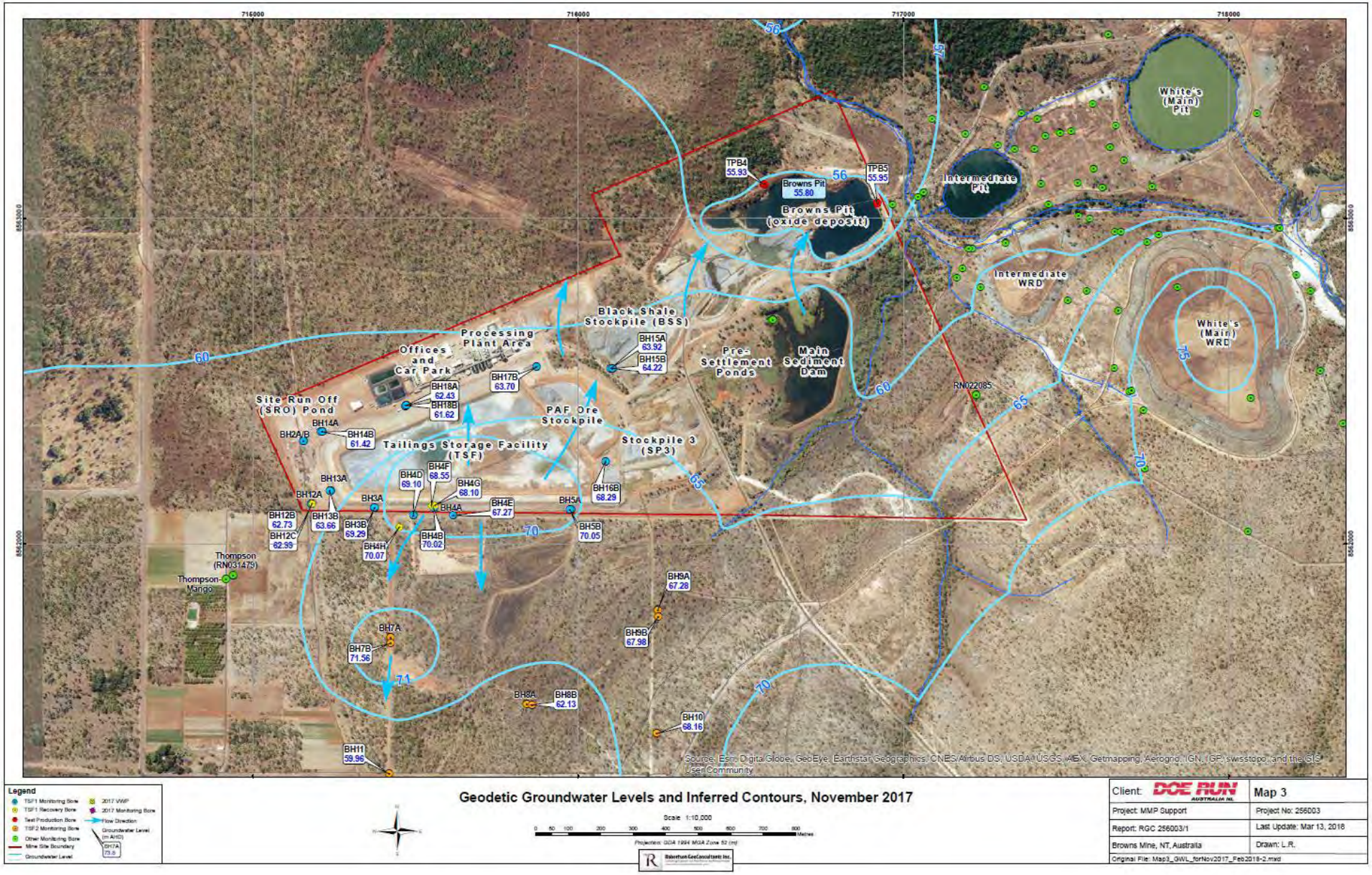


Figure 5-1 – Geodetic Groundwater Levels and Inferred Contours, November 2017 (RGC, 2018)

6. GROUNDWATER QUALITY

6.1 Representative (Verified) Data (RGC, 2018)

Selected groundwater quality results for each bore on site and regional bores are provided in **Table 6-1.** Most of the samples were collected in 2017 and 2018 when the reliability of data appears to have improved. Previously-collected data were selected for bores without reliable data for 2017 and 2018 (see Methods and Approach - **Appendix 1**). The median RPD value for the samples in **Table 6-1** is 4.7%. Samples from bores BH4A, BH4B, and BH4E with high RPD values (up to 30%) are included because they are the most reliable data collected over the last three years and the only recent samples for which there are complete results available, i.e. Fe, major ions, etc. The data in **Table 6-1** are reasonably representative of current conditions at the site.

6.2 Groundwater Quality Time Trends (RGC, 2018)

Groundwater monitoring data collected in 2016, 2017, and 2018 are tabulated in RGC, 2018 - Appendix D and the complete record to present is available digitally upon request. Groundwater quality time trends for field pH, SO_4, and Cu are provided in Figures 4-20 to 4-38 of RGC, 2018. Time trends for these parameters and alkalinity, Al, Cd, Co, Fe, Mn, Ni, Pb, and Zn are also provided in RGC 2018 – Appendix D. The data for pairs of bores, e.g. BH4A and BH4B, or two or three bores very close to one another are plotted together in the time trends to illustrate the condition of groundwater in a certain area. The data are plotted on a log scale to more clearly show the range of concentrations observed in groundwater.

RGC detailed some key observations from the groundwater quality time trends and are listed here and discussed further in Section 5 of RGC, 2018.:

- Groundwater quality results for the TSF2 bores to the south of the TSF reflect background conditions for the site (see Section 5.1). Most of the groundwater quality time trends for bores within the Browns site show some possible impact by ARD. Groundwater quality for most bores is either stable or there is no statistically significant trend over time due to the scatter in the historic data.
- The time trends for bores BH4A and BH4B are characterized by a step trend with peak concentrations of SO_4 and dissolved metals and depressed pH values observed in January 2009 (see Figures 4-28 to 4-31 of RGC, 2018). Water quality impacts are related to undiluted liquor from the TSF that likely displaced groundwater from these bores in 2008. This is consistent with water level mounding in 2008 and 2009. After the initial increase in SO4 and metal concentrations, concentrations decreased exponentially (R2 = 0.86) from 2009 to 2012. For the last 5 years, concentrations appear to be relatively stable and groundwater levels have returned to near the levels observed in 2007, i.e. before acidic liquor was discharged to the TSF.
- Groundwater from bore BH4D, about 50 m southwest of bores BH4A and BH4B, is impacted by liquor stored in the TSF in 2008 (see Figure 4-32 to 4-35 of RGC, 2018). This bore is screened relatively deep (16.5 to 38.5 m bgs) in Whites Formation shale, so samples collected in 2009 (with 10,000 µg/L Cu) could reflect a mixture of liquor and unimpacted groundwater from the deeper aquifer in this area. Bores BH3A/B and BH5A/B may also have been characterized by diluted liquor from the TSF.
- Liquor from the TSF appears to have impacted groundwater to the west of the TSF at bore BH13B. This bore is screened in laterite/saprolite from 15 to 21 m/bgs. The very low pH and high metal concentrations observed at bores BH4A and BH4B were not observed in this area but 30,000 µg/L Cu was observed in groundwater in 2009. Groundwater from bore BH13A was

not impacted to the same extent, as it was only characterized by a few hundred mg/L SO_4 and up to 13 µg/L Cu in 2009. Bore BH13A is screened from 34.4 to 40.4 m bgs in the Coomalie Dolostone and therefore appears to be too deep to be affected by liquor from the TSF.

- Recovery bore BH12C was installed near the southwestern TSF berm to intercept the impacted groundwater identified at bore BH13B. Bore BH12C is screened in Coomalie Dolostone from 13.9 to 22.6 m bgs, or about the same interval that is screened by bore BH13B. Bore BH12C intercepted the type of groundwater identified in the Coomalie Dolostone at bore BH13A, i.e. elevated SO4 and no metals, from 2010 to December 2017 when the pump became clogged and was removed from the bore.
- Metal concentrations in groundwater from bore BH13B have decreased since 2009 and there is some evidence of a seasonal trend in metals that could be related to larger loads from the TSF when water levels in the pond increase each year (see Figure 4-81 to 4-83 of RGC 2018). This cannot be confirmed without a detailed record of the pond extent(s) within the TSF. The long-term decrease suggests some dilution/dispersion and/or attenuation and is unrelated to pumping from bore BH12C.

Table 6-1 – Representative Groundwater Quality Data (RGC, 2018)

Bore ID	Sampling Date	Field pH	Field EC,	Total Alka-linity	Ca,	Mg,	Na,	K	HCO_3	SO_4	Cl	Al-f	Cd-f	Co-f	Cu-d	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	µS/cm	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	%
TSF1 Bores																						
BH3A	14-Jan-15	4.2	102	5	< 0.5	0.9	7.4	0.9	6	3	10	60	0.1	15	150	<50	43	13	2	0.4	57	1.7
BH3B	14-Jan-15	3.8	137	< 5	1	1	10	2	0	11	12	250	0.2	20	300	<50	63	16	13	1.2	89	4.5%
BH4A	8-Jul-17	2.8	1,527	< 5	150	84	28	7	0	1,400	8	22,000	8.9	10,000	29,000	780	24,000	4,900	48	200	2,700	17.4
BH4B	17-Aug-16	3.3	1,201	< 5	70	69	33	3	0	1,300	17	19,000	7	13,000	27,000		36,000	6,000	11	140	2,900	27.4
BH4D	5-Jan-18	3.6	381	< 20	9	12	25	3	0	120	7	1,200	1	1,400	1,200	80	3,700	640	9	<5	370	5.4
BH4E	5-Jan-18	5.7	327	40	12	16	22	3	49	88	31	< 50	1	990	19	9,600	2,800	460	<1	<5	220	1.5
BH4F*	28-Dec-17	7.3	147	69	4	4	11	5	84	5	32	< 50	< 0.2	<1	<1	2900	220	<1	<1	<5	6	29.7
BH4G*	9-Jan-18	3.8	877	<5	43	40	24	4	0	370	15	6,900	3	5,400	7,700	1,800	15,000	2,100	43	39	1,100	2.4
BH4H*	5-Jan-18	7.2	103	24	3	1	9	1	29	2	7	< 10	< 0.1	3	2	50	1600	1	<1	<5	12	1.0
BH5A	8-Jul-17	6.3	265	70	8	10	13	1	85	20	3	< 50	0.2	210	17	60	3000	83	2	<5	27	1.1
BH5B	2-Aug-17	5.9	98	29	5	7	5	< 0.5	35	5	16	< 50	< 0.2	1	4	< 50	35	21	<1	<5	43	3.5
BH12A	10-Jul-17	5.9	486	86	5	56	10	< 0.5	105	150	3	< 50	< 0.2	78	<1	< 50	<5	1	<1	7	21	3.7
BH12B	2-Aug-17	6.4	889	280	18	120	7	< 0.5	342	290	15	< 50	< 0.2	<1	<1	< 50	14	10	<1	<5	17	4.1
BH12C**	9-Jan-18	7.6	454	94	6	56	3	< 0.5	115	140	8	< 50	< 0.2	<1	<1	< 50	24	<1	<1	<5	<5	0.6
BH13A	1-Sep-16	-	2,100	550	90	170	210	6	671	940	13	< 10	< 0.1	<1	3		9	4	<1	38	<5	5.4
BH13B	9-Jan-18	5.7	1,180	66	17	170	6	1	81	580	8	< 50	2	15	380	< 50	170	150	<1	5	140	5.3
BH14A	18-Apr-17	6.5	1,816	260	10	270	4	< 0.5	317	790	6	< 50	< 0.2	<1	<1	< 50	72	4	<1	<5	<5	2.5
BH14B	11-Jan-18	6.6	474	120	4.4	96	6.7	< 0.5	146	230	4	< 50	< 0.2	6	3	110	420	9	<1	<5	19	7.2
BH15A	11-Jan-18	5.1	55	<5	< 0.5	2	5.7	< 0.5	0	5	8	50	4	16	10	< 50	10	50	180	<5	980	16.6
BH15B	18-Jan-18	6.6	196	79	10	7	16	3.5	96	10	16	< 50	< 0.2	10	6	1200	150	50	180	<5	540	7.4
BH16B	29-Apr-17	6.0	2,797	37	260	260	14	1	45	1600	17	< 50	0.7	<1	<1	50	120	53	<1	<5	18	0.7
BH17B	21-Apr-10	6.8	2,056	298	68	82	11	1	364	187	4	10	0.1	74	3	< 50	927	51	1	5	38	3.3
BH18A	10-Jul-17	5.7	332	73	2	36	10	1	89	76	5	50	0.2	2	15	< 50	10	21	2	<5	190	5.0
BH18B	11-Jan-18	5.7	1,924	88	77	290	12	1	107	1200	4	< 50	0	220	74	< 50	1,900	240	1	5	70	2.7
TSF2 Bores																						
BH7B	5-Jan-18	6.3	145	77	7	12	5	1	94	5	7	< 50	<0.2	<1	<1	60	13	2	<1	<5	<5	8.7

Bore ID	Sampling Date	Field pH	Field EC,	Total Alka-linity	Ca,	Mg,	Na,	K	HCO_3	SO_4	Cl	Al-f	Cd-f	Co-f	Cu-d	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	µS/cm	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	%
BH8A	13-May-14	6.6	147	30	2	5	2	1	37	2	2	20	0.1	2	1	< 50	72	1	<1	0.1	6	4.7
BH8B	4-Jan-18	6.9	291	170	19	25	4	2	207	2	4	< 50	<0.2	<1	1	< 50	5	<1	2	<5	9	4.5
BH9A	16-Jun-14	6.5	398	200	12	44	15	3	244	2	3	<10	<0.1	<1	3	< 50	<1	1	<1	0.2	8	9.1
BH9B	19-Nov-14	7.0	506	190	9	40	15	3	232	2	3	<10	<0.1	<1	1	< 50	5	<1	<1	0.5	<5	6.8
BH10	4-Jan-18	7.3	485	290	6	67	2	1	354	5	4	<50	<0.2	<1	<1	< 50	<5	4	<1	<5	11	0.7
BH11	13-May-14	7.0	201	60	7	8	2	1	73	2	2	10	0.2	<1	<1	50	<1	2	<1	0.1	<5	5.9
Other Bores																						
TPB4	9-Jan-18	7.4	455	260	17	46	3	1	317	5	8	<50	<0.2	2	2	1,500	100	1	<1	<5	7	6.6
TPB5	8-Jul-17	7.6	1,004	88	55	120	15	2	107	570	12	<50	<0.2	<1	<1	< 50	35	4	<1	<5	5	2.4
RN23137	9-Oct-17	6.5	568	190	64	30	7	3	232	130	12	<50	<0.2	1	<1	450	550	3	<1	<5	11	5.9
RN22085	23-Apr-09	7.4	508	190	35	34	2	1	232	1	2	2	0.02	0.7	<1	20	415	0.2	0.03	2	2	8.7
Thompson	7-Jul-17	6.7	336	170	24	22	8	1	207	2	3	< 50	<0.2	<1	<1	370	56	1	<1	<5	<5	1.3
Thompson-Mango	7-Jul-17	6.1	140	48	3	9	10	3	59	4	3	< 50	<0.2	2	<1	7200	130	6	<1	<5	6	21.3

Representative groundwater data from mid-wet season 2020 is provided in Table 6-2, showing a general small improvement is groundwater quality around the site.

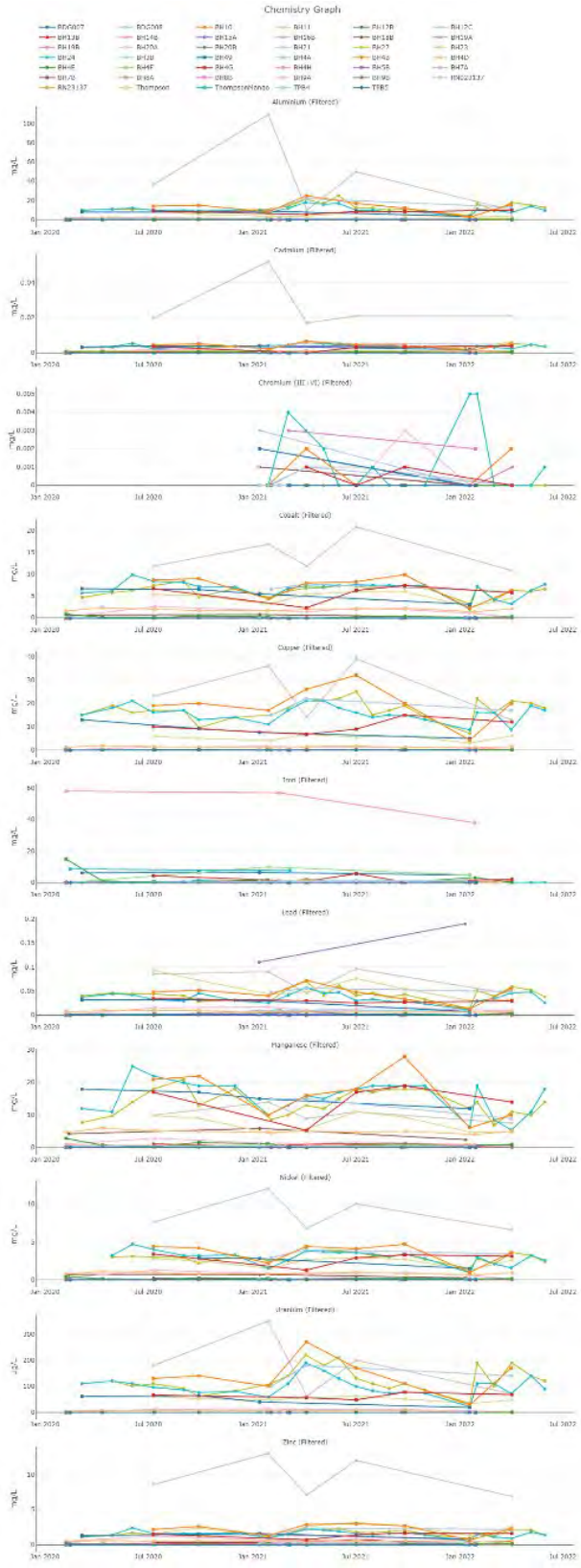
Table 6-2 Select groundwater quality results from mid wet season 2020

Bore ID	Sampling Date	Alkalinity as CaCO3	Cl	Na	Ca	Mg	K	SO4	Hardness as CaCO3	TSS	Lead	Pb-f	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	U-f	Zn-f
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BH4D	7/02/2020	<20	27			13		160	76	2.7	8	7	1,300	1	1,700	1,300	<50	4,700	800	5	410
BH 4D	11/04/2020	<20	15	20	13	15	2.4	190	94	6.1	10	9	1,800	1.4	2,400	1,900	<50	6,000	1,100	8	610
BH4E	7/02/2020	59	31			14		110	85	38	4	<1	<50	0.3	920	7	15,000	2,800	450	<5	240
BH 4E	11/04/2020	<20	37	12	3.2	4.3	1.5	44	26	9.2	3	<1	60	0.3	250	31	1,000	720	130	<5	100
BH 4E	11/04/2020	<20	32	12	3.3	4.3	1.5	49	26	8.8	3	<1	60	0.3	240	31	1,000	710	130	<5	100
BH4H	8/02/2020	97	11			0.6		<5	5.7	56	<1	<1	<50	<0.2	<1	<1	58,000	650	1	<5	6
BH5B	12/02/2020	47	92	3.8	3.7	3.4	0.5	5.5	23	2.0	2	<1	<50	<0.2	<1	6	<50	17	24	<5	66
BH7B	6/02/2020	73	30			21		<5	190	2.3	<1	<1	<50	<0.2	1	5	<50	9	18	<5	38
BH7B	6/02/2020	74	51			9.5		<5	50	3.1	<1	<1	<50	<0.2	1	5	<50	9	18	<5	38
BH8B	6/02/2020	170	40			30		<5	190	1.9	<1	<1	<50	<0.2	<1	<1	<50	<5	5	<5	14
BH9A	7/02/2020	560	36			92		<5	400	29	<1	<1	<50	<0.2	<1	2	<50	<5	8	<5	26
BH9B	7/02/2020	240	65			37		<5	170	7.3	1	<1	<50	<0.2	<1	<1	<50	32	5	<5	12
BH10	7/02/2020	300	38			56		<5	250	77	12	<1	<50	<0.2	<1	<1	<50	<5	5	<5	13
BH11	7/02/2020	98	43			12		<5	79	58	4	<1	<50	0.7	<1	<1	<50	33	6	<5	10
BH 18 B	12/02/2020	70	25	400	120	93	8.6	1,200	690	<1	<1	<1	<50	<0.2	<1	<1	<50	980	<1	<5	<5
BH 18 B	12/02/2020	76	62	11	79	260	1.2	1,200	1,300	<1	2	1	<50	0.6	760	130	<50	4,200	730	<5	170
BH19B	8/02/2020	140	7.3			11		6.2	68	6.8	<1	<1	<50	<0.2	2	<1	610	230	30	<5	12
BH20A	8/02/2020	<20	5.3			7.5		81	62	74	13	<10	1,900	<2	310	90	<500	1,100	280	<50	520
BH20B	8/02/2020	<20	13			1		8.2	9.8	110	4	2	300	<0.2	25	9	<50	270	27	<5	55
BH22	6/03/2020	<20	18	6.4	93	42	<5	460	410	1.2	45	40	9,800	2.9	4,800	15,000	<50	7,700		110	1,100
BH24	6/03/2020	<20	24	12	86	47	<5	510	410	15	39	37	10,000	3.2	5,800	15,000	120	12,000		110	1,200
THOMPSON	14/02/2020	160	13	<5	25	19	<5	<5	140	<1	<1	<1	<50	<0.2	<1	<1	220	39	<1	<5	<5

Bore ID	Sampling Date	Alkalinity as CaCO3	Cl	Na	Ca	Mg	K	SO4	Hardness as CaCO3	TSS	Lead	Pb-f	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	U-f	Zn-f
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
THOMPSON MANGO	*14/02/2020*	*63*	*3.6*	*<5*	*<5*	*8.2*	*<5*	*5.4*	*36*	*1.0*	*<1*	*<1*	*<50*	*<0.2*	*2*	*<1*	*8,500*	*140*	*5*	*<5*	*5*
TPB 5	*15/02/2020*	*120*	*32*	*9.3*	*70*	*140*	*<5*	*640*	*760*	*<1*	*<1*	*<1*	*<50*	*<0.2*	*<1*	*<1*	*<50*	*22*	*2*	*<5*	*<5*

Representative groundwater data from 2020 to 2022 is provided in Figure 6-1, showing a general stable groundwater quality around the site.

Figure 6-1 – Groundwater filtered metal concentrations 2020-2022



7. GROUNDWATER CONTAMINANTS

7.1 Background Water Quality

7.1.1 Groundwater Quality (RGC, 2018)

Groundwater quality data for bores RN022085 and RN023140 at the former Rum Jungle mine are representative of background conditions in the Coomalie Dolostone near the Browns site, i.e. groundwater that is unimpacted by ARD or liquor lost from the TSF in 2008. Groundwater samples from the TSF2 bores and groundwater collected from bores BH4A and BH4B before December 2008 reflect background conditions in Whites Formation and the overlying laterite/saprolite. Unimpacted groundwater from Whites Formation is characterized by circum-neutral to slightly acidic pH values and EC values that range from 100 to 500 µS/cm.

Figure 7-1 illustrates the major ion composition of unimpacted groundwater at the Browns site or in the surrounding area. Unimpacted groundwater from the Coomalie Dolostone and Whites Formation is Mg-HCO_3 type water that is characterized by less than 2 mg/L SO_4. Groundwater from Whites Formation can be slightly more acidic (i.e. pH 5 to 6) than groundwater from the Coomalie Dolostone because fewer carbonates are present to buffer pH values for groundwater. Metal concentrations in groundwater from the Coomalie Dolostone and Whites Formation are often low (i.e. 1 to 5 µg/L) or non-detectable. Fe and Mn are exceptions, as both can be elevated in unimpacted groundwater.

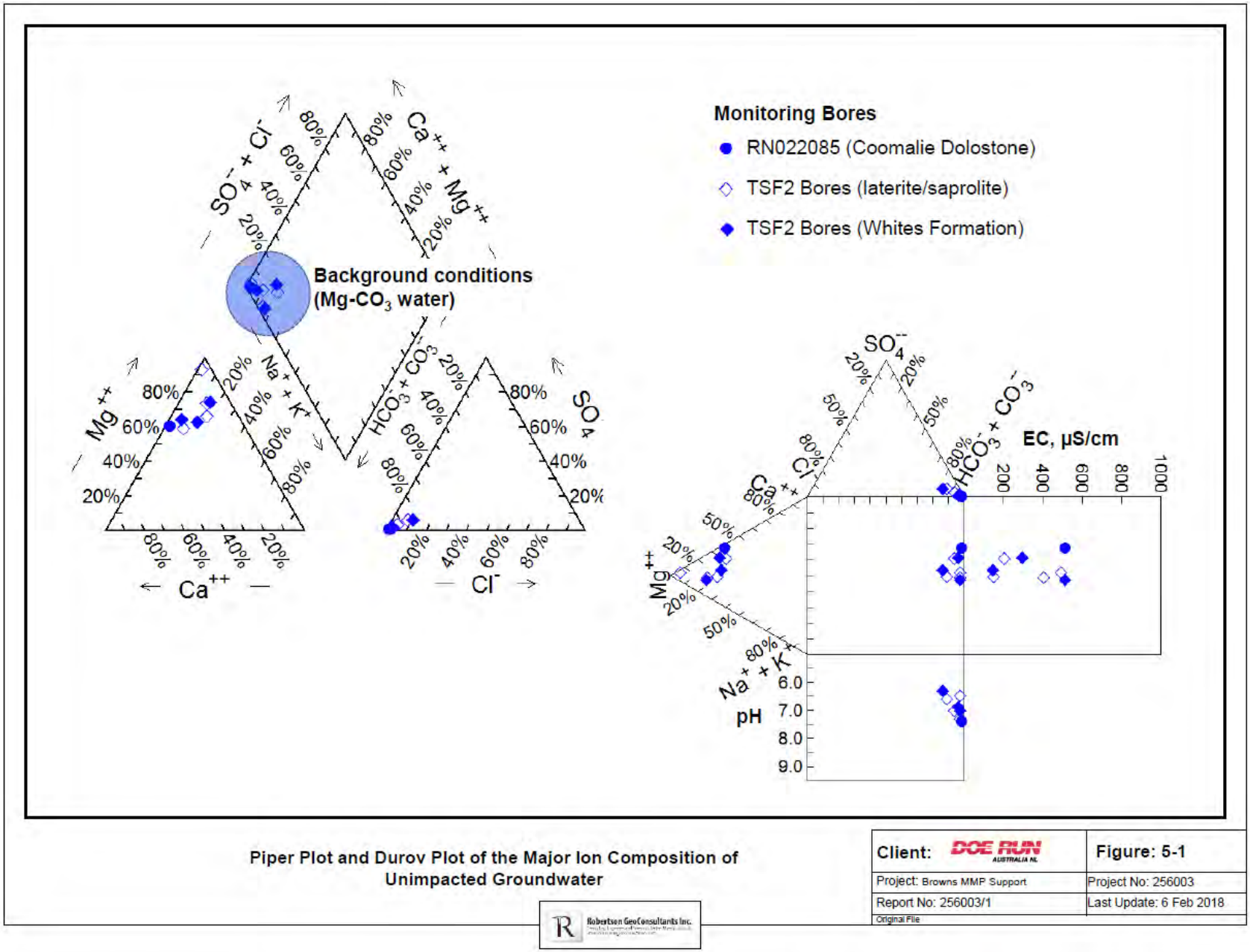


Figure 7-1 – Piper Plt and Durov Plot of the Major Ion Composition of Unimpacted Groundwater (RGC, 2018)

7.1.2 ML/ARD Indicators and Contaminants of Concern (RGC, 2018)

Groundwater characterised by more than 5 mg/L SO_4 is likely impacted by ARD or the acidic liquor lost from the TSF in 2008 (**Section 7**). For most metals, concentrations higher than 10 µg/L likely imply some impact, but it is important to recall that many of the historic data are not reliable and some elevated metal concentrations could be related to cross-contamination during sampling. Most groundwater quality impacts at the Browns site are not ambiguous however and there is little uncertainty regarding which bores are impacted given the high concentrations in contaminant sources.

7.2 Site Wide Groundwater Flow Regime

7.2.1 Recharge Areas (RGC, 2018)

RGC (2018) developed a conceptual groundwater budget that includes recharge rates to groundwater from the Sediment Dam, the TSF pond, and the ore stockpiles. Also provided are recharge rates for undisturbed land areas and estimated flow rates to the Browns Pit from the surrounding aquifer. Undisturbed areas provide the majority of recharge to the model domain. This recharge, and potential recharge from the flooded pits at the former Rum Jungle mine site, may dilute contaminant loads in groundwater.

Recharge rates for the ore stockpiles, Sediment Dam, and the TSF pond are used to estimate contaminant loads to groundwater in **Section 8**. The ore stockpiles are considered preferential recharge areas because the infiltration rates to groundwater for the coarse ore that is stockpiled are higher than infiltration rates for undisturbed land areas. Recharges from the Sediment Dam and TSF pond are also relatively high because a strong vertical hydraulic gradient is caused by the standing water in these ponds.

7.2.2 Inferred Flow Field (RGC, 2018)

Figure 5-1 shows geodetic groundwater levels in January 2018 and the inferred flow field and groundwater flow directions. The inferred flow field to the south of the TSF and along the northern property boundary i.e. north of the offices and processing plant, are still rather uncertain due to the lack of monitoring bores in these areas. Additional information from the monitoring bores to be installed in 2018 is needed to refine the local groundwater flow field for these areas and determine groundwater flow directions with more certainty (see Section 6.2 for proposed drilling locations).

Key observations from RGC 2018 from the preliminary flow field provided here are summarised below:

- Groundwater levels are highest to the south of the TSF near bores BH7A/B where ground elevations naturally increase to ~88 m AHD. High groundwater levels in this area suggest that the gradient in this area is weak and that groundwater may currently flow towards the TSF from the south at certain times of the year. A gradient towards the south could have occurred in 2008 when there was standing water in the TSF but there is no evidence that liquor from the TSF impacted bores BH7A or BH7B or any other TSF2 bores.

- Some mounding is observed along the southern TSF berm from bore BH3A to bore BH5B near the eastern end of the TSF. These elevated water levels could reflect a hydraulic connection between the TSF pond and groundwater beyond the TSF berm. This mounding suggests ongoing seepage to groundwater from the TSF pond and could explain impacts to groundwater at bores BH3B, BH13B, and BH4D.

- Groundwater generally flows across the Browns site from the TSF area towards the Browns Pit. This flow pattern is related to the low water level in the pit (56 to 57 m AHD since 2012), which depresses groundwater levels nearby and causes the pit to act as a local sink for groundwater throughout the year.

7.2.3 Potential Groundwater Fluxes (RGC, 2018)

Table 7-1 summarises a conceptual groundwater budget for the Browns site. RGC developed a 3D numerical groundwater flow model. The model was developed to simulate groundwater inflow rates to the de-watered underground workings at the end of the proposed mine life.
Shallow (< 30 m depth), unconfined aquifers near ground surface, i.e. laterite, saprolite, and bedrock units, are grouped together as a single unit in RGC's flow model. The simplified representation of shallow aquifer units as a single unit in the model precluded the use of the numerical model for this report. Instead, groundwater flows from the conceptual groundwater budget from RGC (2018) are used in this report to estimate annual contaminant loads to groundwater.

Table 7-1 – Estimated Seepage Flows to Groundwater

Source	Flow Rate	
	L/s	Contribution
Loads to Groundwater		
TSF pond	5	51%
Main Sediment Dam	2.6	26%
Small Sediment Dam	0.3	3%
PAF Ore Stockpile	0.7	7%
Low Grade Ore Stockpile	0.3	3%
Intermediate Ore Stockpile	1.1	11%
TOTAL:	9.9	100%

7.3 Contaminant Sources to Groundwater

7.3.1 Acidic Liquor in TSF (RGC, 2018)

In August 2008, Compass Resources began discharging tailings and liquor to the TSF. Pumping records indicate that ~530 ML of liquor and 200,000 t of tailings were discharged to the TSF between August 2008 and January 12th, 2009, when discharge ceased. The liquor was acidic (pH 3.1) and characterized by up to 1,550 mg/L Cu and elevated concentrations of most other metals. Approximately 75% of the liquor was discharged to a western pond within the TSF and the remainder was discharged to an eastern pond. The two ponds were separated by an un-engineered bund that was built with Potentially Acid Forming (PAF) waste rock (ATC Williams, 2009).
In January and February 2009, internal records show that the previous operator (Compass Resources) recovered about 400 ML of liquor from an eastern and western pond within the TSF and treated it in the processing plant. 132 ML of residual liquor remained in the western pond in February 2009 when pumping from the TSF ceased.
On December 30th, 2008, elevated Electrical Conductivity (EC) and low pH values were observed while purging monitoring bores BH4A and BH4B prior to routine sampling. These bores are located south of the TSF near the current mine lease boundary. Lab testing later confirmed that water samples from these

bores were characterized by metal concentrations that were comparable to concentrations in liquor in the TSF ponds (see **Table 7-2**). The high concentrations are attributed to undiluted liquor lost from the western and/or eastern TSF ponds. These high concentrations suggest undiluted liquor was lost from the TSF, possibly via a fracture zone associated with faults that run beneath the TSF.
In 2009 and 2010, several seepage recovery bores were installed near the TSF to recover liquor and/or impacted groundwater. Seepage recovery bores BH4G and BH12C have been operated since 2010 and delivered flows to the TSF.

Table 7-2 - Condition of Liquor Released in 2008 and Concentrations in BH4A/B in 2009 (RGC, 2018)

Bore ID or Sampling Location	**Analysis Date**	**pH**	**EC**	**SO_4** mg/L	**Mg** mg/L	**Al-d,** mg/L	**Co-f,** mg/L	**Cu-d,** mg/L	**Fe-f,** mg/L	**Mn-f,** mg/L	**Ni-f,** mg/L	**Pb-f** mg/L	**Zn-d** mg/L
Liquor discharged to TSF at decant													
Western side of bund	5-Jan-09	3.4	3,900	-	-	638	243	1,550	1,450	439	120	4	40
Water samples collected within the TSF													
Western pond	5-Jan-09	3.1	3,270	-	-	638	243	1,550	1,450	439	120	4	40
Eastern pond (NW corner)	5-Jan-09	5.5	75	-	-	1,142	254	1,146	2,920	382	146	5	88
Eastern pond (NW corner)	5-Jan-09	5.3	75	-	-	1,129	261	1,169	2,943	378	150	5	91
Eastern pond (NE corner)	5-Jan-09	3.1	5,530	-	-	1,176	273	1,164	3,126	401	156	6	105
Eastern pond (NE corner)	5-Jan-09	3.0	-	-	-	1,157	268	1,143	3,108	393	153	6	103
Samples from bores BH4A and BH4B, January 2009													
Bore BH4A	14-Jan-09	2.7	8,256	8,370	507	703	110	609	177	296	52	0.1	24
Bore BH4B	13-Jan-09	2.2	12,460	15,200	689	1,130	169	1,000	458	453	80	0.04	7

Previous reports by URS and GHD have characterised groundwater quality impacts by liquor to some extent and have outlined strategies to recover impacted groundwater. These strategies mainly involved continued operation of recovery bores BH4G and BH12C. Flow records for these bores are not available and a detailed assessment of their past performance has not been completed. RGC completed a preliminary assessment of groundwater quality impacts near the TSF in 2017 and was later retained to prepare the Water Quality Review and Load Balance Assessment (**Appendix 1**).

7.3.2 Seepage from Existing Ore and Waste Rock Stockpiles

There are no surface expressions of seepage from the existing stockpiles that are routinely sampled (if any occur at all). **Table 7-2** summarises the condition of seepage from waste rock excavated from the trial mine pit in 2002. The trial mine pit was excavated when Compass Resources intended to mine the sulphide ore deposit by open pit. Water samples were collected by site staff for EGI (2002).

Table 7-3– Seepage Water Quality (Trail Mine Pit Samples, 2002) – (RGC, 2018)

Dump/Stockpile	Field pH	Field EC	Mg	SO_4	Al-f	Co-f	Cu-f	Fe-f	Mn-d,	Ni-f	Pb-d,	Zn-f
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Seepage from Sulphide Ore Dump												
Sulphide Ore Dump	2.2	20,000	539	39,448	435	966	17,335	1,441	60	771	10	632
Sulphide Ore Dump	2.4	19,700	427	29,600	342	821	15,128	748	59	609	0.3	423
Sulphide Ore Dump	1.5	17,100	80	18,945	317	697	5,997	1,672	3	405	4	927
Sulphide Ore Dump	1.6	14,500	72	14,123	206	473	4,116	1,354	2	313	3	495
Sulphide Ore Dump	1.8	10,500	256	10,762	330	238	3,249	722	45	176	2	271
Sulphide Ore Dump	1.9	8,290	147	8,241	173	130	1,952	465	7	107	3	146
Seepage from Waste Rock Dump												
Waste Rock Dump	2.2	11,800	1,926	15,961	-	-	-	-	-	-	-	-
Waste Rock Dump	2.4	10,800	1,633	14,381	1,004	11	16	79	25	18	1	300
Waste Rock Dump	1.9	10,500	988	13,928	1,008	14	15	952	20	21	1	285
Waste Rock Dump	2.7	10,300	2,056	12,161	604	9	2	31	94	22	0.2	7
Waste Rock Dump	1.6	10,800	465	11,757	741	16	17	1,761	12	22	3	454
Waste Rock Dump	2.4	7,020	842	7,608	658	8	6	47	24	11	1	178
Waste Rock Dump	3.3	3,050	408	2,357	15	1	0.2	1	7	2	1	1
Waste Rock Dump	3.2	2,280	325	1,704	10	1	0.2	1	5	2	1	0
Seepage from Oxide Ore Dump												
Oxide Ore Dump	3.2	910	58	481	17	5	34	1	3	4	5	22
Oxide Ore Dump	3.4	670	51	356	8	4	26	0.2	3	3	4	13
Oxide Ore Dump	4.9	80	4.0	27	-	-	-	-	-	-	-	-
Oxide Ore Dump	5.6	90	3.0	18	0.0006	0.3	4	<0.02	0.1	0.3	2.5	0.1
Oxide Ore Dump	5.5	30	1.3	12	0.0030	0.1	0.3	-	0.0	0.1	3.5	0.2
Oxide Ore Dump	5.5	80	1.1	8	0.0030	0.1	0.2	<0.02	0.0	0.1	2.3	0.1

7.3.3 TSF Berm (RGC, 2018)

ATC Williams (2007) indicates that PAF waste rock was used to construct the TSF berm. However, an as-built report is not available, and there are no known expressions of seepage along the berm. Groundwater near the berm (where there are no other known sources) can be characterized by elevated SO_4 and some metals. Seepage from the TSF is therefore considered a potential (if not secondary) contaminant source to groundwater that may explain localized water quality impacts in some areas and discussed below.

8. GROUNDWATER QUALITY IMPACTS AND CONCEPTUAL LOAD BALANCE

8.1 Seepage and Liquor-related Water Quality Impacts (RGC, 2018)

Figure 8-1 and **Figure 8-2** shows groundwater quality results that are reasonably representative of current conditions. These are the same (verified) data provided in **Table 6-1.** The major ion composition of groundwater at the Browns site is illustrated in **Figure 8-3** (Piper plot) and **Figure 8-4** (Durov plot). Conceptual cross-sections that show how SO_4 and Cu concentrations vary with depth near the southern and western TSF berms. Geodetic groundwater levels from the January 2018 survey are plotted in the cross-sections. Cross-section alignments are shown in **Figure 8-1** with site features shown and with surficial geology in **Figure 8-2.**

The key observations made by RGC (2018) regarding the current impacts to groundwater are summarised below.

- Approximately 530 ML of liquor was discharged to the TSF from September 2008 to December 2008. This volume is about three times higher than the average annual rainfall volume to the TSF (167 ML). By December 2008, a pond within the TSF was likely 5 to 6 m deep based on the EAV curve from GHD (2016a). Internal records indicate that 75% of the liquor was discharged to the western pond and 25% was discharged to an eastern pond. After pumping in January 2009, there was a single pond near the western end of the TSF.
- For several months in 2008, groundwater level data for bores BH4A and BH4B indicate substantial, if not localized, mounding near the southern TSF due to the increased seepage (recharge) from the TSF pond. The groundwater flow field would have been radial, but still skewed towards the dewatered pit (~35 m AHD during mining). Some localized mounding near the southern perimeter of the TSF is inferred to occur today but it is not widespread as often observed near TSFs at other sites that are filled with more water and tailings, or which are underlain by less permeable aquifer materials than Whites Formation shales and the Coomalie Dolostone.
- In December 2008 and January 2009, undiluted liquor was identified during sampling bores BH4A and BH4B. Liquor was likely be lost from the western pond and/or the eastern pond in 2008 via a fracture zone(s) or some other disturbance within the foundation. Prior to liquor being discharged to the TSF, groundwater quality at bores BH4A and BH4B was unimpacted (see Table 8-1).
- Liquor from the TSF was likely lost via two fault zones running beneath the TSF. One of the faults runs north-to-south and dips to the west. The other fault is oriented roughly northeast-to-southwest and runs beneath the former eastern pond. URS (2009) identified the fault that runs from east-to west as the likely pathway for liquor from the eastern pond to the bores BH4A and BH4B.
- Since peak concentrations were observed in December 2008 and January 2009, metal concentrations in groundwater samples from bores BH4A and BH4B have decreased by at least an order of magnitude. Cu concentrations in water from bore BH4B, for instance, decreased from 1,106,000 µg/L Cu in January 2009 to ~30,000 µg/L Cu in 2017. SO4 concentrations have decreased by an order-of-magnitude since 2009, i.e. from 12,320 mg/L SO4 in 2009 to 1,201 mg/L SO4 in 2016.
- Metal concentrations in groundwater from bores BH4A and BH4B are now comparable, if not lower than, concentrations in TSF water (see Table 8-1). Water in the TSF consists of residual liquor from 2008 that has been diluted by rainfall during each subsequent wet season and by small volumes of impacted groundwater pumped from recovery bores BH4G and BH12C since 2010.

Comparable water quality in the pond and bores BH4A and BH4B suggests there is still a direct connection between the western TSF pond and the sub-surface near these bores. These bores likely received undiluted liquor from the former eastern pond for several months in 2008 (until it was drained) and have continued to receive water from the western pond since 2009. This is supported by preliminary simulations of the Cu concentrations in TSF pond with the Goldsim model.

- The decrease in metal concentrations at bores BH4A and BH4B appears to be unrelated to the minimal pumping rates achieved by seepage recovery bores BH4G and BH12C. Groundwater from recovery bore BH12C is also characterized by nearly non-detectable Cu concentrations, so it does not intercept any appreciable metal load. RGC (2018) recommended that it no longer be operated and the pump was removed in December 2017 because it was clogged.
- South of the TSF, elevated Cu concentrations can occur in bores other than bores BH4A and BH4B. However, only concentrations in groundwater from monitoring bore BH4D and recovery bore BH4G are characterized by Cu concentrations higher than 1,000 µg/L Cu (see Figure 8-1). Elevated Cu in bores BH4D and BH4G is likely related to a diluted, possibly localized plume that is sustained by ongoing seepage from the TSF pond.
- SO4 and metal concentrations in the other TSF1 bores, i.e. to the west and north of the TSF, are much lower than in groundwater from bores BH4A and BH4B. Lower concentrations indicate that most of the bores around the TSF are not connected to the fracture or other preferential flow path(s) between the TSF pond and bores BH4A and BH4B. The modest impact observed in bores to the east of the TSF, e.g. BH16B and BH17B, is likely related to seepage from the ore stockpiles and/or a TDS (SO4) plume that originates beneath the TSF and is migrating towards the Browns Pit.

Table 8-1– Selected Water Quality Observations for Bores BH4A and BH4B, 2009 to 2017 (RGC, 2018)

Bore ID	Sampling Date	Field pH	Field EC	SO4	Mg	Al-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	
BH4A	28-Aug-0	5.3	86	1	<0.1	165	0.2	1	100	14	0.4	0.	4	3%
BH4A	30-Dec-0	4.5	6,649	5,000	320	-	75,800	431,000	78,100	213,000	34,900	11	16,400	-
BH4A	7-Jan-0	5.3	8,138	-	490	626,300	119,300	715,400	161,800	289,800	58,550	33	23,060	-
BH4A	14-Jan-0	2.7	8,256	8,370	507	703,000	110,000	609,000	177,000	296,000	52,000	9	24,400	2%
BH4A	30-Apr-0	3.3	8,049	8,200	516	474,000	107,000	440,000	399,000	324,000	49,000	19	25,600	3%
BH4A	1-Jul-0	3.5	6,191	5,480	398	235,000	88,000	267,000	265,000	260,000	36,800	12	18,500	0.2%
BH4A	31-Aug-0	3.7	5,554	4,370	378	127,000	77,700	157,000	148,000	189,000	33,600	11	15,800	0.4%
BH4A	15-Jan-1	3.4	3,380	2,610	243	68,600	47,800	94,800	2,660	114,000	20,900	9	10,800	7%
BH4A	8-Jul-1	2.8	1,527	1,400	84	22,000	10,000	29,000	780	24,000	4,900	4	2,700	35%
BH4B	28-Aug-0	5.8	60	0.6	0.3	91	1	1	60	62	1	0.	9	17%
BH4B	30-Sep-0	5.3	55	0.5	0.3	390	0.3	1	160	13	1	0.	5	43%
BH4B	7-Nov-0	5.4	54	0.6	0.2	16	0.2	1	60	8	0.3	0.	2	22%
BH4B	9-Dec-0	6.3	59	3.1	0.3	79	11	40	40	48	6		10	29%
BH4B	30-Dec-0	4.5	6,057	4,850	301	370,000	73,900	-	78,100	226,000	33,500	9	16,000	-
BH4B	8-Jan-0	4.9	12,320	-	612	970,200	168,900	1,106,000	432,600	433,300	81,760	34	31,940	-
BH4B	13-Jan-0	2.2	12,460	15,200	689	1,130,000	169,000	1,000,000	458,000	453,000	80,400	3	37,600	11%
BH4B	30-Apr-0	3.2	8,067	8,670	507	490,000	107,000	450,000	424,000	321,000	49,800	12	25,800	6%
BH4B	1-Jul-0	3.4	6,327	5,370	382	232,000	88,100	256,000	265,000	253,000	37,100	8	18,500	1%
BH4B	31-Aug-0	3.6	5,548	4,380	387	119,000	78,600	150,000	142,000	185,000	34,500	8	16,300	0.3%
BH4B	15-Jan-1	3.3	4,520	3,800	315	85,000	70,000	106,000	95,600	179,000	29,300	7	13,900	9%
BH4B	17-Aug-1	3.3	1,201	1,300	69	19,000	13,000	27,000	-	36,000	6,000	1	2,900	-
TSF Pond	**17-Jan-1**	**4.2**	**1,146**	**580**	**49**	**12,000**	**6,100**	**32,000**	**80.0**	**1,700**	**4,100**	**62**	**1,100**	**4%**

Notwithstanding the above analysis, recent (2019-22) water quality data measured at BH4A and BH4B (see Table 8-2) indicates a substantial improvement in groundwater quality, with a substantial reduction in filterable metals being measured, indicating further dilution of dissolved metal load from the TSF.

Table 8-2 BH4A and BH4B water quality average in 2019-22

Bore ID	Sampling Date	Field pH	Field EC	SO4	Al-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	Zn-f
BH4A	2019/20	3.0	1367	720	25,000	7,800	19,000	25,000	22,000	2,700	500	2,500
	2020/21	3.3	1187	695	16,000	7,300	18,000	1,900	15,000	4,000	52	1,900
	2021/22	3.5	1304	580	13,000	6,100	17,000	<500	8,900	3,400	49	2,200
BH4B	2019/20	3.2	1482	750	20,000	9,700	21,250	7,650	26,000	4,100	160	2,825
	2020/21	3.9	1277	740	9,000	7,600	20,000	6,200	17,000	3,800	67	2,200
	2021/22	3.5	1205	530	12,000	6,800	19,000	2,100	16,000	3,400	37	2,200

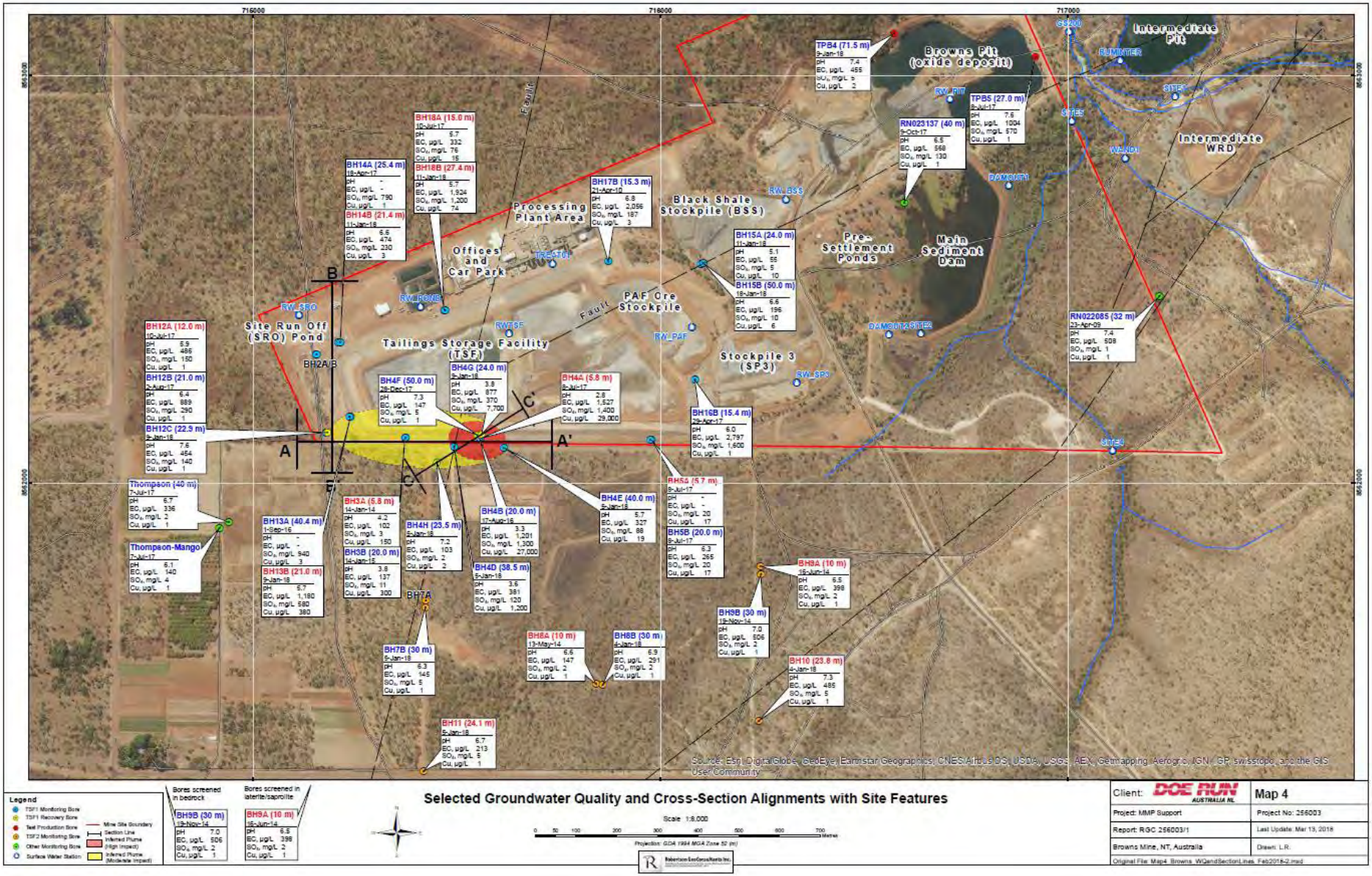


Figure 8-1- Selected Groundwater Quality and Cross Section of Alignment with Site Features (RGC, 2018)

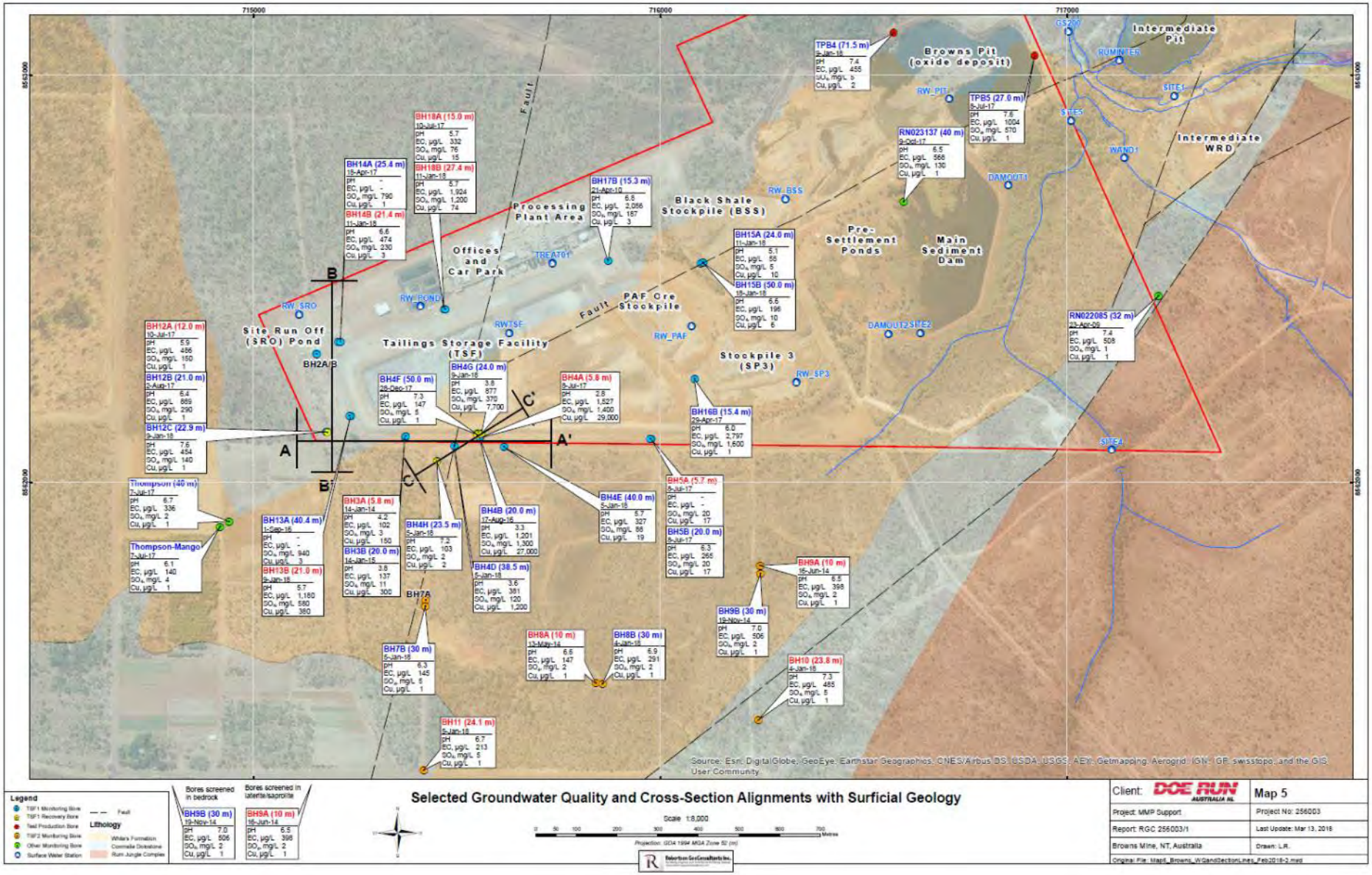


Figure 8-2 – Selected Groundwater Quality and Cross Section Alignments with Surficial Geology

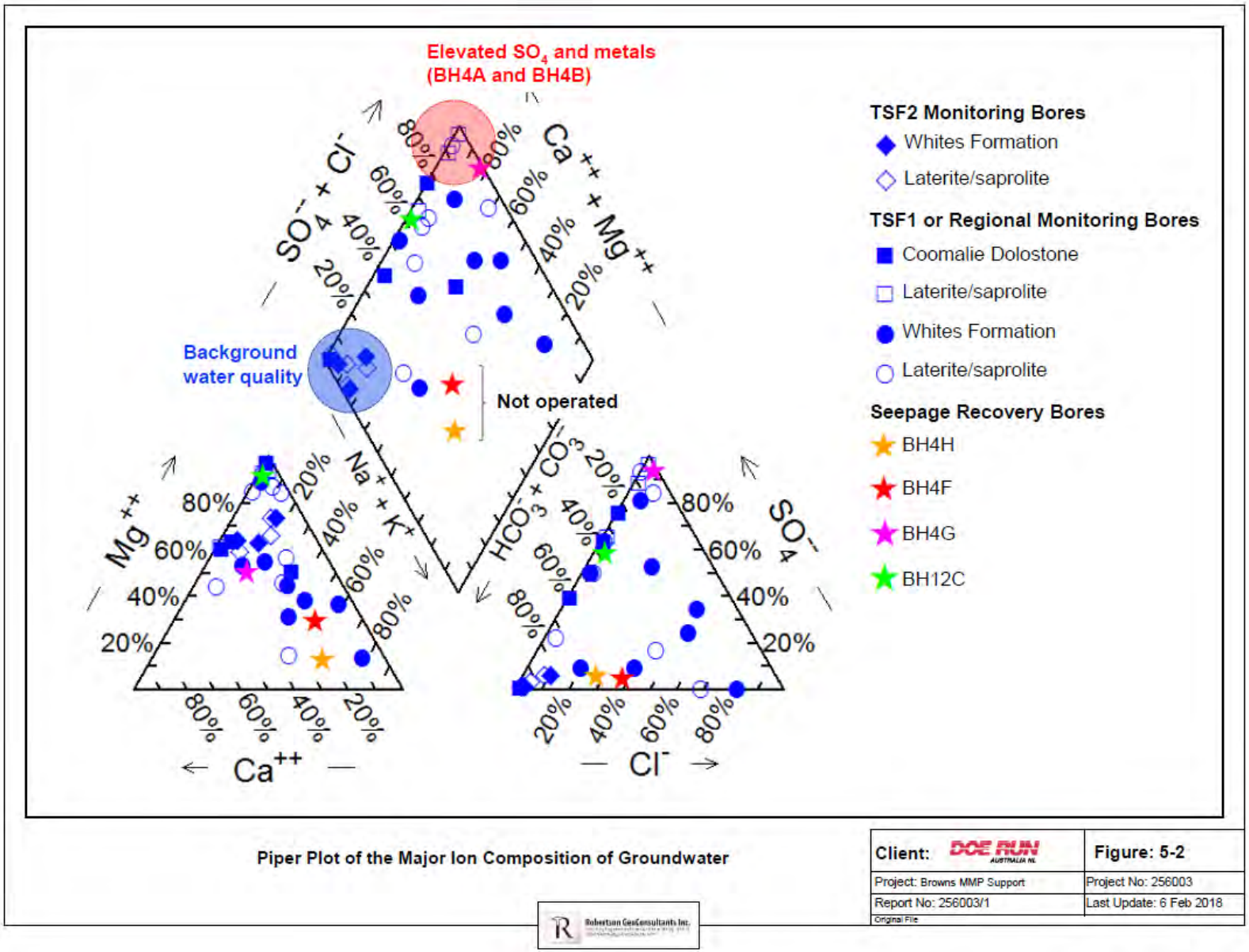


Figure 8-3 – Piper Plot of Major Ion Composition of Groundwater (RGC, 2018)

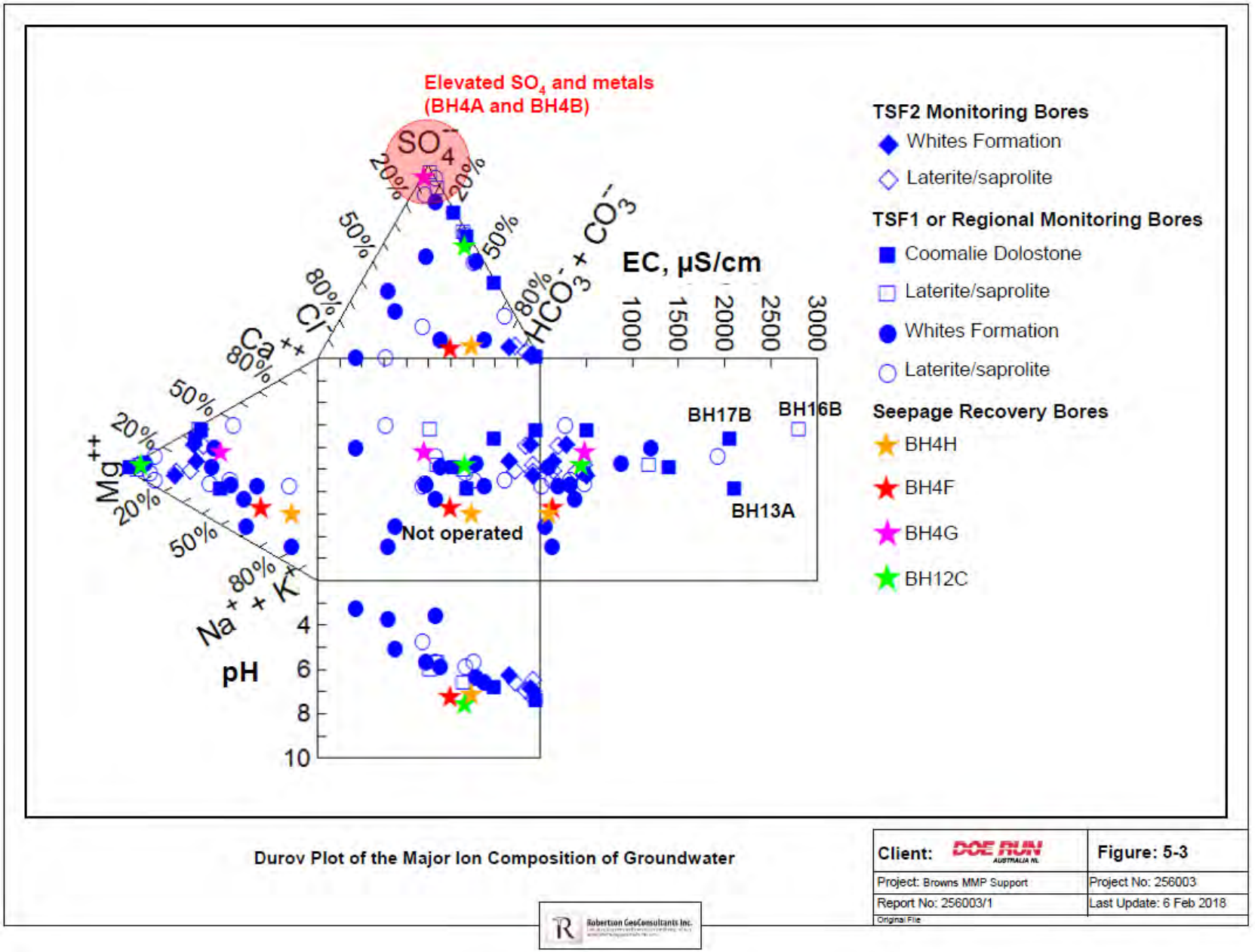


Figure 8-4 – Durov Plot of the Major Ion Composition of Groundwater (RGC, 2018)

8.2 Statistical Trends (RGC, 2018)

Table 8-3 summarises the results of the Mann-Kendall trend analysis for 22 bores on site or to the south of the TSF. Five bores at the Browns site had insufficient data for a trend analysis because these bores have been damaged or could not be routinely sampled because they are typically dry. Descriptive statistics for the Dry Season samples selected for the trend analysis are provided in the table to provide an indication of the degree of water quality impact for each bore and the range of concentrations included in the trend analysis. Descriptive statistics are also provided for the bores that that were not included in the Mann- Kendall trend analysis for reference. 50% of the seasonally-adjusted time trends analysed were identified as stable and the other 50% had no trend, i.e. concentrations are not increasing or decreasing but there is too much scatter in the data to be classified as stable. The trends for bores BH4A, BH4B, BH4D, and BH4G were each identified as stable[1]. S values are negative, suggesting a possible decrease over time, but the downward trend was not statistically significant. This is important because it indicates that the Cu concentration in groundwater impacted by liquor from the TSF has been consistent for five years. This implies that the current seepage recovery strategy is not effective and that groundwater quality will not likely improve unless additional recovery measures are implemented (RGC, 2018). As such NTR have a drilling program scheduled for 2018 which includes the installation of 6 observation bore and one recovery bore as recommended by RGC, 2018.
Bores identified as having no trend are characterized by a large degree of scatter in the historic data and hence a high COV. Should these bores continue to be sampled routinely, it is likely that many of these bores would eventually be classified as stable given the improving reliability of routine monitoring data at the site. It would take years to collect the additional data and it does not seem warranted given the low metal concentrations for the recommended scope of future routine groundwater monitoring).

[1] RGC fit an exponential curve (R2 = 0.86) to data collected from January 2009 to January 2012 to characterize the initial decline in Cu concentrations that occurred after liquor was lost. An exponential curve could not be fit to the data collected from 2009 to 2017 because concentrations have not been decreasing in recent years.

Table 8-3 - Summary of Mann-Kendall Trend Analysis for Selected Bores (RGC, 2018)

Bore ID	Series	Descriptive Statistics				Mann-Kendall Trend Analysis			
		n	Median [Cu], µg/L	Mean [Cu] µg/L	SD	COV	S	Confidence Factor	Concentration Trend
Cu concentrations predominantly non-detectable (no trend analysis completed)									
BH4H	Recovery	5	1	2	1	-	-	-	-
BH7A	TSF2	5	1	1	0	-	-	-	-
BH7B	TSF2	5	6	5	2	-	-	-	-
BH8A	TSF2	5	1	1	0	-	-	-	-
BH8B	TSF2	5	1	2	3	-	-	-	-
BH9A	TSF2	5	1	1	2	-	-	-	-
BH9B	TSF2	5	1	2	1	-	-	-	-
BH10	TSF2	5	2	2	1	-	-	-	-
BH11	TSF2	5	1	1	0	-	-	-	-
BH12C	Recovery	5	1	1	0	-	-	-	-
TPB4	Regional	5	1	1	0	-	-	-	-
TPB5	Regional	5	1	1	0	-	-	-	-
Thompson	Regional	5	1	3	5	-	-	-	-
Thompson-Mango	Regional	5	1	1	1	-	-	-	-
Detectable Cu concentrations									
BH3A	TSF1	5	14	18	19	0.5	-8	75.8%	Stable
BH3B	TSF1	5	150	157	137	0.9	-6	88.3%	Stable
BH4A	TSF1	5	34,000	34,800	8,757	0.3	-2	59.2%	Stable
BH4B	TSF1	5	32,000	31,000	8,573	0.2	-6	81.5%	Stable
BH4D	TSF1	5	2,100	2,335	1,510	0.4	-2	59.2%	Stable
BH4G	Recovery	5	8,700	8,655	2,440	0.2	-4	75.8%	Stable
BH13B	TSF1	5	320	382	210	0.6	0	40.8%	Stable
BH14B	TSF1	5	26	26	26	1.0	-4	75.8%	Stable
BH15A	TSF1	5	17	22	15	0.7	-4	75.8%	Stable
BH15B	TSF1	5	9	7	5	0.6	0	40.8%	Stable
BH16B	TSF1	5	14	18	16	0.9	-4	75.8%	Stable
BH2B	TSF1	5	7	22	26	1.2	-6	88.3%	No Trend
BH4E	TSF1	5	79	88	30	0.4	4	75.8%	No Trend
BH4F	Recovery	5	1	13	22	1.8	-3	67.5%	No Trend
BH5A	TSF1	5	18	45	66	1.5	4	75.8%	No Trend
BH5B	TSF1	5	5	7	9	1.2	-2	53.5%	No Trend
BH12A	TSF1	5	2	5	6	1.3	1	50.0%	No Trend
BH12B	TSF1	5	1	4	6	1.5	-10	86.2%	No Trend
BH17B	TSF1	4	2	14	25	1.8	-4	83.3%	No Trend
BH18A	TSF1	5	13	14	4	0.2	2	59.2%	No Trend
BH18B	TSF1	5	125	130	96	0.8	6	88.3%	No Trend
RN023137	Regional	5	3	5	5	1.2	6	66.8%	No Trend

8.3 Conceptual Load Balance for Groundwater (RGC, 2018)

Table 5-6 provides a conceptual load balance for the shallow groundwater system at the Browns site, i.e. up to 30 m/bgs. Flows from the conceptual groundwater budget provided by RGC and summarised in **Table 7-1** are assumed for the load calculations. The average SO_4, Cu, and Zn concentration in surface runoff from the existing ore stockpiles were used as source terms. Other concentrations, i.e. for the TSF pond and Sediment Dam, are median concentrations for the routine surface water quality monitoring. Water balance modelling indicates that there is no loss of water from the ponds that receive runoff from the existing ore stockpiles so these ponds are not considered sources to groundwater (see **Section 9** for further discussion).

Table 8-4 - Conceptual Load Balance for Groundwater (RGC, 2018)

Source	Flow Rate*		SO_4 mg/L	Cu mg/L	Zn mg/L	SO_4 Load		Cu Load		Zn Load	
	L/s	Contribution				t/year	Contribution	kg/year	Contribution	kg/year	Contribution
Loads to Groundwater											
TSF pond	5	51%	280	13	1	44	66%	2,050	38%	84	29%
Sediment Dam	2.6	26%	120	0.01	0.02	10	15%	1	0.02%	2	1%
SRO	0.3	3%	25	0.4	0.08	0.2	0.31%	3	0.06%	1	0%
PAF S/P	0.7	7%	330	66.0	7	7	11%	1,457	27%	159	56%
SP3	0.3	3%	170	8.6	1	2	2%	81	2%	9	3%
BSS	1	10%	110	55.0	1	3	5%	1,734	33%	32	11%
TOTAL (IN):	**9.9**	**100%**	-	-	-	**67**	**100%**	**5,327**	**100%**	**286**	**100%**
Recovered from Groundwater											
Bore BH4G	1.9	50%	370	7.7	1.1	22	73%	461.4	100%	65.9	14%
Bore BH12C	1.9	50%	140	**0.001**	**0.005**	8	27%	0.1	0%	0.3	0%
TOTAL (OUT):	**3.8**	**100%**	-	-	-	**31**	**100%**	**461.4**	**100%**	**66.2**	**14%**

The contaminant load balance is intended to provide an indication of the potential magnitude of loads to groundwater and how they compare to surface water loads that report to the water treatment system. The load balance is not calibrated because there are too few reliable data to develop calibration targets. Moreover, groundwater quality near the existing stockpiles is not characterized to the extent that the concentrations inferred from estimated loads in **Table 8-3** can be compared to observed concentrations in groundwater. The model is, however, instructive and suggests that most of the annual Cu load to groundwater is related to seepage from the western TSF pond whereas seepage from the existing ore stockpiles accounts for the majority of annual SO_4 and Zn loads to groundwater.

The large loads from the TSF pond are consistent with the severity of groundwater quality impacts due to liquor losses from the TSF in 2008. However, it should be acknowledged that the nature of the connection between the pond and the aquifer near bores BH4A and BH4B is not yet well-understood. Additional information from pump testing a new recovery bore is needed to determine the volume of impacted groundwater that still resides near the southern TSF and how it compares to the volume of liquor released in 2008. The pumping test will also allow the hydraulic connection between the pond and the aquifer near bores BH4A and BH4B to be assessed.

8.4 Seepage Recovery System Performance (RGC, 2018)

Key aspects of the current seepage recovery strategy as summarised by RGC (2018) and are listed below:

- Groundwater recovered from recovery bore BH4G is characterized by ~370 mg/L SO4 and elevated Cu, i.e. 7,700 µg/L Cu in January 2018. These concentrations are much lower than in groundwater from bores BH4A and BH4B. Recovery bore BH4G has a long (12-m) screen from 6 to 18 m bgs. This bore likely captures a mixture of the severely-impacted groundwater observed at bores BH4A and BH4B and less impacted groundwater from other depths in the aquifer. These concentrations suggest the plume is likely confined to discrete zones within a fractured and/or heterogeneous aquifer.
- Recovery bore BH4G may recover about 460 kg/year Cu. This assumes a pumping rate of 1.9L/s and the 7,700 µg/L Cu observed in January 2018. This load is less than 0.5% of the mass of Cu that remained in the TSF pond(s) after pumping liquor back in February 2009. Moreover, it is unlikely that bore BH4G has consistently yielded 1.9 L/s since 2009. More likely is that bore BH4G currently recovers no appreciable load due to the minimal flow rates achieved, i.e. ~0.1 L/s. This recovery bore could be of use if future well testing supports the installation of a larger pump, as it does intercept groundwater with substantial Cu and other metals.
- Pumping the residual liquor and/or impacted groundwater that has been identified at bores BH4B cannot be achieved by continued pumping from recovery bore BH4G. A new, 150 to 200mm diameter recovery bore that can achieve the higher (~5 L/s) flow rates observed during a short-term pumping test by URS in 2009 is therefore recommended. If this flow rate is achieved from the new recovery bore, it is unlikely that bore BH4G and the new recovery bore can be operated together in this area without some interference unless the aquifer yield is much higher than expected.
- Groundwater pumped from recovery bore BH12C is characterized by 140 mg/L SO4 and less than the 1 µg/L detection limit for Cu. The SO4 concentration likely represents a small seepage load to the area from the TSF pond that has been buffered and/or attenuated in the Coomalie Dolostone. Continued pumping from recovery bore BH12C is therefore not expected to capture liquor lost from the TSF in 2008 and is unlikely to improve groundwater quality to the west near bore BH13B.
- Recovery bores BH4F and BH4H are not currently operated. Groundwater from bore BH4F is unimpacted, as it appears to be screened too deep in the aquifer to be affected by liquor from the TSF. Recovery bore BH4H is located ~100 m south west of bores BH4A and BH4B and likely beyond the area affected by TSF liquor. Neither of these bores is useful for future seepage recovery but they could be retained to monitor drawdown near a new seepage recovery bore.
- Bores BH4A and BH4B may receive water directly from the TSF pond that has remained since 2009. This implies that water from bores BH4A and BH4B is essentially pond water that continues to be lost to the sub-surface and that the long-term decrease in contaminants likely reflects the dilution of pondwater by rainfall each year. Reducing concentrations at bores BH4A and BH4B may require eliminating the source of contaminants (pond water) and then pumping the impacted groundwater ("residual plume") that currently resides in the aquifer near this bore. The former could be achieved by sealing the TSF floor near bores BH4A and BH4B and/or treating the existing (contaminated) pond so only clean rainfall accumulates in the pond in future years.

9. WATER BALANCE MODEL

9.1 Model Inputs and Structure (RGC, 2018)

RGC developed a water balance model (WBM) in Goldsim to simulate the current 'care and maintenance' configuration of the water management infrastructure on site, including the pumps, pipelines, and drainage ditches that convey surface water to and from water treatment system in the processing plant and the seepage recovery bores near the TSF (BH4G and BH12).
The following storage reservoirs are represented in the model (see
Figure 9-1):

- Browns Pit.
- TSF.
- SRO.
- PAF Stockpile.
- Black Shale Stockpile (Intermediate)
- Stockpile 3 (Low Grade)
- Processing water storage ponds (or PLS ponds).
- Pre-Settlement Ponds.
- Sediment Dam.

Controlled discharge from the Sediment Dam to the EBFR and flows in the EBFR at gauging station GS8150200 are simulated by the model. The model was operated on a daily time step to capture the highly transient hydrological regime of the region. Daily flows from the ungauged catchments were estimated using the Australian Water Balance Model (AWBM).

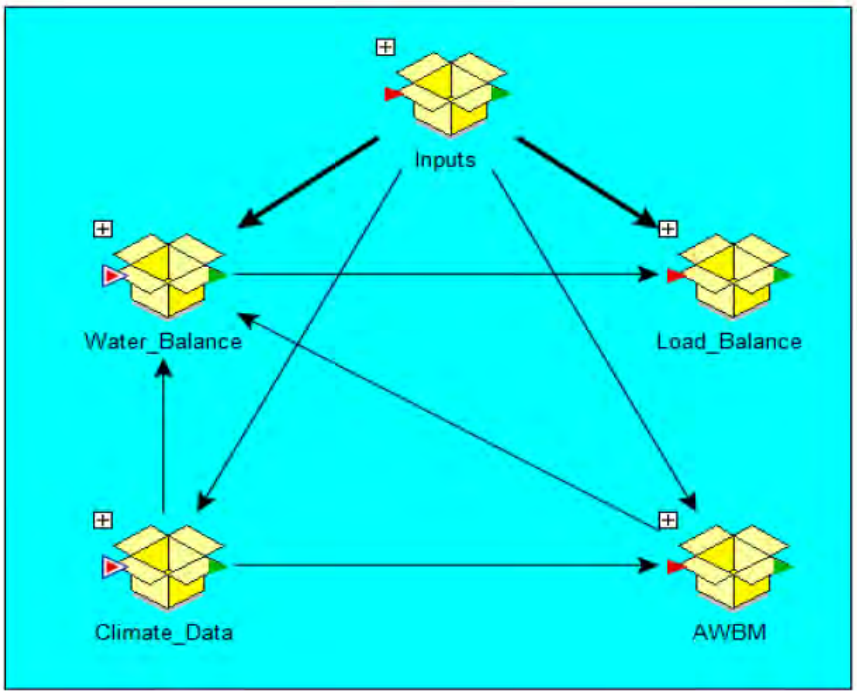


Figure 9-1– Opening Screen of Water Balance and Load Balance Model (RGC, 2018)

Figure 9-2 – Contents of Water Balance Container (RGC, 2018)

9.2 Simulated Water Balance for 2016/17 Wet Season (RGC, 2018)

A summary of the model is discussed below while detailed description of the WBM is located in Section 5.5 of **Appendix 1**.

Figure 9-3 illustrates the movement and storage of water within the boundaries of the Browns site and the linkages between the mine site and the EBFR that were simulated in the model. One symbol represents the EBFR and the other symbols denote key mine elements, such as the Browns Pit, the TSF, and the rainwater collection ponds downstream of the existing ore stockpiles. The broad, coloured arrows represent inputs to or outputs from the model domain. The inputs are:

- Direct rainfall to a pond surface.
- Runoff from the catchment upstream.
- Groundwater inflows.

Outputs are:

- Direct evaporation from a pond surface.
- Infiltration losses to the groundwater system.
- Discharge via the Sediment Dam

ΔS in indicates the difference in storage (in millions of litres, ML) from July 2016 to July 2017. A positive ΔS indicates that more water was stored at the end of the simulation than at the beginning and a negative ΔS value indicates the opposite. The thin, black lines indicate flows between the model elements, such as the water pumped from the Browns Pit or the water collection ponds to the WTP or water discharged from the Sediment Dam to the EBFR. The values in parentheses next to the flowlines in **Figure** 9-3 are simulated flows (in ML) for the 2016/2017 Wet Season.

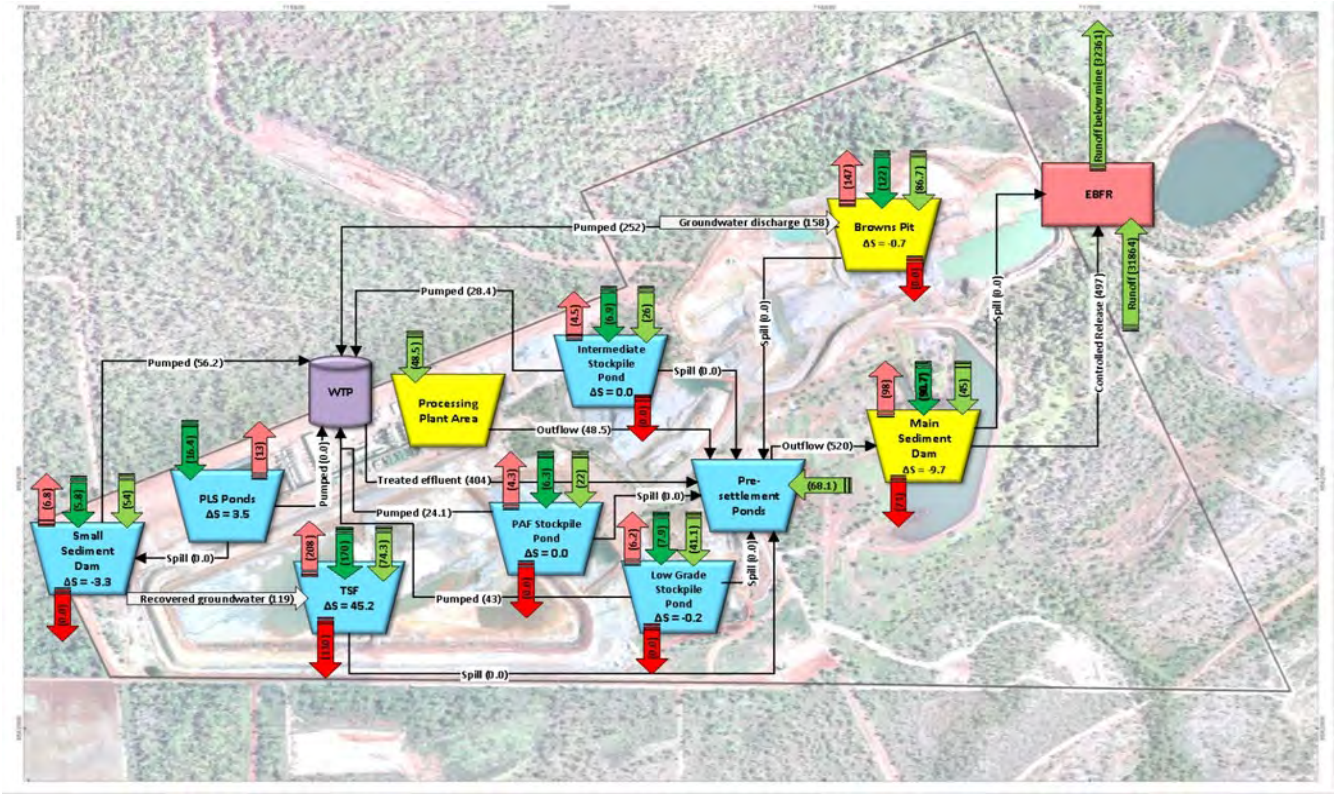


Figure 9-3 – Simulated Water Balance for 2016/17 Wet Season (RGC, 2018)

Each of the flowlines except the line that represents controlled discharge from the Sediment Dam to the EBFR are ungauged. Daily flows from the ungauged flowlines were estimated using the AWBM. To apply the AWBM, the model parameters that dictate the overall magnitude and shape of the hydrographs simulated by the model must be estimated. These parameters were estimated by calibrating the model against the daily flow record for the EBFR at GS8150097 from 1965 to 2009. The assumption is that the model parameters adopted for the EBFR catchment apply to constituent areas of that catchment. **Figure 9-4** shows an example of the fit obtained between modelled and observed flows in the EBFR at GS8150097 for 1990/1991 Wet Season

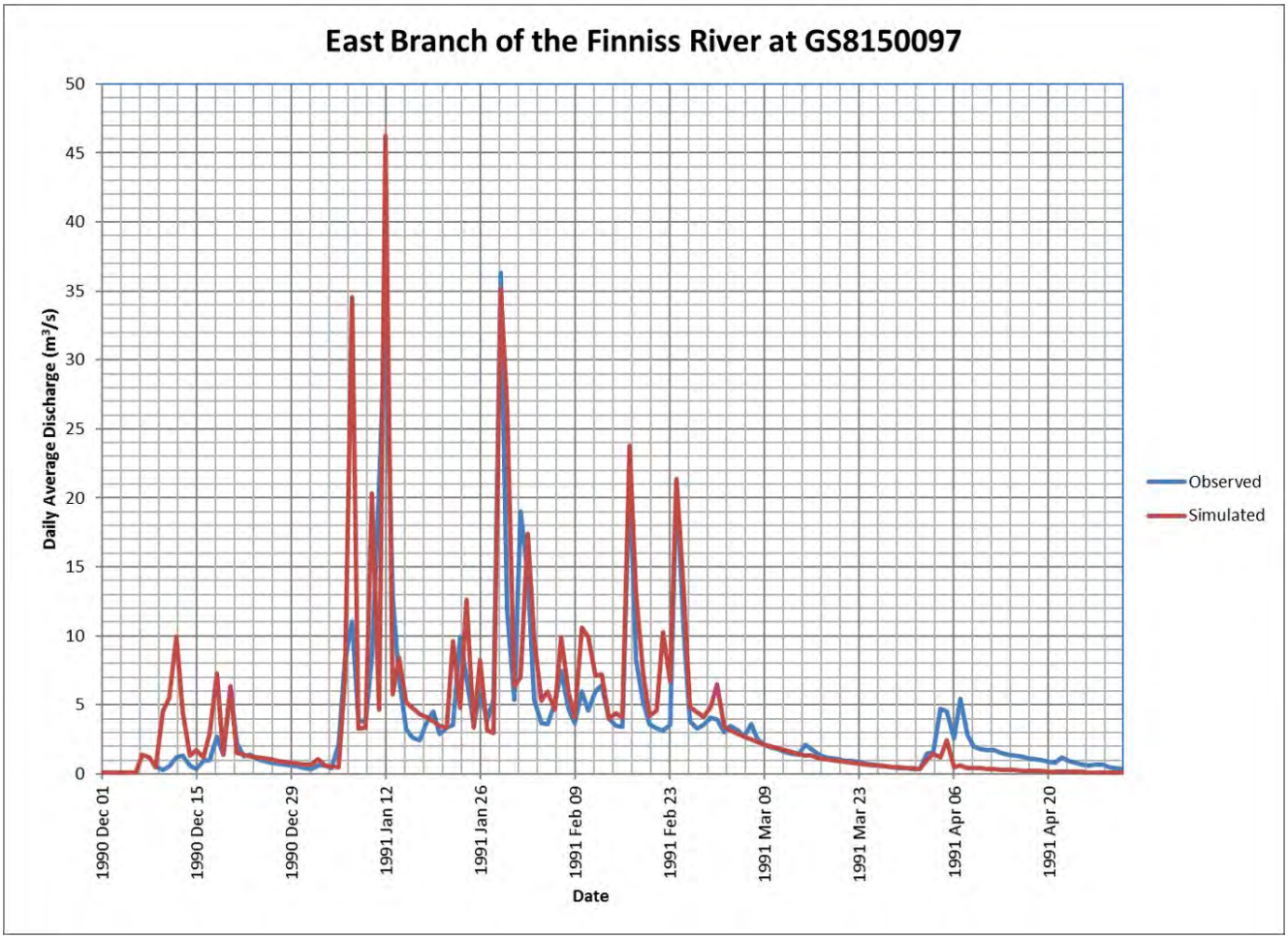


Figure 9-4 – Simulated and Observed Flow in the EBFR at t GS8150097, 1990/1991 Wet Season (RGC, 2018)

9.3 Simulated Flows to Water Treatment System and EBFR (RGC, 2018)

Table 9-1 summarises simulated flows to and from the water collection ponds, the TSF, and the Browns Pit for the 2016/2017 Wet Season. This is the only near-complete wet season (water year) since the electronic sensor was installed at the outlet pipeline from the Sediment Dam and most of the flows occurred during the monitoring period for WDL177-06 (December 2016 to January 2018). **Table 9-2** summarises flows to and from the Sediment Dam for the 2016/2017 Wet Season.

Table 9-1 - Simulated Flows to the Water Treatment System, 2016/2017 Wet Season (RGC, 2018)

Source	Inputs			Outputs		ΔS ML	Pumped to WDL ML
	Direct Rainfall ML	Runoff from Upstream Catchment ML	Groundwater Inflow ML	Evaporation ML	Infiltration to Groundwater ML		
Browns Pit	122	86.7	158	147	0.0	-1	252
TSF	170	74.3	119	208	1.1	-45	0
SRO Pond	5.8	54.0	54.0	6.8	0.0	-3.3	56.2
PLS ponds	16.4	0.0	0.0	13.0	0.0	-3.5	0.0
PAF Pond	6.3	22.0	0.0	4.3	0.0	0.0	24.1
SP3 Pond	6.9	26.0	0.0	4.5	0.0	0.0	28.4
BSS Pond	7.9	41.1	0.0	6.2	0.0	-0.2	43.0
TOTAL (IN):	335	304	331	390	0	-53	404

Table 9-2 - Simulated Flows to the Sediment Dam 2016/2017 Wet Season (RGC, 2018)

Source	Inputs			Outputs		ΔS ML	Pumped to WDL ML
	Direct Rainfall ML	Runoff from Upstream Catchment ML	Groundwater Inflow ML	Evaporation ML	Infiltration to Groundwater ML		
Sediment Dam	90.7	45%	521	98	71%	-9.7	497

Notes:

Flows to the Pre-settlement Ponds:40ML from WT, 48.5ML from Processing Plant Area and 68.1ML of runoff.
Simulated controlled discharge (497ML) from the Sediment Dam is 1.5% of the flow in the flow in the EBFR during 2016/2017 Wet Season (31.864ML)

Observed controlled discharge volume for 2016/2017 Wet Season was 469ML (6% lower than the simulated controlled discharge volume.

Some key observations from these tables are summarised below:

- 404 ML was simulated to flow to the WTP during the 2016/2017 Wet Season. This is 81% of the simulated volume of controlled discharge (497 ML) from the Sediment Dam during the 2016/2017 Wet Season. The observed volume of controlled discharge from the Sediment Dam during the 2016/2017 Wet Season was 469 ML, or 6% lower than the simulated volume.
- Simulated flows to the WTP (404 ML) were 36% higher than the average simulated flow to the water treatment system for the 6-year calibration period. These higher flows are related to higher rainfall during the 2016/2017 Wet Season than in previous wet seasons except the 2010/2011 Wet Season (the wettest season of the calibration period).
- Simulated flows from the Browns Pit account for 62% of the simulated flows to the WTP. Pit water is pumped to the processing plant as the main feed sources to the WTP and is used to blend the stockpile contact water. Substantial groundwater inflows to the Browns Pit (158 ML) are simulated by the model to ensure that pit water could be directed to the water treatment system while maintaining the constant pit water level that was inferred from bore TPB5 for the 2016/2017 Wet Season[2]. These groundwater flows (5 L/s annualized) are

[2] No records are maintained of the volumes of water withdrawn from the pit so a definitive assessment of groundwater inflows could not be made. Groundwater inflows were therefore inferred by assuming that groundwater levels at bore TPB5 are a proxy for the water level in the pit. The groundwater/pit water level remains reasonably constant during the Dry Season when the only significant loss from the pit

equivalent to annual evaporation from the pit and are consistent with RGC's CSM for the site. Flows are also consistent with substantial withdrawals of water from the pit for use as the main feed water to the WTP.

- The TSF is simulated to be an enclosed basin because it has sufficient empty storage to fully capture any direct rainfall. This is true for each wet season of the 6-year calibration period, including the 2010/2011 Wet Season (2500 mm rainfall). Flows from the TSF to the WTP are therefore not simulated by the model. Instead, water stored in the TSF is simulated to be lost by evaporation (which is estimated by the AWBM) and infiltration to groundwater. In the model, infiltration to groundwater was increased until simulated flows to the water treatment were not required to maintain a closed system. For the 2016/2017 Wet Season, 110 ML of water from the TSF pond was simulated to infiltrate to groundwater. Annualized, this is 3.5 L/s, which is within the 1 to 10 L/s range estimated in RGC.
- 24% of the simulated flows to the WTP are related to water pumped from the PAF ore stockpile pond, the Black Shale Stockpile pond, and the Stockpile 3 pond. Flows from the SRO account for the other 14% of the simulated flows to the WTP.

is direct evaporation from the pond surface. For the pit pond level to remain roughly constant while it is subject to large evaporation losses, an inflow of nearly equal magnitude would be required to offset the losses. This inflow stream was assumed to be the result of a net positive groundwater inflow to the pit.

10. WATER ACCOUNT

The Water Quality Review and Load Balance Assessment conducted by RGC (2018) provided the Water Account for the 2016/2017 period. Below is an extract from this report.
The Browns Site is currently managed under a care and maintenance and there are no active mining operations on site. The Water Account provided here is for the 2016/2017 Wet Season, July 2016 to July 2017. This is the period for which there are reliable estimates of controlled discharge volume from the Sediment Dam, as a new electronic sensor was installed in 2016.

10.1 Water Quality Description (RGC, 2018)

The following water categories are identified in Water Accounting Framework (WAF):

- Category 1. Close to the drinking water standards, as it only requires minimum treatment (disinfection) to be safe for human consumption. It can be used for all purposes.
- Category 2. Suitable for some purposes. Treatment will be required to remove TDS and/or adjust other parameters to be safe for human consumption and more sensitive agricultural and recreational purposes.
- Category 3. Water unsuitable for most purposes due to high salinity (> 5000 mg/L TSD) or highly unsuitable pH (<4 or >10). Will require significant treatment to be considered Category 1 or Category 2.

For this report, water that meets ADWGs is considered Category 1 water. Category 2 water meets some of the ADWGs, but some metals exceed guideline concentrations. Category 3 water is acidic and exceeds the ADWGs for SO_4 and most metals.
Surface water at the Browns site is categorized as follows:

Category 1

- SITE3. Sediment Dam.
- SITE4. Middlebrook Creek upstream of boundary discharge.

Category 2

- TREAT01. Treated effluent to Sediment Dam.
- SITE2. Sediment Dam.
- SITE5. Middlebrook Creek downstream of boundary discharge.
- RWPOND. Process water storage pond.
- RSPIT. Browns Pit.

Category 3

- SITE1. EBFR Upstream.
- DAMOUT1. Sediment Dam at discharge pipe outlet.
- RWTSF. TSF Pond.
- RWSRO. Small Sediment Dam
- RWBSS. Intermediate ore stockpile pond.
- RWSP3. Low Grade and Lead ore stockpile pond.
- RWPAF. PAF ore stockpile pond.
- Groundwater recovered by recovery bores BH4G and BH12C is Category 3 water.

10.2 Input-Output model (RGC, 2018)

The system boundary for the Browns site is the mine lease boundary. Rainfall runoff on site is collected and treated in the processing plant. Treated effluent is then released to the Sediment Dam. Water from the Sediment Dam is released to the EBFR as per WDL177-06.
The input-output model is summarised below:

Inputs

- Surface Water Rainfall and Runoff.
- Groundwater Seepage interception by BH4G and BH12C.

Outputs

- Discharge Controlled discharge from Sediment Dam.
- Groundwater Seepage to groundwater (stockpiles, TSF pond).

Table 10-1 provides an Input-Output statement for the 2016/2017 Wet Season.

Table 10-1– Input-Output Statement July 2016 – July 2017 (RGC, 2018)

Input-Output	Element	Sub-Element	Water Quality			Note	How were the flows obtained and what if the confidence level?
			Cat 1 ML	Cat 2 ML	Cat 3 ML		
Inputs	Surface Water	Rainfall and runoff	12.8	20.6		1	Simulated, medium
	Groundwater	Aquifer interception			3.8	2	Estimated, low
	TOTAL INPUTS		**12.8**	**20.6**	**3.8**		
Outputs	Discharge	Controlled Discharge	10.4			3	Measured, high
	Groundwater	Seepage			6.1	4	Estimated, Low
	Other	Evaporation	17.2			5	Simulated, low
	TOTAL OUTPUTS		**17.2**	**10.4**	**6.1**		

Note

1.Rainfall Runoff from the site was simulated with a hydrological model (AWBM). Medium confidence in simulation.

2. Flow rates from previous reports assumed because no pumping records are available. Low confidence, field observations suggest lower flows.

3. Controlled discharge volume for 2016/2017 Wet Season measured with new electronic sensor, high confidence in flows

4. Seepage to groundwater inferred from Darcy flow calculations or calibration of water balance model.

5. Estimated with hydrological model (AWBM)

10.3 Accuracy Statement (RGC,2018)

The only flow on site that is measured is controlled discharge from the Sediment Dam. Other flows, i.e. rainfall runoff, evaporation, were simulated with a hydrological model that incorporated the Australian Water Balance Model (AWBM). Simulated controlled discharge from July 2016 to July 2017 was within 6% of the observed volume of controlled discharge volume. This suggests the hydrological model can reasonably simulate flows on site. There is medium confidence in these simulated flows because the hydrological model is uncalibrated. Pumping rates for two seepage recovery bores (BH4G and BH12C) from previous reports were assumed here. Recovered groundwater flows are estimated as no flow records are available. Recent field observations contradict the flows assumed here (from historic records), so there is low confidence in them.

Observed, estimated, and simulated flows are summarised here:
Observed flows.

- Controlled discharge from the Sediment Dam.

Estimated flows.

- Flows of recovered groundwater from BH4G and BH12C.
- Surface water losses by direct evaporation from ponds and the Browns Pit.
- Surface water losses by infiltration to groundwater from ponds and Browns Pit.

Simulated flows

- Rainfall runoff to water treatment system.

Table 10-2 below provides an accuracy statement for the Browns Site.
Table 10-2 – Accuracy Statement (RGC,2018)

Flow Types	% of All Flows	Confidence (%) High	Medium	Low
Measured	15%	15%	0%	0%
Estimated	14%	0%	0%	14%
Simulated	71%	0%	71%	0%
TOTAL		**15%**	**71%**	**14%**

10.4 The Operational Model (RGC,2018)

Raw water is water that is received as an input and has not been used in a task. Worked water is water that has been through a task and treated water is water that has been treated on site.
The site received 328 ML of raw water from July 2016 to July 2017. None of the water on site is considered worked water because there are no operations on site (and hence no tasks). 328 ML of treated water was released from the Sediment Dam.

11. KEY FINDINGS AND RECOMMENDATIONS (RGC, 2018)

The Water Quality Review and Load Balance Assessment (RGC, 2018) was a comprehensive review of the Project water management and water quality. Several key findings and recommendations were proposed by RGC as a summary to this report and these have been presented below;

11.1 Key Findings Pertaining to Groundwater (RGC,2018)

Key findings are summarised below:

1. SO_4 and metal concentrations in water samples from bores BH4A and BH4B have decreased by an order-of-magnitude since 2009. Concentrations of most metals are now comparable to concentrations observed in the TSF pond, i.e. 30 mg/L Cu. The TSF pond consists of residual liquor from 2008 that has been diluted by rainfall and flows of less impacted groundwater from two recovery bores installed in 2009 and 2010.

   More recent (2019-2022) water quality data measured at BH4B indicates that groundwater quality continues to improve.

2. Groundwater quality is not being improved by the minimal contaminant loads recovered by pumping from bores BH4G and BH12C. Instead, the MK trend analysis indicates that groundwater quality at bores BH4A and BH4B has been stable for the last five years. Previous consultants have reported 120 ML/year pumped from bores BH4G and BH12C. This flow rate (3.8 L/s annualized) could not be verified due to the lack of flow records for these bores.
3. Elevated SO_4 and metal concentrations in samples from bores BH4A, BH4B, and BH4D suggest some impacted groundwater and/or undiluted liquor has migrated beyond the southern lease boundary. The extent of contamination downgradient of bores BH4A and BH4B and the mass of contaminants that may have migrated beyond the southern lease boundary cannot be determined until additional monitoring bores and a new recovery bore have been installed in this area and appropriately monitored and pump tested.
4. Liquor lost from the TSF has impacted bores BH4A and BH4B, BH4D, BH5A and BH5B, and BH13B. Each of these bores is located within 100 m of the outer TSF berm. Groundwater from the 'TSF2' bores to the south of the TSF are not impacted by liquor losses from the TSF in 2008 or seepage from any other on-site sources, e.g. the ore stockpiles or PAF waste rock in the TSF berm.
5. A preliminary, un-calibrated load balance suggests that ~67 t/year SO_4 and 5,300 kg/year Cu may report to groundwater at the Browns site. Loads from the TSF pond account for two-thirds of the estimated SO_4 and Cu loads to groundwater. The other one-third is primarily related to seepage to groundwater from the PAF ore stockpile and the Black Shale Stockpile.

11.2 Key Findings Pertaining to Surface Water (RGC,2018)

Key findings are summarised below:

1. A water balance model (WBM) was developed to simulate ungauged flows to the WTP and flows from the Sediment Dam during controlled discharge events. The WBM simulates 404 ML of pit water and rainfall runoff to the water treatment plant (WTP) during the 2016/2017 Wet Season. The simulated annual controlled discharge volume from the Sediment Dam for the 2016/2017 Wet Season was 497 ML, or approximately 6% higher than the observed volume (469 ML).

2. Flows from the Browns Pit account for two-thirds of the simulated flow to the WTP during the 2016/2017 Wet Season. The other one-third of simulated flows is related to flows from the Site Run Off (SRO) pond and the ponds that collect rainfall runoff from the existing ore stockpiles. The TSF is an enclosed basin that does not contribute any flows to the WTP.
3. A contaminant load balance for surface water indicates that flows from the Browns Pit accounts for approximately 80% of the simulated annual SO4 load to the WTP. Rainfall runoff from the ore stockpiles accounts for the other 20% of the SO4 load and 100% of the simulated Cu load to the WTP.
4. At Site 5, Cu and Co are the metals that exceed their respective trigger values most frequently. There were eight occasions from December 2016 to mid-January 2018 when the Cu concentration at Site 5 was greater than or equal to a value that is two times the trigger value for Cu. There were 19 instances when the trigger value (2.5 µg/L Cu) was exceeded.
5. The highest concentrations of Cu, Co, and other metals since routine monitoring at Site 5 began were observed in November and December 2017. The high concentrations, e.g. ~2000 µg/L Cu, are attributed to a large 'first flush' event during the build up to the 2017/2018 Wet Season. Environmental impacts to the EBFR were likely minor because high concentrations in the EBFR related to seepage from the former Rum Jungle mine site also occurred at the time.
6. The WBM simulated some spillage from the water collection ponds during Cyclone Carlos in February 2011. Water management facilities and infrastructure on site have since been improved and additional changes are planned for 2018. In RGC's opinion, the Browns site may be able manage surface water flows associated with the 1 in 100-year, 72-hour rainfall event if rainfall runoff is directed to the Browns Pit and the Sediment Dam is used effectively to regulate water releases to the EBFR via Middlebrook Creek. Further assessment and hydrological modelling is needed to evaluate the performance of the water management system on site during this event.
7. In January 2018, the site received 460 mm of rainfall over three days. This is less than the 1 in 100-year design event as the largest one-day precipitation (225 mm) had a return period of 30 years. Some flooding occurred on site during the event but there were no water quality impacts to the EBFR. A strategy has been developed to prevent future flooding and are presented in this management plan.

11.3 Recommendations Pertaining to Groundwater Management (RGC,2018)

RGC recommends the following with respect to routine groundwater monitoring:

1. Reduce the frequency of water quality sampling for most monitoring bores to annual and continue to collect quarterly samples from bores BH4A and BH4B and the new bores recommended to support seepage remediation monitoring (see Table 15-2).
2. The recommended program is commensurate with current groundwater quality impacts on site and involves sampling few bores containing unimpacted groundwater, e.g. the TSF2 bores. It also better reflects the future focus on groundwater remediation monitoring.
3. Collect manual groundwater level and pit water level measurements monthly in the Dry Season and fortnightly in the Wet Season and place pressure transducers in selected bores to continuously monitor changes in groundwater levels (see

4. Table 15-2).
5. Discontinue the analysis of groundwater samples for total metal concentrations and include a gravimetric analysis of the Total Dissolved Solids (TDS) content in the future suite of water quality parameters that are analysed.
6. Implement a QA/QC program to check the reliability of each groundwater sample collected and re-sample groundwater if a sample is flagged as suspect, i.e. RPD (CBA) > 10%.
7. Survey the gauge height and creek bottom elevation at Station GS8150200, the staff gauge near the Browns Pit, and the TOC elevation of each bore on site after the 2018 drilling program is complete.
8. Investigate site-specific trigger values for groundwater that are supported by a statistical analysis of water quality and historic time trends and a list of specific remedial actions and/or additional monitoring that will be undertaken if a trigger value is exceeded.

RGC recommends a phased approach to the remediation of groundwater near the TSF. The Phase I objective is to further delineate the extent of impacted groundwater near the TSF and refine the local groundwater flow field near bores BH4A and BH4B. The following is recommended for the Phase I (interim) remediation strategy:

1. Complete a 24-hour pumping test of recovery bore BH4G before the next hydrogeology drilling program commences.
2. Install additional monitoring bores and a new, 150 to 200 mm diameter seepage recovery bore screened from 3 to 21 m/bgs near bore BH4B.
3. Operate the new seepage recovery bore and bore BH4G as per pending recommendations in RGC's Task 2 report (to be completed after drilling program).
4. Collect quarterly water quality samples from the new recovery bore and other new bores near bores BH4A and BH4B.
5. Deliver recovered groundwater from bore BH4G and the new recovery bore to the processing plant for treatment (not to the TSF pond) if yields exceed 1 L/s.

Works associated with BH4G have been implemented. The Phase II objective is to develop a final remediation strategy for impacted groundwater near the TSF. A site-wide groundwater flow model is recommended to support the Phase II remediation strategy. The model would be calibrated to current conditions since 2016 and be used to simulate the performance of the Phase I recovery strategy and, if required, assess additional seepage recovery options, i.e. additional recovery bores, treatment of the TSF pond, etc.

11.4 Recommendations Pertaining to Surface Water Management (RGC,2018)

RGC recommends the Browns Pit be used as the prime storage reservoir for contact water during periods of intense rainfall, including the 1-in-100 year, 72-hour rainfall event, and that the release of controlled discharge from the Sediment Dam be optimized to ensure sufficient storage capacity in this reservoir to receive treated water from the WTP. The factors that affect the live storages of the Browns Pit and the Sediment Dam include the following:

1. The rate that pit water can be pumped to the WTP.
2. The capacity of the WTP and when it operates.
3. The discharge threshold in the WDL, i.e. currently 1 m3/s.
4. The rate of controlled discharge from the Sediment Dam.

5. Potential inflows to the pit from the EBFR if the safety berm overtops.

RGC recommends these factors be assessed to ensure the site can manage the 1-in-100 year, 72- hour rainfall event and that lesser events can be managed efficiently, i.e. with fewer pumps.
NTR have already initiated many of these recommendations where possible and have addressed these within the MMP.

12. COMMITMENTS FOR 2023 WMP

The following table details all the commitments made in this WMP that can be completed in the upcoming reporting period.

Table 12-1 – 2022 WMP Commitments

Commitment	Due Date	Performance Indicator
Undertake surface water monitoring in accordance with WDL177	Ongoing	Compliance with Site 5 limit conditions and all WDL monitoring requirements
Undertake groundwater monitoring program	Ongoing	Undertake groundwater monitoring as described in this WMP
Discontinue biological sampling program	Now	WDL discharge data consistently demonstrates that metal concentrations from Site 5 are lower than in the East Finnis River. Any biological impacts are likely to arise from water quality issues from Rum Jungle.
Discontinue radionuclide monitoring	Now	Radionuclide monitoring was discontinued from NTEPA in WDL177-9
Continue all other water monitoring as prescribed in MMP during the care and maintenance regime at site.	Ongoing	Monitoring results
Investigate the need for additional groundwater monitoring and extraction bores for polluted groundwater from TSF	December 2023	Based on TFS Operations Manual update

13. RADIONUCLIDE MONITORING PLAN

Under Condition 8 of the then WDL177-08 Northern Territory Resources was required to maintain and implement a Radionuclide Monitoring Plan.
This program required sampling of the WDL locations once at the end of the dry season / beginning of the wet season and once at end of the wet season / beginning of the dry season. This sampling was very much dependant on Site 4 to start flowing before samples can be taken. The results of the samples collected during the monitoring program are reported in the table below.

Table 13-1 – Radionuclide Analysis Results

WDL Sample Location	Date Sampled	Radium 226 (Bq/kg)	Polonium 210 (Bq/L)	Lead 210 (Bq/kg)	U -filtered (µg/L) / (Bq/L)*
Trigger		0.5 Bq/L (total)			17
SITE1 East Finniss Upstream	25 May 2017	0.3 ± 1.1	0.008	0.6 ± 1.3	<5 / <0.0617
	17 Jan 2018	<0.1	0.01	1 ± 1	<5 / <0.0617
	6 Feb 2019	0.03±0.012	0.009±0.003	0.015	<5 / <0.0617
	9 Apr 2019	0.032	0.005	0.012	<5 / <0.0617
	5 Feb 2020	<0.042	<0.02	<0.18	<5 / <0.0617
SITE2 Sediment Dam	25 May 2017	0.9	0.008	<1	<5 / <0.0617
	17 Jan 2018	0.08	0.001	<4	<5 / <0.0617
	6 Feb 2019	0.029±0.012	0.002±0.001	0.14	<5 / <0.0617
	9 Apr 2019	0.038±0.028	0.005	0.072±0.077	<5 / <0.0617
	5 Feb 2020	<0.047	<0.02	<0.18	<5 / <0.0617
SITE4 Upstream from Site 5	25 May 2017	0.1 ± 0.9	0.008	<1	<5 / <0.0617
	17 Jan 2018	0.00009	0.001	<0.8	<5 / <0.0617
	6 Feb 2019	0.022±0.022	0.013±0.003	0.078±0.043	<5 / <0.0617
	9 Apr 2019	0.026	0.006	0.13	<5 / <0.0617
	5 Feb 2020	0.026±0.012	<0.02	<0.083	<5 / <0.0617
SITE5 Middlebrook Creek	25 May 2017	0.3 ± 1.1	0.008	<1	<5 / <0.0617
	17 Jan 2018	<0.2	0.01	<2	<5 / <0.0617
	6 Feb 2019	0.018±0.009	0.007±0.003	<0.14	<5 / <0.0617
	9 Apr 2019	0.019±0.01	0.006	0.12	<5 / <0.0617
	5 Feb 2020	0.028±0.017	<0.02	<0.15	<5 / <0.0617

*(where 1 µg U = 0.01234 Bq)

To date, results have indicated that surface water measured at the WDL monitoring points is < 0.5 Bq/L which is well below ANZECC gross alpha trigger value criteria of livestock drinking water, and well below the 17µg/L trigger for uranium specified in the Australian Drinking Water Guidelines. It is apparent that no significant radionuclide contamination of water from the current operation is occurring. Note that a change in laboratory methods took place in 2019 to provide much more precise data. The NTEPA agreed that the radionuclide monitoring program be discontinued whilst the site is in

care and maintenance and removed the requirement from WDL177-09. Radionuclide monitoring will cease as part of this WMP.

14. FINNISS RIVER AQUATIC SURVEY

In 2017 and 2018 EcOz Environmental Consultants (EcOz) undertook an aquatic survey of the Finniss River system targeting macroinvertebrate and fish species. This survey aligns with commitment AR33 of the Mining Management Plan to conduct a stream biological monitoring program. The primary objective of the Finniss River aquatic survey is to gather abundance and distribution data for macroinvertebrate and fish species, in addition to water quality and sediment quality data (**Section 14.1.2**). The survey sites have been established along both the Finniss River trunk stream and the East Branch the latter of which receives runoff from the historic Rum Jungle Mine site.

The aquatic survey site characteristics are described in **Table 14-1** and the specific sampling locations provided in **Figure 14-1.** The survey program utilised historic aquatic monitoring survey sites for fish and macroinvertebrate sampling in the Finniss River trunk stream (FR) and the East Branch. The survey site names remain consistent with the historical site names. Monitoring at all six sites involved analysis of water and sediment quality and macroinvertebrate and fish diversity and abundance. This aquatic survey was conducted in late May - early June 2017, timed to coincide with cessation of wet season flushing.

Table 14-1 - Aquatic Survey Monitoring Location

Sites	Site Location & Characteristics
FR3	Historic sampling location for fish and macroinvertebrates. Furthest downstream site of the EB confluence with the FR.
FR4	Historic sampling location for fish and macroinvertebrates. Located downstream of the EB confluence with the FR.
FR6	Historic sampling location for fish and macroinvertebrates. Located upstream of the EB confluence with the FR. Upstream FR reference site.
EB4	Located at confluence of EB with minor tributary. Downstream of project and RJM.
EB6	Located on the EB, adjacent to RJM and upstream from the Browns Oxide WDL monitoring location.
EB8AU	Site located on the EB, upstream from the project and RJM. Upstream EB reference site

All locations were sampled for macroinvertebrates, fish, water quality and sediment quality.

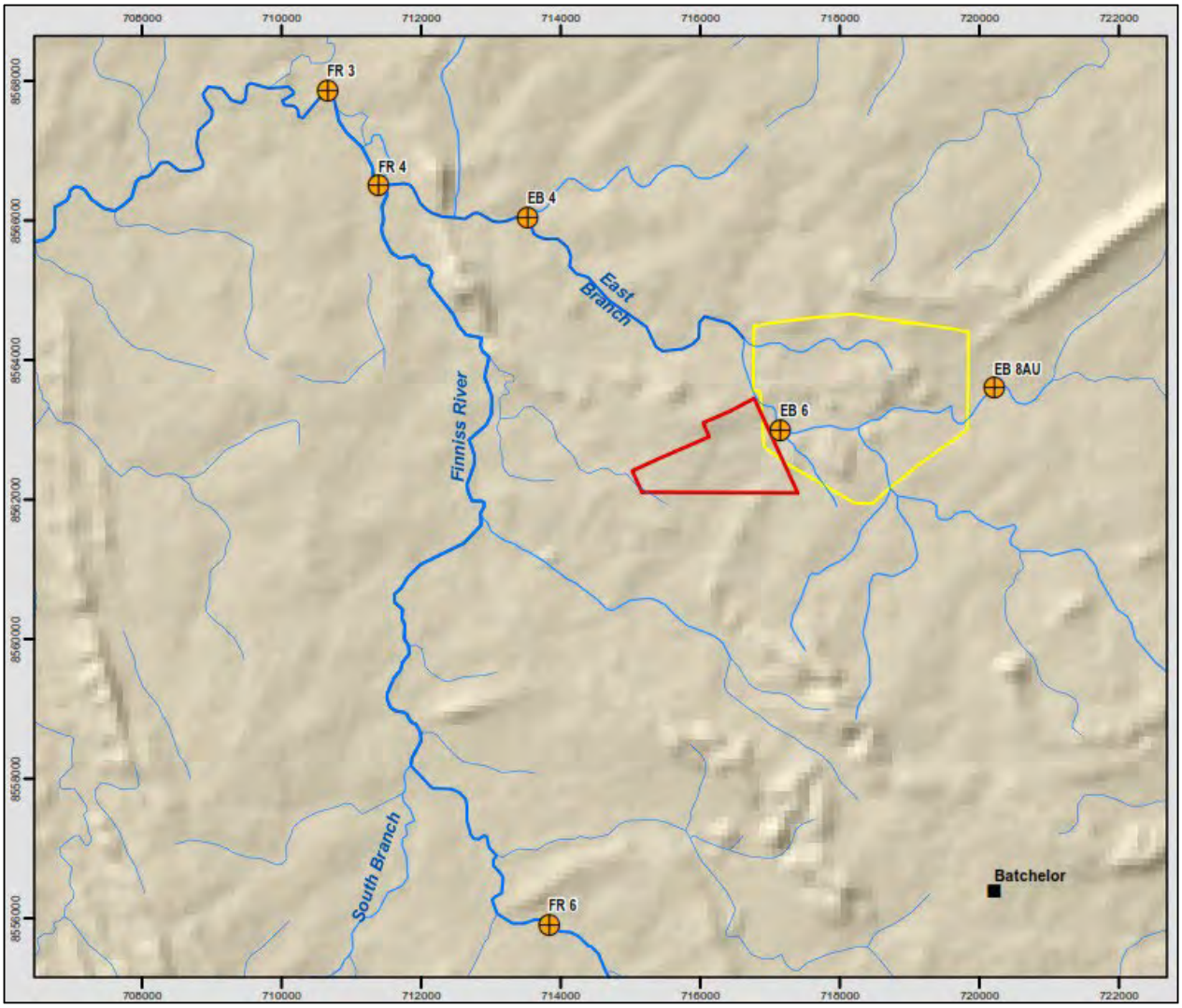


Figure 14-1 – Map of Aquatic Survey Sampling Locations

A summary of the findings is discussed below.
Results of sediment sampling revealed very high concentrations of copper and nickel at Site EB6 (adjacent to the project and RJM). The downstream Site EB4 revealed high levels of copper and nickel, although these were at the lower end of the relevant ANZECC guidelines. Site FR4, further downstream from EB4, also recorded elevated copper levels.
A similar trend was revealed for water quality sampling, with Site EB6 recording exceedances for EC, aluminium, cadmium, cobalt, copper, iron, manganese, nickel, uranium, zinc and low pH values. Site EB4 recorded elevated EC and copper, although these were greatly reduced in comparison to the results recorded for EB6. These reduced concentrations at Site EB4 are indicative of the likely dilution of contaminants in downstream reaches where streamflow volumes are increased.
Since 1973 there have been several historical aquatic surveys of both fish and macroinvertebrates carried out in both the Finniss River trunk stream and East Branch. Survey methods, locations, timing and sampler(s) all varied throughout these aquatic surveys, limiting the opportunity for direct comparison of survey data.

The key findings of this survey were: (EcOz, 2017)

- macroinvertebrate and fish species diversity are higher in the Finniss River trunk stream than for the East Branch

- for the Finniss River trunk stream, fish species diversity is highest in the upstream reference reach (no trend for macroinvertebrates)
- for the East Branch, macroinvertebrate and fish species diversity is greatly reduced at sites in close proximity to the RJM and Browns Oxide project
- for the East Branch, the upstream reference reach demonstrates good water quality results, but low fish and macroinvertebrate diversity.

High metal concentrations within the sediments and water samples, low pH and low aquatic fauna diversity, distribution and abundance indicate significant contamination in comparison to the Finniss River reach (Sites FR3, FR4 and FR6). This is likely to be directly associated with RJM activities and drainage of runoff from the RJM site (particularly ongoing acid mine drainage).

The Northern Territory Department of Industry, Tourism and Trade have commissioned aquatic surveys at the same locations as described above in both 2019 and 2022. There has been general agreement that aquatic surveys being undertaken by the NT Government by the Rum Jungle Rehabilitation Project adequately meet the commitment previously made by NTR to assess the environmental attributes on the East Branch of the Finnis River.

These surveys demonstrate significant aquatic impairment in the East Branch of the Finnis River. This impairment is attributed to acidic, high metal concentration discharge from the Rum Jungle site. These reports are available at Rum Jungle rehabilitation plan | Department of Industry, Tourism and Trade.

In the 2022 review of the Waste Discharge License for NTR, the NTEPA observed that;

'A review of monitoring data has confirmed that current water quality at the compliance point already meets 90% species protection trigger values for all parameters, with the exception of copper (set at 80%)'.

In effect, water discharged from the Brown Site is diluting existing pollution in the River that emanates from the Rum Jungle site.

Given the regular assessment of aquatic assemblage by the NT Government, and the recognition that aquatic impairment in the EBFR is related to the Rum Jungle complex, particularly in light of the relatively good quality water being discharges from NTR, it is recommended that further aquatic survey work not be undertaken by NTR.

14.1 Sediment Monitoring Program

Sediment quality downstream of mine sites is important for assessing potential impacts on the aquatic and riparian systems and will augment water quality samples. Metals associated with particulate matter have the potential to be transported as suspended solids and be deposited in the river sediments. Collection of sediments deposited in the preceding wet season will provide an indication of the contaminated particulate matter mobilised during the previous wet season. Sediment samples were taken during the Finniss River aquatic survey program at the same sites used in that program.

Table 14-2– Sediment Quality Parameters

Type	Parameters
Physio-chemical	pH, Particle Size Distribution, Total Organic Carbon
Metals	Aluminum (Al), Arsenic (As), Cadmium (Cd), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Uranium (U), Zinc (Zn) and Iron (Fe).

14.1.1 Sediment Trigger Values

The sediment results were compared against the Simpson and Batley (2016) interim sediment quality guidelines as shown in Table 4-11 and exceedances are to be investigated following ANZECC (2000) guidelines

Table 14-3– Sediment Quality Guidelines

Metals	Units	SQG – Low	SQG - High
Arsenic	mg/kg	20	70
Cadmium	mg/kg	1.5	10
Copper	mg/kg	65	270
Lead	mg/kg	50	220
Nickel	mg/kg	21	52
Zinc	mg/kg	200	410

14.1.2 Sediment Sampling Results

The sediments collected during the previous aquatic biological surveys have been compared with the ANZECC 2000 Sediment ISGC guidelines for the assessment of soil, sediment and water. The results are provided in Table 14-4.

Site EB6 triggered the ANZECC 2000 Sediment ISG- guidelines with high levels of copper and nickel. The copper contaminants at this particular site were found to be over six times higher than the ANZECC 2000 Sediment ISGC- 'high' guidelines. Physical observations also showed the presence of a precipitate settled out on the riverbed profile. Site EB4 exceeded the ANZECC 2000 Sediment ISGC – low guideline values for copper and nickel contaminants. Site FR4 also revealed low levels of copper within the subsurface sediments.

All of the other survey sites were found to be under the ANZECC 2000 Sediment ISGC guidelines for sediment quality. The lowest concentrations of metals were recorded from the upstream sites EB8AU and FR6.

Table 14-4 – Sediment Sample Results

Site	Inorganics			Metals				
	Moisture Content	pH	TOC	Arsenic	Cadmium	Copper	Nickel	Zinc
	%	-	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ANZECC 2000 Sediment ISGC-High				70	10	270	52	410
ANZECC 2000 Sediment ISGC-Low				20	1.5	65	21	200
2017								
FR3	13	6.8	2000	2.7	<0.4	46	15	14
FR4	14	7.0	1000	5	<0.4	83	20	24
FR6	33	5.4	13000	<2	<0.4	<5	<5	<5
EB4	17	6.1	2000	5.9	<0.4	96	22	31
EB6	13	5.8	6000	20	<0.4	1,700	91	120
EB8AU	16	6.2	2000	<2	<0.4	<5	<5	<5
2018								
FR3			6000		<0.4	55	7	15
FR4			3000		<0.4	40	7	14
FR6			18000		<0.4	<5	<5	<5
EB4			<1000		<0.4	9	19	16
EB6			11000		<0.4	220	61	110
EB8AU			<1000		<0.4	<5	<5	<5

In light of the above mentioned aquatic surveys being undertaken by the NT Government, NTR will not undertake further sediment analysis in the East Branch Finnis River.

15. MONITORING PROGRAM

15.1 Surface Water

The table below details the surface water monitoring program.

Table 15-1 – Surface Water Monitoring Program

Site ID	Eastings	Northings	Description	Monitoring Status or Purpose	Monitoring Frequency		
					Field Measure-ments	Metals and Major Chemistry	Radiological
Monitoring sites for WDL177-10							
SITE1	717263	8562948	East Branch of the Finniss River (EBFR) Upstream	Active	W	W	B
SITE2	716810	8562738	Sediment Dam	Active	W	W	B
SITE4	717109	8562080	Middlebrook Creek upstream of boundary discharge	Active	W	W	B
SITE5	717009	8562888	Middlebrook Creek ~0.2 km downstream of boundary discharge	Active	D / U	W	B
TREAT1	715751	8562533	Treated effluent discharging to the Sediment Dam	Active	W	W	-
Other surface water monitoring sites (pits, creeks, and effluent)							
DAMOUT2	716560	8562364	Sediment Dam emergency spillway (when flowing)	Active	U	U	-
WAND1	717140	8562796	Wandering Creek upstream of Middlebrook Creek	Active	W	W	-
GS200	717003	8563107	EBFR ~0.4 km downstream of discharge	Active	W	W	-
Rainwater collection ponds							
RW_TSF	715628	8562366	TSF Stormwater Collection Pond	Active	F	Q	-
RW_SRO	715112	8562411	Small Sediment Dam	Active	F	Q	-
RW_PAF	716077	8562383	PAF Stockpile Pond	Active	F	Q	-
RW_SP3	716334	8562245	Low Grade Ore Pond	Active	F	Q	-
RW_BSS	716308	8562695	Intermediate Stockpile Pond	Active	F	Q	-

Site ID	Eastings	Northings	Description	Monitoring Status or Purpose	Monitoring Frequency		
					Field Measure-ments	Metals and Major Chemistry	Radiological
RW_POND	715410	8562432	Process water storage pond	Active	F	B	-
RW_PIT	716710	8562941	Oxide pit	Active	F	B	-

Abbreviations:
Field measurements: water level (m), pH, EC (µS/cm), DO (% sat.), turbidity (NTU), and water temperature (ºC)
Metals and metalloids (total and filtered, i.e. < 0.45 um): Al, Cd. Co, Cu, Fe, Pb, Mn, Ni, U, and Zn
D = Daily (when discharging)
W = Weekly (when discharging)
F = Fortnightly (when flowing)
U = Upon discharge
M = Monthly
Q = Quarterly (Jan, Apr, Jul, Oct)
B = Biannual (Jan and Jul) (Radiological = Start and the end of wet season

15.2 Routine Groundwater Monitoring Program

The table below details the groundwater monitoring program as recommended by RGC (2018) and adopted since the 2018 MMP was approved.

Table 15-2– Proposed Routine Groundwater Monitoring Program

Bore ID	Water Quality	Water Level Surveys	Comment/Rationale
TSF2 Monitoring Bores			
BH7A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH7B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH8A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH8B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH9A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH9B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH10	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH11	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
TSF1 Monitoring Bores			
BH2A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH2B	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Improperly installed or not developed, contains 'slime' (possibly drilling mud)
BH3A	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH3B	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH4A	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly sampling for seepage recovery assessment
BH4B	Quarterly*	Monthly and Fortnightly (Wet Season)	Quarterly sampling for seepage recovery assessment
BH4D	Quarterly	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to delineate capture zone around new recovery bore
BH4E	Quarterly	Monthly and Fortnightly (Wet Season)	Impacted, may be influenced by future seepage recovery
BH5A	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH5B	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to delineate capture zone around new recovery bore
BH12A	Annual	Monthly and Fortnightly (Wet Season)	Routine monitoring of bore BH12C sufficient for this area
BH12B	Annual	Monthly and Fortnightly (Wet Season)	Routine monitoring of bore BH12C sufficient for this area
BH13A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH13B	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly monitoring for seepage recovery assessment
BH14A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH14B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring

Bore ID	Water Quality	Water Level Surveys	Comment/Rationale
BH15A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH15B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH16A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH16B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH17A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH17B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH18A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH18B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BDG007	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BDG008	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH24	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly monitoring for seepage recovery assessment
TSF1 Recovery Bores			
BH4F	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Unimpacted groundwater
BH4G	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly monitoring for seepage recovery assessment
BH4H	Annual	Monthly and Fortnightly (Wet Season)	Unimpacted groundwater
BH12C	Quarterly	Monthly and Fortnightly (Wet Season)	Not operated as recovery bore (only monitoring)
Regional Monitoring Bores or Other 'On-Site' Bores			
TPB4	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
TPB5	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to continuously monitor pit water level
RN023137	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
Thompson	Annual	Quarterly	Low-priority, long-term monitoring
Thompson-Mango	Annual	Quarterly	Low-priority, long-term monitoring

Table 15-3 - Summary of Analytical Methods

Parameter	Internal Method ID	Method Description (from Eurofins)	Units	LOR*	Holding Time
Physical Parameters					
Suspended Solids	LTM-INO-4070	Analysis of Suspended Solids in Water by Gravimetry	mg/L	5	7 days
Alkalinity and Major Ions					
Alkalinity (speciated)	APHA 2320	Alkalinity by Titration	mg/L as $CaCO_3$	20**	14 days
Chloride	E045/E047	Chloride	mg/L	1	28 days
Sulphate	E045/E047	Anions by Ion Chromatography	mg/L	2	28 days
Calcium and Magnesium	LTM-MET-3010	Alkali Metals	mg/L	0.5	180 days
Hardness	E020.1	Hardness in water	mg/L as $CaCO_3$	1	28 days
Heavy Metals					
Aluminium	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	50	180 days
Cadmium	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	0.2	180 days
Cobalt	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Copper	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Iron	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	50	180 days
Lead	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Manganese	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days
Nickel	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Uranium	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days
Zinc	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days

* Limit of Reporting
**For total and carbonate alkalinity
Other abbreviations:
APHA: American Public Health Association

15.3 Sampling Methodology

Detailed sampling procedures with methodology have been included in **Appendix 4** and **Appendix 5.** NTR now have dedicated employees to conduct the routine water sampling to improve sampling reliability. In addition, and all employees conduct annual refresher training prior to the onset of the wet season.

15.4 Quality Assurance and Quality Control

Quality Assurance (QA) involves all of the actions, procedures, checks and decisions, undertaken to ensure the representativeness and integrity of samples and accuracy and reliability of analytical results

(National Environmental Protection Council, 1999). Quality Control (QC) involves protocols to monitor and measure the effectiveness of QA procedures.
The QA/QC procedures outlined in the following Sections are based on AS 5567.1 – 1998 and will be implemented during sampling.

15.4.1 Data Quality Indicators

To minimise the potential for unrepresentative data, the following Data Quality Indicators (DQIs) will be used to evaluate sampling techniques and laboratory analysis of collected samples:

- Data representativeness - expresses the degree which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples in an appropriate pattern across the Project, and by using an adequate number of sample locations to characterise the site. Consistent and repeatable sampling techniques and methods are utilised throughout the sampling program.
- Completeness - defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set as being sufficient valid data generated during the monitoring program. If there is insufficient valid data, then additional data are required to be collected.
- Comparability - is a qualitative parameter expressing the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples and ensuring analysing laboratories use consistent analysis techniques and reporting methods.
- Precision - measures the reproducibility of measurements under a given set of conditions. The precision of the data is assessed by calculating the Relative Percent Difference (RPD) between duplicate sample pairs.

$$\text{RPD}(\%) = \frac{|C_o - C_d|}{C_o + C_d} \times 200$$

Where C_o = Analyte concentration of the original sample

C_d = Analyte concentration of the duplicate sample

A nominal acceptance criterion of 30% RPD for field duplicates and splits for inorganics will be adopted, however it is noted that this will not always be achieved, particularly at low analyte concentrations.

- Accuracy - measures the bias in a measurement system. Accuracy can be undermined by such factors as field contamination of samples, poor preservation of samples, poor sample preparation techniques and poor selection of analysis techniques by the analysing laboratory. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes, laboratory blanks and analyses against reference standards. The nominal “acceptance limits” on laboratory control samples are defined as follows:
  - Laboratory spikes – 70-130% for metals/inorganics, 60-140% for organics;
  - Laboratory duplicates – <30% for metals/inorganics, <50% for organics; and
  - Laboratory blanks – <practical quantitation limit.

Accuracy of field works is assessed by examining the level of contamination detected in field and equipment blanks. Blanks should return concentrations of all organic analytes as being less than the practical quantitation limit of the testing laboratory.

The individual testing laboratories will conduct an internal assessment of the laboratory QC program; however, the results will also be independently reviewed and assessed.

15.4.2 Summary of Data Quality Acceptance Criteria

Data quality acceptance criteria adopted for this Project are set out in **Table 5-1.** These are generally based on the minimum requirements detailed in the Australian Standard AS4482.1-2005.

Table 15-4 - Data Quality Acceptance Criteria

Measurement	Sediment	Water	Frequency	Acceptance Criteria	
				RPD (%)	Recovery (%)
Quality control samples to be prepared or taken on site (field)					
Blind field duplicate (BFD) samples (primary laboratory)	Yes	Yes	1 in 20 samples collected or 1 per batch.	30 or 50	-
Quality control samples to be prepared by laboratory					
Laboratory blanks	Yes	Yes	1 per batch.	-	-
Laboratory duplicates	Yes		1 in 10 samples collected or 1 per batch (whichever is smaller)	30	-
Matrix spike recoveries	Yes		1 per batch	-	70 to 130
Laboratory control sample spike recoveries	Yes		1 per batch	-	70 to 130
Surrogate spikes	Yes	Yes	Each analysis done by GC-MS (all organics except TPH $_{C>10}$)		

Note: Water includes surface and groundwater. Batches are the sum of samples collect throughout a sampling event (i.e. a batch can be collected over two days or more).

15.4.3 Field Program

All field work will be conducted with reference to the advisory note of the Department of Resources (2009) for the sampling of surface waters and groundwaters. Key requirements of these procedures are as follows:

- Decontamination procedures - including the use of new disposable gloves for the collection of each sample, decontamination of all multiple use sampling equipment between each sampling location (using a phosphate free detergent and potable water) and the use of dedicated sampling containers provided by the laboratory;
- Sample identification procedures - collected samples will be immediately transferred to sample containers of appropriate composition and preservation for the required laboratory analysis. All sample containers to be clearly labelled with a sample number, sample location, sample depth (for groundwater) and sample date. The sample containers are then transferred to an ice filled cooler for sample preservation prior to and during shipment to the testing laboratory;

- Chain of custody protocols - a chain-of-custody form is to be completed and forwarded to the testing laboratory with each discrete batch of samples; and
- Sample duplicate frequency - field duplicates (blind) to be collected and analysed at a rate not less than ten per cent (i.e. not less than one duplicate per ten primary samples).

15.4.4 Field Quality Control

Field quality control procedures will include the collection and analysis of the following:

- Blind field duplicates (BFDs): Comprise a single sample that is divided into two separate sampling containers. Both samples are sent anonymously to the primary Project laboratory. Blind duplicates provide an indication of the analytical precision of the laboratory, but are inherently influenced by other factors such as sampling techniques and sample media heterogeneity.

16. RISK MANAGEMENT

16.1 Identify Hazards and Rank Risks

NTR undertook a risk assessment as part of the overarching Mining Management Plan (MMP). The risk assessment is located in **Appendix 6.** The risk assessment and associated management processes was developed with reference to Standards Australia HB 203:2012 Environmental Risk Management-Principles and Processes.
The risks were identified through knowledge of the existing environment and include potential and routine environmental effects and the risks arising from the operations in relation to water management. Four levels of risk were identified within the risk assessment:

- Extreme: the development of strategies to reduce or mitigate the level of risk is of the highest priority.
- High: high priority; management attention to develop strategies is still required.
- Medium: moderate priority; management responsibility must be specified.
- Low: risks fall within the bounds of normal project parameters that can be managed by routine procedures and processes.

16.2 Key Risks

An Operational Risk Register is in place for the care and maintenance operations of the Project and is reviewed annually or when there are operational changes planned for the site. The Risk Register in **Appendix 6** encompasses the proposed changes presented in the MMP and this WMP.
There are two key aspects of the overall water management which include;

- Releases to Land and/or Water,
- Resource Consumption.

Table 16-1 details the potential impacts and risk mitigation measures implemented during the previous reporting period. During the past reporting period NTR have implemented the following improvement initiatives;

- Construction of a Diversion Drain to direct contact stormwater away from the Sediment Dam and redirect it to the Pit.
- Construction of Emergency Spillways for PAF, SP3 and BSS catchment ponds which will allow overflow water to be directed to the pit in extreme rain events,
- Installation and operation of a new recovery bore to improve seepage recovery efforts.
- Modifications to be made to the water treatment facility to increase throughput.

These improvements have resulted in a slight decrease to the residual risk scores for several of the project areas on site.

Table 16-1 – Water Management Aspects and Impacts Register

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	*Browns Pit* - No mining excavation planned for the upcoming reporting period. - Water Treatment - Water currently used for Process water - Largest water catchment - Proposed to divert water from the Process Plant to the Pit - Propose to install emergency spillways on SP3, PAF and BSS which will flow to the pit in extreme rain events.	- Poor water quality discharged into the East Finniss River - Erosion and sediment control issues impacting surrounding environment. - Spill or leak to the environment with potential to contaminate land resources. - Impact to Threatened Species. - Extreme rainfall event has potential to flood the East Finniss River into the pit.	Medium 14	- Safety berm in place between the pit and the East Finniss River. This was successful in keeping the EFR flood waters at bay in the January 2018 flooding. - Pit levels monitored with maximum level of 55 AHD. - Daily visual inspections. - Water Management Plan. - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m^3)	Low 5
	Ore Stockpiles - Existing ore stockpiles with high metal content left insitu in bunded catchment. - Extreme rain event.	- Erosion and sedimentation issues impacting surrounding environment. - Spill or leak of low pH water to the environment with potential to contaminate land, surface or groundwater resources.	Medium 14	- Stockpile areas bunded to prevent runoff. - Collected water pumped to processing plant for treatment and bund levels kept to minimum. - Emergency spillways to be installed to direct the water to the pit during extreme rain event and prevent discharging to the Sediment Dam - Standard Operating Procedure for water treatment.	Low 6
	Processing Plant - Water Treatment - Large holding tanks in bunded facilities (diesel, low pH water) - Maintenance of plant and equipment.	- Spill or leak to the environment with potential to contaminate land, surface or groundwater resources.	Medium 13	- Diversion Drain to be constructed to divert water from the plant to the pit and not the Sediment Dam. - Use, store and handle chemicals in accordance with legislation and Australian Standard AS1940.	Low 4

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
	- Propose to construct a Diversion Drain to direct away from the Sediment Dam and to the Pit.			- Hazardous and bulk storage tanks contained within bunded areas. - Regular service and maintenance. - Spill kits and SDS when chemicals being stored or used. - Spill Response Procedure - NTR-ENV-PRO-004	
Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	*TSF* - Groundwater contamination from existing tailings stored in the unlined TSF. - Walls contain PAF material. - Recovery bores - Water monitoring activities.	- Seepage into groundwater for unlined facility. - Low pH water generated from the PAF in the TSF wall. - Inappropriate erosion and sedimentation management impacting surrounding environment.	Extreme 24	- Install a new recovery bore and 6 new observation bores with data to inform a remediation plan. - Continue recovery of groundwater seepage. - Continue to conduct water quality monitoring to inform future management decisions. - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m3) - Capacity to hold a 1 in 100 year rain event (96,000kL). - TSF Operations and Maintenance Manual.	Med 14
	Chemical Storage - Diesel, sulfuric acid, hydrated lime, flocculent, glyphosate, soda ash. - Waste products awaiting disposal paint, old reagents, waste oils.	- Spill or leak to the environment with potential to contaminate land, surface and groundwater resources.	Medium 14	- Use, store and handle chemicals in accordance with legislation and Australian Standard AS1940. - Hazardous and bulk storage tanks contained within bunded areas. - Ensure sufficient capacity of the bunding and oily water separator for any new oil filled assets being commissioned as part of this project. - Spill kits and SDS when chemicals being stored or used.	Low 5

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
				- Removal of waste products vial a licenced contractor. - Locate chemical storage 50 metres from waterways or drainage lines. - Hazardous Goods and Waste Management Plan. - Spill Response Procedure - NTR-ENV-PRO-004	
Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	*Environmental Monitoring* - Water Quality monitoring of Ground and surface waters to an approved schedule. - Dust Monitoring. - Handling of contaminated products.	- Inappropriate disposal with potential to contaminate land resources. - Inappropriate sampling procedures resulting in non-representative samples.	Medium 14	- Dispose of in accordance with *Waste Management and Pollution Control Act*. - Hazardous Materials and Waste Management Plan. - Water Monitoring Procedure - NTR-ENV-PRO-001. - Water Sampling Work Instruction - NTR-ENV-WIN-001. - Spill Response Procedure - NTR-ENV-PRO-004 - Training in water sampling procedures.	Low 3
	Transport Activities - Transportations of dangerous goods and hazardous materials.	- Spill or leak to the environment with potential to contaminate land resources.	Medium 14	- Use of licenced transport operators for the transportation of dangerous or hazardous goods. - Spill Response Procedure - NTR-ENV-PRO-004 - Spill Response Kits.	Low 5
	Utilities - The use of diesel run pumps and generators	- Spill or leak to the environment with potential to contaminate land resources	Low 6	- Regular service and maintenance of equipment. - Standard operating procedures for refuelling.	Low 3

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
				- Employee training and awareness of these procedures. - Spill Response Procedure - NTR-ENV-PRO-004. - Spill Response Kits.	
Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	*Water Discharge from Sediment Dam* - Licenced discharge via DAMOUT1 - Emergency spillway in place for extreme rain events. - Treated water to be used as process water instead of pit water.	- Unauthorised discharge to the East Finniss River - Discharge of water exceeding WDL licence trigger values - Poor water quality discharged into the East Finniss River - Impact to threatened species.	High 18	- An approved Waste Discharge Licence WDL177-06 - Daily Monitoring during the wet season. - Water Monitoring program - Standard operating procedures. - Employee training and awareness of these procedures. - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m^3). - Engineered emergency spillway constructed to protect the dam wall integrity during high rainfall events. - Maintenance programs to protect the integrity of the dam wall.	Medium 8
	Rehab /Closure - Land rehabilitation of pre-disturbed areas.	- Unsuccessful rehabilitation techniques causing erosion and sedimentation issues impacting surrounding environment. - Failure of rehabilitation efforts. - Erosion removing soil and preventing establishment of vegetation.	Medium 10	- Investigation into rehabilitation techniques, rehab trials and appropriate ongoing monitoring to measure rehab success. - Control erosion in accordance with IECA Australia Best Practice Erosion and Sediment Control. - Biological and Land Management Plan. - Annual maintenance to fix any areas of erosion or slumping.	Low 6

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
				- Weed management program.	
Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	*Extreme Rainfall Event* - Water Treatment Program - Catchment Ponds including Pit, PAF, SP3, BSS, SRO and tanks in plant. - Emergency spillway on the Sediment Dam - Emergency Spillway to be constructed at SP3, PAF and BSS to direct water from the Sediment Dam to the Pit. - Diversion Drain to be constructed to direct water away from the Sediment Dam to the Pit. - Pit to be maintained as minimum levels. - Safety Berm on pit wall to prevent inundation from the EFR is flooding.	- Discharge of poor quality water to Sediment Dam. - Unauthorised discharge to the East Finniss River. - Discharge of water exceeding WDL licence trigger values. - Poor water quality discharged into the East Finniss River. - Extreme rainfall event has potential to flood the East Finniss River into the pit. - Impact to Threatened Species.	High 17	- Construction of a diversion channel to redirect water from the plant area to the Pit. - Install emergency spillways of BSS, PAF and SP3 to divert emergency overflow to the pit. - Continue water treatment of the pit over the dry season and evaporate in the Sediment Dam. - Convert process water to utilise Sediment Dam water to reduce the levels in the Dam throughout the year. - Maintain minimum storage levels prior to and during the wet season to maximise potential storage capacity in the event of extreme rainfall. - Purchase of an additional pump. - Modifications to be made to the WTP to increase throughput.	Medium 12
Resource Consumption	- Limited water demand during care and maintenance. - Process water to be sourced from the treated water in the Sediment Dam. - No water abstraction required for operational activities. - Potable water sourced from a supplier.	- Depletion in Natural Resources - Reduction in water discharge events.	Medium 9	- Water balance will require water to be discharged off site during care and maintenance operations. - Water Management Plan - Regular maintenance of water devices. - Investigate alternative means to discharging.	Low 3

Aspect	Project Area – Description	Potential Impacts	Inherent Risk Score	Risk Mitigation	Residual Risk Score
	- Water required for dust suppression during the dry season.				

16.3 Knowledge Gaps

NTR has identified areas requiring greater knowledge for the continual development of the Project. The gaps/future focus areas were identified though the development of the WMP and associated documentation including the RGC Water Quality Review and Load Balance Assessment.

Groundwater Flow Field

RGC has identified that knowledge gaps pertain to the groundwater flow field and the spatial extent of contaminant plumes on site, i.e. near the TSF and downgradient of the ore stockpiles. The proposed monitoring bores near the northern site boundary and the southern TSF berm will enable the groundwater flow field to be refined for the next report, thereby filling this knowledge gap.

Groundwater Bore Census

Surveys of groundwater bores across the Project to validate conditions. The census will include elevation of ground level, top of internal casing, depth to top and base of screen, bore depth, bore diameter and integrity of casing. This will also assist with determining the local flow fields with any certainty with the verified and reliable elevation data.

Improvements to the Water Model and Water Account

Conducting a site survey to update the contours and to calculate the capacity of each catchment pond will assist in determining catchment areas with more accuracy and it will enable the EAV curves being used in the current Water Balance Model to be verified.

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Appendix 1 - Water Balance and Load Balance Assessment

DOCUMENT NO. 256003/1

BROWNS MINE SITE

WATER QUALITY REVIEW AND LOAD BALANCE ASSESSMENT

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March 2018

EXECUTIVE SUMMARY

This report reviews groundwater and surface water quality at the Browns site in Australia's Northern Territory (NT). It was prepared by Robertson GeoConsultants Inc. (RGC) in support of the 2018 'Care and Maintenance' Mining Management Plan (MMP) and Water Management Plan (WMP) and an annual Monitoring Report that is required for Waste Discharge License (WDL)-177-06.

Study Objectives

The objective of this report is to satisfy the annual reporting requirements for WDL177-06 and support the WMP in the 2018 'Care and Maintenance' MMP for the Browns site.

Scope of Work

The scope of work for the current report is described in a proposal from October 2017. The scope of work includes the following:

- Document trigger value exceedances at the compliance point for boundary discharge (Site 5) and discussion of potential environmental implications.
- Discuss potential surface water quality impacts during a 1 in 100-year, 72-hour rainfall event.
- Identify potential contaminant sources to groundwater and the extent of groundwater quality impacts near the Tailings Storage Facility (TSF) and ore stockpiles.
- Provide a detailed scope for the hydrogeology drilling program that will be completed in support of an interim (Phase I) remediation strategy for groundwater near the TSF.
- Assess the reliability of routine groundwater and surface water quality monitoring data.
- Recommend a routine groundwater monitoring program that is commensurate with current water quality impacts on site and future remediation objectives.

This report is the Task 2 deliverable from RGC's October proposal. Task 1 is to support the completion of the 2018 hydrogeology drilling investigation(s) and develop an interim (Phase I) remediation strategy for impacted groundwater near the TSF.

Background

In 2008, 532 Mega liters (ML) of liquor from the metallurgical processing plant was discharged to the TSF. The liquor was acidic (pH 3.1) and characterized by up to 1,550 mg/L Cu and elevated concentrations of most other metals. Comparable concentrations were observed in water samples collected from bores BH4A and BH4B near the southern lease boundary in December 2008. These high concentrations suggest undiluted liquor was lost from the TSF, possibly via a fracture zone associated with faults that run beneath the TSF.

In January and February 2009, internal records show that the previous operator (Compass Resources) recovered about 400 ML of liquor from an eastern and western pond within the TSF and treated it in the processing plant. 132 ML of residual liquor remained in the western pond in February 2009 when pumping from the TSF ceased. In 2009 and 2010, several seepage recovery bores were installed near the TSF to recover liquor and/or impacted groundwater. Seepage recovery bores BH4G and BH12C have been operated since 2010 and delivered flows to the TSF.

Previous reports by URS and GHD have characterized groundwater quality impacts by liquor to some extent and have outlined strategies to recover impacted groundwater. These strategies mainly involve continued operation of recovery bores BH4G and BH12C. Flows records for these bores are not

available and a detailed assessment of their past performance has not been completed. RGC completed a preliminary assessment of groundwater quality impacts near the TSF in 2017 and was later retained to prepare the current report in support of a Monitoring Report for WDL177-06 and the WMP in the 2018 'Care and Maintenance' MMP.

Methods and Approach

RGC reviewed groundwater levels and groundwater quality data, surface water flows in the East Branch of the Finniss River (EBFR), and surface water quality monitoring data collected since December 2016 for WDL177-06. Groundwater and surface water quality results are tabulated in the appendices of this report with a statistical summary of the data. Representative water quality data collected during the current monitoring period are illustrated on maps and summarized in tables to aid in the discussion of current conditions on site.

Groundwater level and water quality time trends were prepared to characterize seasonal fluctuations in the data and any changes that are occurring over time. Seasonally-adjusted groundwater quality trends for the last five years were assessed with the Mann-Kendall (MK) trend test. The MK trend test is a non-parametric test that is used to (i) assess the stability of groundwater quality and (ii) evaluate the statistical significance of potential trends in the data. The MK trend test is a non-parametric trend analysis method that is most widely used to assess trends in environmental data and it is one of the statistical methods preferred by the U.S. Environmental Protection Agency (EPA) for their Super Fund sites.

Key Findings – Groundwater

Key findings from this report that pertain to groundwater are summarized here:

1. SO_4 and metal concentrations in water samples from bores BH4A and BH4B have decreased by an order-of-magnitude since 2009. Concentrations of most metals are now comparable to concentrations observed in the TSF pond, i.e. 30 mg/L Cu. The TSF pond consists of residual liquor from 2008 that has been diluted by rainfall and flows of less impacted groundwater from two recovery bores installed in 2009 and 2010.
2. Groundwater quality is not being improved by the minimal contaminant loads recovered by pumping from bores BH4G and BH12C. Instead, the MK trend analysis indicates that groundwater quality at bores BH4A and BH4B has been stable for the last five years. Previous consultants have reported 120 ML/year pumped from bores BH4G and BH12C. This flow rate (3.8 L/s annualized) could not be verified due to the lack of flow records for these bores.
3. Elevated SO_4 and metal concentrations in samples from bores BH4A, BH4B, and BH4D suggest some impacted groundwater and/or undiluted liquor has migrated beyond the southern lease boundary. The extent of contamination downgradient of bores BH4A and BH4B and the mass of contaminants that may have migrated beyond the southern lease boundary cannot be determined until additional monitoring bores and a new recovery bore have been installed in this area and appropriately monitored and pump tested.
4. Liquor lost from the TSF has impacted bores BH4A and BH4B, BH4D, BH5A and BH5B, and BH13B. Each of these bores is located within 100 m of the outer TSF berm. Groundwater from the 'TSF2 bores to the south of the TSF is not impacted by liquor losses from the TSF in 2008 or seepage from any other on-site sources, e.g. the ore stockpiles or PAF waste rock in the TSF berm.

5. A preliminary, un-calibrated load balance suggests that ~67 t/year SO_4 and 5,300 kg/year Cu may report to groundwater at the Browns site. Loads from the TSF pond account for two-thirds of the estimated SO_4 and Cu loads to groundwater. The other one-third is primarily related to seepage to groundwater from the PAF ore stockpile and the Black Shale Stockpile.
6. The current routine monitoring program does not seem appropriate given the extent of groundwater quality impacts and a program that is more focused on conditions near bores BH4A and BH4B is recommended (see Section 6.2).

Key Findings – Surface Water

Key findings from this report that pertain to surface water flows and quality are summarized here:

7. A water balance model (WBM) was developed to simulate ungauged flows to the WTP and flows from the Main Sediment Dam during controlled discharge events. The WBM simulates 404 ML of pit water and rainfall runoff to the water treatment plant (WTP) during the 2016/2017 Wet Season. The simulated annual controlled discharge volume from the Main Sediment Dam for the 2016/2017 Wet Season was 497 ML, or approximately 6% higher than the observed volume (469 ML).
8. Flows from the Browns Pit account for two-thirds of the simulated flow to the WTP during the 2016/2017 Wet Season. The other one-third of simulated flows is related to flows from the Site Run Off (SRO) pond and the ponds that collect rainfall runoff from the existing ore stockpiles. The TSF is an enclosed basin that does not contribute any flows to the WTP.
9. A contaminant load balance for surface water indicates that flows from the Browns Pit account approximately 80% of the simulated annual SO_4 load to the WTP. Rainfall runoff from the ore stockpiles accounts for the other 20% of the SO_4 load and 100% of the simulated Cu load to the WTP.
10. At Site 5, Cu and Co are the metals that exceed their respective trigger values most frequently. There were eight occasions from December 2016 to mid-January 2018 when the Cu concentration at Site 5 was greater than or equal to a value that is two times the trigger value for Cu. There were 19 instances when the trigger value (2.5 µg/L Cu) was exceeded.
11. The highest concentrations of Cu, Co, and other metals since routine monitoring at Site 5 began were observed in November and December 2017. The high concentrations, e.g. ~2000 µg/L Cu, are attributed to a large ‘first flush’ event during the build up to the 2017/2018 Wet Season. Environmental impacts to the EBFR were likely minor because high concentrations in the EBFR related to seepage from the former Rum Jungle mine site also occurred at the time.
12. The WBM simulated some spillage from the water collection ponds during Cyclone Carlos in February 2011. Water management facilities and infrastructure on site have since been improved and additional changes are planned for 2018. In RGC’s opinion, the Browns site may be able manage surface water flows associated with the 1 in 100-year, 72-hour rainfall event if rainfall runoff is directed to the Browns Pit and the Main Sediment Dam is used effectively to regulate water releases to the EBFR via Middlebrook Creek. Further assessment and hydrological modeling is needed to evaluate the performance of the water management system on site during this event.
13. In January 2018, the site received 460 mm of rainfall over three days. This is less than the 1 in 100-year design event as the largest one-day precipitation (225 mm) had a return period of 30 years. Some flooding occurred on site during the event but there were no water quality impacts to the EBFR and a strategy has been developed to prevent future flooding.

Recommendations for Groundwater Monitoring

RGC recommends the following with respect to routine groundwater monitoring:

1. Reduce the frequency of water quality sampling for most monitoring bores to annual and continue to collect quarterly samples from bores BH4A and BH4B and the new bores recommended to support seepage remediation monitoring (see Table 6-1).
2. Collect manual groundwater level and pit water level measurements monthly in the Dry Season and fortnightly in the Wet Season and place pressure transducers in selected bores to continuously monitor changes in groundwater levels (see Table 6-1).
3. Discontinue the analysis of groundwater samples for total metal concentrations and include a gravimetric analysis of the Total Dissolved Solids (TDS) content in the future suite of water quality parameters that are analyzed.
4. Implement a QA/QC program to check the reliability of each groundwater sample collected and re-sample groundwater if a sample is flagged as suspect, i.e. RPD (CBA) > 10%.
5. Survey the gauge height and creek bottom elevation at Station GS8150200, the staff gauge near the Browns Pit, and the TOC elevation of each bore on site after the 2018 drilling program is complete.
6. Investigate site-specific trigger values for groundwater that are supported by a statistical analysis of water quality and historic time trends and a list of specific remedial actions and/or additional monitoring that will be undertaken if a trigger value is exceeded.

Recommendations for Groundwater Remediation

RGC recommends a phased approach to the remediation of groundwater near the TSF. The Phase I objective is to further delineate the extent of impacted groundwater near the TSF and refine the local groundwater flow field near bores BH4A and BH4B.

The following is recommended for the Phase I (interim) remediation strategy:

1. Complete a 24-hour pumping test of recovery bore BH4G before the 2018 hydrogeology drilling program commences.
2. Install additional monitoring bores and a new, 150 to 200 mm diameter seepage recovery bore screened from 3 to 21 m bgs near bore BH4B.
3. Operate the new seepage recovery bore and bore BH4G as per pending recommendations in RGC's Task 2 report
4. Collect quarterly water quality samples from the new recovery bore and other new bores near bores BH4A and BH4B.
5. Deliver recovered groundwater from bore BH4G and the new recovery bore to the processing plant for treatment (not to the TSF pond) if yields exceed 1 L/s.

RGC understands that the new recovery bore and six new monitoring bores will be installed in 2018 as part of a staged implementation of the Phase I remediation strategy. The Phase II objective is to develop a final remediation strategy for impacted groundwater near the TSF. A site-wide groundwater flow model is recommended to support the Phase II remediation strategy. The model would be calibrated to current conditions since 2016 and be used to simulate the performance of the Phase I recovery strategy and, if required, assess additional seepage recovery options, i.e. additional recovery bores, treatment of the TSF pond, etc.

Recommendations for Surface Water Management

RGC recommends the Browns Pit be used as the prime storage reservoir for contact water during periods of intense rainfall, including the 1-in-100 year, 72-hour rainfall event, and that the release of controlled discharge from the Main Sediment Dam be optimized to ensure sufficient storage capacity in this reservoir to receive treated water from the WTP. The factors that affect the live storages of the Browns Pit and the Main Sediment Dam include the following:

1. The rate that pit water can be pumped to the WTP.
2. The capacity of the WTP and when it operates.
3. The discharge threshold in the WDL, i.e. currently 1 m^3/s.
4. The rate of controlled discharge from the Main Sediment Dam.
5. Potential inflows to the pit from the EBFR if the safety berm overtops.

RGC recommends these factors be assessed to ensure the site can manage the 1-in-100 year, 72-hour rainfall event and that lesser events can be managed efficiently, i.e. with fewer pumps.

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BROWNS MINE SITE

WATER QUALITY REVIEW AND LOAD BALANCE ASSESSMENT

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Appendix I Water Account for Browns Site

LIST OF ACRONYMS AND ABBREVIATIONS

AHD	Australian Height Datum
ARD	Acid Rock Drainage
bgs	below ground surface
BOM	Bureau of Meteorology
COV	Coefficient of Variation
CSM	Conceptual Side Model
DEM	Digital Elevation Model
DPIR	Department of Primary Industry and Resources
DTW	depth-to-water
EC	Electric Conductivity
EBFR	East Branch of the Finniss River
EFDC	East Finniss Diversion Channel
EPA	Environmental Protection Agency
HCO_3	Bicarbonate
K	Hydraulic Conductivity
MAP	Mean Annual Precipitation
NT	Northern Territory
NTR	Northern Territory Resources
PAF	Potentially Acid Forming
PVC	polyvinyl chloride
RGC	Robertson GeoConsultants Inc.
RN	Registration Number
S	Mann-Kendall statistic
SO_4	Sulphate
SRO	Site Run Off
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
WRD	Waste Rock Dump

DOCUMENT NO. 256003/2

BROWNS MINE SITE

WATER QUALITY REVIEW AND LOAD BALANCE ASSESSMENT

1 INTRODUCTION

1.1 GENERAL

This report reviews groundwater and surface water quality at the Browns site in Australia's Northern Territory (NT). It was prepared by Robertson GeoConsultants Inc. (RGC) in support of the 2018 'Care and Maintenance' Mining Management Plan (MMP) and Water Management Plan (WMP) for the site and an annual Monitoring Report that is required for Waste Discharge License (WDL)177-06.

1.2 TERMS OF REFERENCE

The Browns site is located about 105 km south of Darwin near the town of Batchelor. The site is adjacent to the former Rum Jungle mine site, a legacy site that has been managed by the NT Department of Primary Industry and Resources (DPIR) since 2009. Groundwater and surface water at the former Rum Jungle mine site are impacted by Acid Rock Drainage (ARD) from several historic Waste Rock Dumps (WRDs) and a mined-out pit that has been backfilled with sulphide-bearing mine waste and spent heap leach material (see RGC, 2016a).

In 2008, the Browns oxide deposit was partially mined by a previous operator (Compass Resources) using open pit mining methods. Mining was undertaken from August 2008 to January 2009 when Compass Resources filed for receivership. The TSF, the flooded Browns pit, a metallurgical processing plant, and several stockpiles of low-grade oxide ore at the Browns site are related to mining in 2008 (Compass Resources, 2016).

In 2008, 532 Mega liters (ML) of liquor from the metallurgical processing plant was discharged to the TSF. The liquor was acidic (pH 3.1) and characterized by up to 1,550 mg/L Cu and elevated concentrations of most other metals. Comparable concentrations were observed in water samples collected from bores BH4A and BH4B near the southern lease boundary in December 2008. These high concentrations suggest undiluted liquor was lost from the TSF, possibly via a fracture zone

associated with faults that run beneath the TSF. Groundwater from several other bores near the TSF was also impacted by liquor but not to the same extent as bores BH4A and BH4B.

On January 12th, 2009, Compass Resources began pumping liquor directly from the TSF and treating it in the processing plant. Pumping continued for 28 days until February 17th, 2009. During this period, Compass Resources estimated they recovered about 75% (~400 ML) of the liquor that had been discharged to the TSF. ~132 ML of liquor therefore remained in the TSF, primarily in a pond near the western end of the TSF. Pond water has not been pumped directly from the TSF since 2009.

Since January 2009, no mining has been undertaken at the Browns site and it has been operated according to a 'Care and Maintenance' MMP. Northern Territory Resources (NTR) is the current owner of the site. NTR purchased the site and related mineral leases from Compass Resources. NTR is the licensee for WDL177-06 and is responsible for updating the MMP each year and for routine care and maintenance of the site.

The scope of work for the current report is described in a proposal from October 2017. This report is the Task 2 deliverable from that proposal. Task 1 is to support the completion of a hydrogeology drilling investigation and develop an interim (Phase I) remediation strategy for impacted groundwater near the TSF. The Phase I objective is to further delineate the extent of impacted groundwater near the TSF, refine the local groundwater flow field, and evaluate the performance of recovery bore BH4G and an additional, potentially higher-yielding recovery bore to be installed near monitoring bore BH4B. The drilling investigation was deferred until the upcoming (2018) Dry Season.

Task 1 was to proceed prior to this report being submitted. It will now proceed when the drilling begins and the interim groundwater remediation plan will be finalized once the water quality results and pump testing data from the new bores are available. Further details on the Phase I and Phase II remediation strategies are provided in Section 6 of this report.

1.3 STUDY OBJECTIVE

The objective of this report is to satisfy the annual reporting requirements for WDL177-06 and support the WMP in the 2018 'Care and Maintenance' MMP for the Browns site.

1.4 SCOPE OF WORK

Routine groundwater monitoring data collected since 2008 and surface water quality data collected from December 2016 to January 2018 are reviewed to meet the study objective. The scope of work for this report is described in an RGC proposal from October 2017 and included the following:

- Review routine groundwater and surface water monitoring data collected for WDL177-06.
- Identify potential water management issues during a 1 in 100-year, 72-hour rainfall event and during a range of other climatic conditions that the site may experience.

- Provide recommendations for a hydrogeological drilling program to be completed in 2018 and outline an interim (Phase I) remediation strategy for impacted groundwater near the TSF.
- Recommend a more focused groundwater and surface water monitoring program that achieves the MMP and WDL monitoring requirements and is commensurate with current water quality impacts on site.

1.5 REPORT ORGANIZATION

This report contains the following sections:

- **Section 1. Introduction.** This section provides terms of reference and summarizes the objectives, scope, and organization of this report.
- **Section 2. Background.** This section describes the location and features of the Browns site, the groundwater and surface water monitoring network, existing seepage recovery bores, and monitoring requirements, trigger values, and stipulations for water release from WDL177-06.
- **Section 3. Methods and Approach.** This section describes the data received from NTR, the methodology used to evaluate the reliability of the data, and the statistical methods used in this report.
- **Section 4. Results (Data Reviewed).** This section describes the monitoring data reviewed for this report, including groundwater levels, groundwater and seepage quality, surface water flows in the EBFR, and surface water quality.
- **Section 5. Discussion.** This section discusses background water quality, potential contaminant sources/loads to groundwater, current water quality impacts due to TSF liquor and ARD from the existing stockpiles, and surface water quality impacts, including a discussion of trigger value exceedances at Site 5 from December 2016 to January 2018.
- **Section 6. Key Findings and Recommendations.** This section summarizes key findings and provides recommendations for future work and routine groundwater monitoring.

2 BACKGROUND

2.1 SITE LOCATION

The Browns site is located 105 km south of Darwin near the town of Batchelor in a low-relief area of the Finniss River catchment (Map 1). The site lies entirely within a 175-hectare (ha) area of granted mineral leases, including Mineral Lease Number (MLN) 139 to 147, MLN 150 to 152, and MLN 1157, MLN1158, and MLN1161.

MLN 1157 is located immediately south of MLN146 and MLN147. MLN1157 was a designated borrow area and was used to store topsoil stripped during project construction. The previously-proposed TSF2 (or 'TSF South') is located within MLN1157. Further south is Area 55, another ore deposit that is part of the Browns lease tenement (see Compass Resources, 2016).

2.2 PHYSICAL SETTING

2.2.1 Climate

The Browns site is characterized by a tropical wet-dry monsoonal climate. Mean annual rainfall is 1422 mm (all of which occurs as rainfall). More than 90% of MAP occurs during the Wet Season from November to April (Figure 2-1). The Dry Season is from May to October. Mean monthly maximum temperatures at the Batchelor Airport range from 31°C in June (Dry Season) to 37°C in October during the 'build up' to the Wet Season.

The 1 in 100-year, 72-hour rainfall event in the last WMP was 489 mm. This was obtained from the Intensity Frequency Duration (IFD) curve specified by Australian Bureau of Meteorology (BOM) for the coordinates of the Browns site (13º S and 131º E). In 2016, the BOM prepared a new set of IFD curves for the country and this resulted in a reduction in the estimated 100-year, 72-hour rainfall at the mine to 453 mm.

2.2.2 Hydrology

The Browns site is located within the EBFR catchment (Map 1). The EBFR and the West Branch of the Finniss River are the major tributaries of the Finniss River. The EBFR flows through the former Rum Jungle mine site to the east. Flows in the EBFR are monitored at gauges GS8150200, GS8150327, and GS8150097 by the DPIR. Peak flows in the EBFR usually occur in January, February, or March. No appreciable flow is observed during the Dry Season due to minimal rainfall.

There are two non-perennial (ephemeral) creeks near the Browns Site: Middlebrook Creek and Wandering Creek. Middlebrook Creek flows to a low-lying wetland near the eastern boundary of the Browns site. The wetland also receives flows during controlled discharge events from the Main Sediment Dam. Water from the wetland then discharges to the EBFR upstream of station GS8150200. Upstream flows from Middlebrook Creek and controlled discharge from the Main Sediment Dam flow

through Site 5, the compliance point for WDL177-06 (see Section 2.5). Wandering Creek flows through the former Rum Jungle mine site and discharges to the EBFR downstream of Site 5.

2.2.3 Topography

The Browns site is in a relatively low-relief region of the NT that is characterized by undulating hills and few natural bodies of surface water. The Browns site is essentially flat, with only a few meters of natural elevation change within the lease boundary. Elevations on site are expressed in m above the Australian Height Datum, or m AHD. The highest elevation around the project area (88 m AHD) is to the south of the TSF (near bores BH7A and BH7B) and the floor of the TSF has an elevation of approximately 75.5 m AHD.

The highest elevation within the site (83 m AHD) is the top of Stockpile 3 and the lowest elevation on site is the bottom of the Browns Pit, which was partially excavated to ~30 meters (m) below ground surface (bgs) during the Browns Oxide project. The TOC elevation for TPB5 indicates that the pit rim elevation nearest the eastern lease boundary (at bore TPB5) is 59 m AHD, so the bottom of the pit is probably around 35 m AHD. This elevation is consistent with water levels observed at bore TPB5 (a proxy for the Browns pit level) during mining operations in 2008 when the pit was de-watered (see Section 4).

The elevation of the EBFR bed to the east of the lease boundary is 56.1 m AHD near gauge GS8150200 (see Section 2.2.4) and the top of the bridge that connects the Browns site and the former Rum Jungle mine site is 60.0 m AHD. These creek channel elevation and bridge deck elevations are from a survey completed in 2010 as part of the Rum Jungle Rehabilitation Project (see RGC, 2011) and are quoted here with permission by the DPIR.

2.2.4 Regional Geology

The Browns site is in a triangular area of the Pine Creek Orogen known as The Embayment (Map 1). Black shales (Whites Formation) and dolomite and magnesite of the Coomalie Dolostone are the two major rock types that occur near ground surface at the Browns site. Both formations are part of the Mount Partridge Group, a sequence of sedimentary rocks that have been folded, faulted and metamorphosed to greenschist facies (McCready et al., 2004).

Polymetallic ore deposits within The Embayment occur within the Whites Formation near its contact with Coomalie Dolostone. These deposits include the Browns deposit, the Main, Intermediate, and Dyson's ore deposits at the former Rum Jungle mine site and the Woodcutters deposit about 10 km to the east. Ore deposits are strongly associated with fault zones, and hence structurally controlled. Specifically, ore was deposited in carbonaceous slates by selective replacement along shear zones that intersect local faults (Ahmad et al., 2006).

A regional fault zone does run through the TSF and may correspond to the contact between the Coomalie Dolostone and the Whites Formation. The Coomalie Dolostone occurs mainly to the north of the fault zone and the Whites Formation occurs to the south of the fault zone (see Map 3). The fault is delineated on a regional geology map so the exact location or depth at the Browns site (if it occurs at all) is not known. It has been identified during exploration drilling at the former Rum Jungle mine site and design reports by ATC Williams mention that it does occur beneath a portion of the TSF. Another fault runs from north-to-south beneath the western pond within the TSF.

2.2.5 Hydrogeology

The hydrogeology of the Browns site is not well-characterized. URS (2010) provides an overview of groundwater conditions on site, including a summary of aquifer properties and water quality impacts. Few details are provided in that report and a comprehensive review of water quality impacts is not provided. RGC (2018b) describes a CSM for the site, but the focus is the deeper groundwater system and how it could be affected by proposed underground mining. Aspects of the CSM that are relevant to a conceptual load balance for groundwater at the Browns site are summarized in Section 5.4. The shallow groundwater system, i.e. up to 30 m bgs, is simplified in the CSM and a detailed hydrostratigraphy that differentiates competent bedrock from highly-weathered bedrock, i.e. laterite and/or saprolite, is not provided.

The physical hydrogeology of the Browns site is similar to the former Rum Jungle mine site where RGC has worked since 2010 and some general observations from that site are summarized below:

- The Coomalie Dolostone and Whites Formation are the key formations near the western boundary of the former Rum Jungle mine site and at the Browns site. The Coomalie Dolostone and Whites Formation both have a relatively high permeability, i.e. hydraulic conductivity (K) = 10^{-6} to 10^{-4} m/s (see RGC, 2016b). Higher K values (>10^{-4} m/s) can occur locally in both formations where bedrock is fractured or where karst occurs in the Coomalie Dolostone, and/or in areas where bedrock is highly-weathered. These factors increase the bulk permeability of bedrock and may thereby cause preferential flow and/or accelerated contaminant transport to occur in areas where there is a strong enough hydraulic gradient.
- Several systems of cavities have been identified in the Coomalie Dolostone at the former Rum Jungle mine site, including a linear system that provides a direct hydraulic connection between the Main Pit (Rum Jungle) and the East Finniss Diversion Channel (EFDC) over several hundred meters. Cavities have also been identified during drilling investigations in the central mining area (RGC, 2011) and in the Old Tailings Dam area (RGC, 2015) and during geophysical investigations of the site (RGC, 2016c). Individual bore yields for the Coomalie Dolostone and Whites Formation typically range from 1 L/s to 50 L/s in bores that intersect cavities and/or fracture zones or historic production bores.

- Groundwater levels typically fluctuate by 5 to 10 m. The lowest groundwater levels occur during the late Dry Season and the highest groundwater levels occur in March or April during the Wet Season. Rainfall is the main source of recharge to groundwater. Most recharge occurs in undisturbed land areas but the WRDs represent preferential recharge areas. The flooded pits at the former Rum Jungle mine site act as a source of recharge to groundwater during the Dry Season when groundwater levels decrease below the pit water level. Groundwater discharges to the pits in the Wet Season when groundwater levels are higher than pit water levels (see RGC, 2016a; RGC, 2018b).
- Groundwater flow directions usually follow surface topography, meaning groundwater flows from higher elevation areas towards Fitch Creek and the EBFR in the central mining area. There is more elevation change at the former Rum Jungle mine site than at the Browns site, but the same trend appears to apply to the Browns site (see RGC, 2017, and Section 5.3). Groundwater at the Browns site likely flows to the Browns Pit or moves beyond the northern property boundary towards the EBFR.
- The EBFR is a regional groundwater discharge zone. It receives substantial flows of groundwater in the Wet Season and pools of water are often maintained by groundwater discharge during the Dry Season. Ephemeral creeks, such as Wandering Creek, are not major discharge zones for groundwater.

2.3 SITE FEATURES AND LAYOUT

Map 2 shows the key features of the Browns site, including the locations of groundwater monitoring bores and recovery bores and surface water monitoring locations. A brief overview of key site features is provided in the sub-sections below. Further details on the bore network and surface water monitoring stations are provided in Sections 2.4 and 2.5, respectively.

2.3.1 Processing Plant

The hydrometallurgical processing plant on site was built in 2008. An acidic leaching process was used to process ore in 2008 during the Browns Oxide Project but numerous technical difficulties were encountered and it was only operational for six months. Two high capacity vessels (thickeners) in the processing plant have been adapted to treat impacted groundwater and rainfall runoff from the site. The cells adapted are Leach Tailings Thickener (350-TH-01) and CCD1 (350-TH-02). Both are designed to process a maximum of 300 m^3/hour, and a third thickener could be added to the water treatment circuit if required (see Section 2.5.2 for further details).

2.3.2 Browns Pit

In 2008, approximately 700,000 t of oxide ore was mined from the Browns Pit as part of the Browns Oxide Project. Mining ceased in January 2009 when Compass Resources filed for receivership. The

Browns Pit is now inundated with water and it contains ~411,000 m^3 of water when the pit water elevation is 57 m AHD (Compass Resources, 2016). In 2010, bunds were constructed around the pit to prevent flows of impacted rainfall runoff to the pit and the eastern wall was heightened in 2011 after Cyclone Carlos to prevent overflow from the pit to the EBFR (GHD, 2016a).

According to Compass Resources (2016), the pit water level fluctuated between 55 m AHD and 60 m AHD from 2008 to 2011. Pit water levels are not routinely monitored but the groundwater level at bore TPB5 is considered a proxy for the water level in the pit (RGC, 2016a). In 2008, the water level at TPB5 was around 35 m AHD, or 24 m below the pit rim elevation.

For about five years starting in 2011, the water level in the pit was managed to not exceed 55.8 m AHD. This is the approximate elevation of the EBFR channel to the east. The pit water level was maintained below this elevation to reduce potential seepage from the Browns pit to the EBFR. The rationale is that seepage flows towards the EBFR may increase if the pit water elevation is higher than the EBFR for a prolonged period. Compass Resources (2016) cites assessments completed in 2011 but no further details are provided.

Preliminary simulations with the flow model suggest some seepage could occur to the EBFR from the Browns Pit area if the pit water level were to exceed 58 m AHD. However, the numerical groundwater flow model is not sufficiently discretized nor calibrated to simulate near-surface groundwater flows and further refinement and calibration of the model would be needed to confirm the preliminary modeling results (see Section 6.2).

2.3.3 Ore Stockpiles

About 40% (~300,000 t) of the ore mined from the Browns Pit was processed from September 2008 to January 2009. The remaining ore and some additional, Run-of-Mine (ROM) ore is stockpiled at surface in the Black Shale Stockpile, Stockpile 3, and the PAF ore stockpile (Table 2-1). Clay bunds have been constructed around the ore stockpiles to contain rainfall runoff before it is pumped to the water treatment system (see Section 2.5).

The ore in the stockpiles has not been characterized by ABA and related tests, so the sulphide content of these materials is unknown. ABA results for sulphide and oxide ore and waste rock from a trial mine pit excavated in 2002 are provided in EGI (2002) and re-interpreted in RGC (2016c). These data suggest the ore stockpiles are PAF material with little Acid Neutralization Capacity (ANC). Seepage samples collected in 2002 suggest drainage is acidic and characterized by elevated concentrations of SO_4 and metals associated with ARD.

Table 2-1. Existing Volumes of Stockpiled Ore

Name	Sub-Unit	Mass, t	Grade**		
			Cu, %	Ni, %	Co, %
Black Shale Stockpile	1A	47,949	1.35	0.073	0.075
	1D	197,394	0.30	0.085	0.075
Stockpile 3	2A	64,413	1.47	1.020	0.233
	2B	66,084	0.86	0.065	0.124
	2C	44,431	0.65	0.093	0.234
	2D	40,711	0.34	0.102	0.099
PAF ore stockpile	-	62,838	0.28	0.026	0.037
	TOTAL:	**523,820**	**-**	**-**	**-**

* Includes ore re-located from ROM pad in 2010
**From 2015 drilling investigation of the stockpiles (see Compass Resources, 2016)

2.3.4 Tailings Storage Facility (TSF)

The TSF (or 'TSF1') was constructed in 2005 to contain tailings from a large open pit that was proposed to access the deeper sulphide deposit beneath the Browns oxide deposit. The TSF is about 600 m long (from east to west) and 300 m across and is the key feature on site (Map 1). A second TSF ('TSF2') was proposed to the south of the existing TSF but was not built. The 'TSF2' monitoring bores are located around the previously-proposed footprint of TSF2. (see Section 2.4).

In August 2008, 200,000 t of tailings and 530 ML of acidic, metal-laden liquor from the processing plant were discharged to the TSF. Some of the liquor discharged to the TSF was lost to the sub-surface near bores BH4A and BH4B. The exact mechanism by which the loss of liquor occurred has not been determined. According to internal records, Compass Resources recovered about 75% (or 400 ML) of the liquor by pumping it from the TSF in January and February 2009 but the tailings remain in the TSF. Residual liquor remains in a pond near the western end of the TSF. The extent of the pond is not routinely monitored. Further discussion of the liquor lost from TSF and related water quality impacts are discussed in Section 5.2.

2.3.5 Site Run Off (SRO) Pond

The Site Runoff (SRO) pond is in the northwest corner of the site and collects rainfall runoff from the area west of the offices and car park. The SRO pond has a maximum operating level of 3 m and a storage capacity of ~13 ML (Compass Resources, 2016).

2.3.6 Pre-Settlement Ponds

The Pre-Settlement Ponds were constructed in September/October 2011. The material excavated to construct the ponds was employed to raise the berm between the Browns Pit and the EBFR. The ponds are vegetated and are intended to slow the flow of rainfall runoff and reduce the sediment load from the mine site to the EBFR (see GHD, 2016a).

2.3.7 Main Sediment Dam

The Main Sediment Dam is located near the eastern site boundary. It has a storage capacity of 125 ML with a maximum storage depth of 2 to 3 m (Compass Resources, 2016). The Main Sediment Dam receives flows of treated water from the processing plant, direct rainfall, and rainfall runoff from a portion of the site via the Pre-Settlement Ponds. Water from the Main Sediment Dam is discharged to the EBFR via Middlebrook Creek during high flow periods in accordance with WDL177-06 (see Section 2.5 for further details).

2.4 GROUNDWATER MONITORING AND SEEPAGE RECOVERY

2.4.1 Monitoring Bores

Map 2 shows the network of monitoring bores at the Browns site and several regional monitoring bores that are beyond the Browns mine lease. Bores at the former Rum Jungle mine site are shown on Map 2 for reference but are not labeled. Construction details, i.e. depths, screened intervals, etc., for the TSF1 and TSF2 bores are provided in Table 2-2 and Table 2-3, respectively. The TSF1 bores were installed by ATC Williams in 2005 as part of geotechnical investigations of TSF1 (ATC Williams, 2007) and the TSF2 bores were later installed around the proposed perimeter of TSF2 (ATC Williams, 2009).

The TSF1 and TSF2 bores were installed to characterize sub-surface (foundation) conditions beneath the proposed tailings facilities during the design phase. Hence the bores are not in strategic areas where groundwater quality is impacted by current contaminant sources to groundwater. Moreover, the screening intervals for the TSF2 bores were selected prescriptively without considering the material types encountered during drilling. This explains the identical screening intervals for the shallow bores (2.8 to 5.8 m bgs) and most of the deeper bores.

The screening intervals for the TSF1 bores appear to have been selected with some consideration of lithology. There is no record of the TSF1 or TSF2 bores being developed (purged) after installation so the bores are often characterized by high turbidity and Total Suspended Solids (TSS) (see Section 3). The TSF1 bores are screened in laterite/saprolite, Whites Formation shales, dolerite, or the Coomalie Dolostone, i.e. magnesite/dolomite. Bores BH4A and BH4B are located south of the TSF near the mine lease boundary. Bore BH4A is screened from 2.8 to 5.8 m bgs in laterite and bore BH4B is screened from 11.0 to 20.0 m bgs in black shale of the Whites Formation. These are the two bores where undiluted liquor was identified in 2008 (see Section 5.3 for further details).

Construction details for the TPB bores and several regional monitoring bores routinely monitored by NTR are provided in Table 2-3. Bores TPB1, TPB2, and TPB3 were installed in 2000 as part of site investigations related to the Browns Oxide Project. Bores TPB4 and TPB5 were installed more recently as de-watering bores. The Thompson bore and Thompson-Mango bores are private, domestic supply bores on the property adjacent to the Browns site. Bore RN023137 is near the Main Sediment Dam and bore RN022085 is beyond the mine lease boundary towards the former Rum Jungle Mine Site.

Table 2-2. Construction Details for TSF1 Bores

Bore ID	Easting, m	Northing, m	Diameter, mm	TOC Elevation, m AHD	Total Depth, m bgs	Screened Interval, m bgs	Screened lithology	Lithologic description	Monitoring Status
TSF1 Monitoring Bores, installed in 2005 (see ATC, 2007)									
BH2A	715154.4	8562316.1	50.0	74.8	5.8	2.8 to 5.8	Laterite/saprolite	Clayey sand (laterite)	Quarterly
BH2B	715155.8	8562314.8	50.0	75.4	20.0	10.0 to 20.0	Laterite/saprolite	Sandy Clay	Quarterly
BH3A	715372.0	8562110.3	50.0	76.9	5.8	2.8 to 5.8	Laterite/saprolite	Dark grey silt	Quarterly
BH3B	715374.0	8562111.7	50.0	77.4	20.0	10.0 to 20.0	Whites Formation	Shale	Quarterly
BH4A	715557.4	8562109.2	50.0	78.0	5.8	2.8 to 5.8	Laterite/saprolite	Silt and Clay	Quarterly
BH4B	715555.3	8562111.1	50.0	78.4	20.0	11.0 to 20.0	Whites Formation	Shale	Quarterly
BH5A	715977.9	8562106.1	50.0	75.1	5.7	2.7 to 5.7	Laterite/saprolite	Silt	Quarterly
BH5B	715975.2	8562106.3	50.0	75.9	20.0	14.0 to 20.0	Whites Formation	Silt/amphibolite	Quarterly
BH6	-	-	50.0	-	20.0	10.0 to 20.0	Whites Formation	Shale	Not routinely monitored
TSF1 Monitoring Bores, installed in 2009 (see URS, 2010)									
BH4D	715493.3	8562088.0	50.0	78.0	38.5	16.5 to 38.5	Whites Formation	Slightly fractured, weathered shale and coarse-grained quartz sand	Quarterly
BH4E	715615.5	8562086.4	50.0	74.7	40.0	23.0 to 39.0	Whites Formation	Highly-weathered shale; fractured and gravelly; quartz	Quarterly
BH12A	715178.7	8562123.3	50.0	75.6	12.0	6.0 to 12.0	Laterite/saprolite	Sandy Gravelly Clay	Quarterly
BH12B	715179.8	8562122.4	50.0	75.6	21.0	12.0 to 21.0	Whites Formation	Shale	Quarterly
BH13A	715238.7	8562162.0	50.0	75.1	40.4	34.4 to 40.4	Coomalie Dolostone	light grey magnesite (possible fractures at 28.7 m bgs)	Quarterly
BH13B	715236.1	8562162.0	50.0	75.2	21.0	15.0 to 21.0	Laterite/saprolite	sandy clay with trace gravel and clay	Quarterly
BH14A	715208.5	8562344.0	50.0	74.8	25.4	19.4 to 25.4	Coomalie Dolostone	magnesite; very hard	Quarterly
BH14B	715213.7	8562344.0	50.0	74.7	21.4	16.4 to 21.4	Laterite/saprolite	Sandy clay with little gravel	Quarterly
BH15A	716099.3	8562538.0	50.0	74.8	24.0	12.0 to 24.0	Whites Formation	Weathered shale with coarse sand; quartz vein and pyrite	Quarterly
BH15B	716105.0	8562539.0	50.0	74.8	50.0	44.0 to 50.1	Whites Formation	Slightly weathered shale with quartz and pyrite	Quarterly
BH16B	716084.0	8562253.0	50.0	76.3	15.4	12.4 to 15.4	Dolerite	"Dolerite??", "very hard rock"	Quarterly
BH17B	715871.7	8562543.0	50.0	78.2	15.3	2.9 to 15.3	Coomalie Dolostone	weathered rock/sand/gravel (quartz vein); cavity	Quarterly
BH18A	715468.7	8562424.0	50.0	77.6	15.0	5.0 to 15.0	Laterite/saprolite	Sandy clay (clay and coarse quartz); Quartz Dolomite?	Quarterly
BH18B	715471.3	8562425.0	50.0	77.7	27.4	18.0 to 27.4	Laterite/saprolite	Clayey, gravelly sand	Quarterly
TSF1 Recovery (Production) Bores, installed in 2009 and 2010 (see URS, 2010)									
BH4F	715549.8	8562118.2	50.0	78.3	50.0	43.0 to 49.0	Whites Formation	Shale and quartz gravel	Quarterly
BH4G	715560.4	8562119.0	50.0	78.8	24.0	6.0 to 18.0	Whites Formation	Black shale (fractured and weathered)	Quarterly
BH4H	715451.0	8562052.0	50.0	78.0	23.5	5.5 to 23.5	Whites Formation	Black shale (fractured and weathered)	Quarterly
BH12C	715182.2	8562124.0	50.0	75.0	22.9	13.9 to 22.6	Coomalie Dolostone	Clay, sand, and silicified dolomite are screened	Quarterly

Note: Monitoring bores BH1A, BH1B, BH16A, and BH17A were not drilled and recovery bore BH4C was backfilled in 2009

Table 2-3. Construction Details for TSF2 Bores and Other Bores near the Browns site

Bore ID	Easting, m	Northing, m	Diameter, mm	TOC Elevation, m AHD	Total Depth, m bgs	Screened Interval, m bgs	Screened lithology	Lithologic description	Monitoring Status
TSF South (TSF2) Monitoring Bores (see URS, 2010)									
BH7A	715422.8	8561711.0	50.0	80.8	10.0	4.0 to 10.0	Whites Formation	Shale	Quarterly
BH7B	715422.6	8561694.3	50.0	81.0	30.0	24.0 to 30.0	Whites Formation	Shale	Quarterly
BH8A	715841.7	8561506.2	50.0	75.0	10.0	4.0 to 10.0	Laterite/saprolite	Clay	Quarterly
BH8B	715857.7	8561505.3	50.0	74.9	30.0	24.0 to 30.0	Whites Formation	Shale	Quarterly
BH9A	716245	8561795.3	50.0	73.6	10.0	4.0 to 10.0	Laterite/saprolite	Clay	Quarterly
BH9B	716246.2	8561775.2	50.0	74.5	30.0	24.0 to 30.0	Whites Formation	Shale	Quarterly
BH10	716241.1	8561417	50.0	78.6	23.8	17.8 to 23.8	Laterite/saprolite	Clayey Sand	Quarterly
BH11	715418	8561293.3	50.0	70.5	24.1	8.5 to 24.1	Laterite/saprolite	Clay	Quarterly
Test Production Bores, installed in November 2000 (see Water Studies, 2000)									
TPB1	-	-	80	-	18.5	10.3 to 15.3	Coomalie Dolostone	Weathered magnesite	Not routinely monitored
TPB2	-	-	80	-	56.3	42.1 to 51.7	Whites Formation	Fractured, silicified siltstone	Not routinely monitored
TPB3	-	-	80	-	51.5	46.5 to 51.5	Whites Formation	Black, sulphidic shale with some fracturing (main fault zone)	Not routinely monitored
Test Production Bores, installed in June/July 2007 (see URS, 2007)									
TPB4	716573	8563103	80	61.5	71.5	17.5 to 47.5, 65.5 to 71.5	Coomalie Dolostone	Fresh, massive, white/grey [magnesite] with red/pink bands	Quarterly
TPB5	716920	8563046	80	59.9	27.0	13.0 to 19.0, 12.0 to 27.0	Coomalie Dolostone	Moderately weathered dolomite, some iron staining	Quarterly
Other Monitoring Bores and Domestic Supply Bores									
RN023137	716598.0	856288.0	50.0	68.0	40.0	21.0 to 40.0	Amphibolite	"clay, quartz, and mica schist"	Quarterly
RN022085	717213.8	8562480.3	50.0	74.0	32.0	24.0 to 32.0	Coomalie Dolostone	"pink, marbled dolomite with layers of calcite"	Quarterly
RN023140	717126.6	8564298.4	50.0	62.3	18.0	11.0 to 16.0	Coomalie Dolostone	"weathered tremolite schist and dolomite"	Not routinely monitored
Thompson*	714788.5	8561387.3	50.0	-	40.0	31.0 to 34.0	Whites Formation	"fractured shale wih quartz and pyrite"	Quarterly
Thompson Mango	714917.0	8561890.0	50.0	-	-		-	-	Quarterly

Notes:

Bore TPB1, un-cased from 15.3 to 18.5 m bgs, screened across contact between Whites Formation and Coomalie Dolostone, 12.5 L/s yield during 24-hour flow test (see URS, 2009)

Bore TPB2, un-cased from 51.7 to 65.3 m bgs, 9.5 L/s yield during 24-hour flow test (see URS, 2009)

Bore TPB3, fault zone identified as “fractured cavernous zone” in fine-grained claystone with fragments of stained sulphide crystals (up to 20 mm in size); 20 L/s yield estimated from 24 hour flow test (see URS, 2009)

Bore TPB4, cavity identified from 21.5 to 24.2 m bgs; 10 L/s airlift yield at 33 m (during drilling); no pump installed; routinely monitored for water quality

Bore TPB5, cavities (silt-filled) identified from 27.5 to 29.5 m bgs and 33.5 to 35.2 m bgs; minor clasts of blue copper oxides in dolomite; iron staining common; no pump installed; routinely monitored for water quality

* Bore RN031479; 7 L/s during 4 hour airlift test

2.4.2 Seepage Recovery Bores

There are four seepage recovery bores around the perimeter of the TSF: BH12C, BH4F, BH4G, and BH4H (Map 2 and Table 2-3). Recovery bore BH4G has been operated since November 2009 and recovery bore BH12C was operated from March 2010 until December 2017 when there was a blockage and pump was subsequently removed (N. Rodwell, personal communication). Groundwater pumped from bore BH12C is characterized by elevated SO_4 and non-detectable concentrations of most metals, e.g. less than 1 µg/L Cu. The rationale for pumping from this bore is unclear and RGC (2017) recommended that pumping be discontinued.

Together, recovery bores BH12C and BH4G have reportedly pumped ~120 ML/year (or 3.8 L/s) of impacted groundwater back to the TSF since 2009 (see GHD, 2016b). However, pumping records for these bores are unavailable, so the magnitude of flows from each bore cannot be differentiated. Moreover, when RGC visited the Browns site in July 2017, less than 0.1 L/s from each of these bores was observed. The bores were operating normally at the time (N. Rodwell, personal communication), suggesting they were not performing as intended.

Recovery bores BH4F and BH4H were installed by URS in April 2009 and October 2009, respectively. According to URS (2009), recovery bore BH4F yielded 5 L/s during a 13-hour pumping test in April 2009 and a 200-m capture zone developed around the bore. A solar-powered Airwell pump was installed after this test and bore BH4F was pumped at 1.5 L/s until November 2009 when the pump was moved to bore BH4G (see URS, 2009). Recovery bore BH4H has not been pump-tested or operated since it was installed. Recovery bores BH4F and BH4H are not currently operated because groundwater from each appears to be unimpacted by liquor from the TSF. Further details on current seepage management and the condition of recovered groundwater are provided in Section 5.3.

2.4.3 Routine Groundwater Monitoring Program

Each of the TSF1, TSF2, and seepage recovery bores is sampled quarterly for water quality. A low flow sampling procedure and a standard (purging) procedure are both used on site. The following field parameters are measured during sampling: pH, EC, redox potential, DO, turbidity and water temperature. A water sample is collected during low flow sampling when each of these parameters have stabilized as per specifications in GHD (2016a). For bores sampled with the standard flow procedure, three bore volumes are purged before a water sample is collected. Groundwater quality sampling procedures are further described in the pending WMP.

Water samples are field-filtered with a 0.45 um filter membrane and preserved with ultrapure nitric acid. Filtered samples are analyzed to determine the dissolved metal content of the sample. Unfiltered, acidified samples are analyzed to determine total metal concentrations in groundwater. Major ions, i.e. SO_4, Cl, are determined for each sample and total, carbonate, and bicarbonate alkalinities are determined by titration (Table 2-4). Water quality analyses have been completed by Eurofins since

2016. Several laboratories have been used for water quality analyses in the past, including NTEL until 2010 and Labmark (now Eurofins) since 2013.

Groundwater levels in each bore on site are monitored monthly with an electronic water level tape. Water levels are also monitored prior to water quality sampling. Depth measurements are recorded to the nearest 1 mm.

Table 2-4. Summary of Analytical Methods

Parameter	Internal Method ID	Method Description (from Eurofins)	Units	LOR*	Holding Time
Physical Parameters					
Suspended Solids	LTM-INO-4070	Analysis of Suspended Solids in Water by Gravimetry	mg/L	5	7 days
Alkalinity and Major Ions					
Alkalinity (speciated)	APHA 2320	Alkalinity by Titration	mg/L as $CaCO_3$	20**	14 days
Chloride	E045/E047	Chloride	mg/L	1	28 days
Sulphate	E045/E047	Anions by Ion Chromatography	mg/L	2	28 days
Calcium and Magnesium	LTM-MET-3010	Alkali Metals	mg/L	0.5	180 days
Hardness	E020.1	Hardness in water	mg/L as $CaCO_3$	1	28 days
Heavy Metals					
Aluminum	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	50	180 days
Cadmium	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	0.2	180 days
Cobalt	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Copper	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Iron	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	50	180 days
Lead	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Manganese	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days
Nickel	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	1	180 days
Uranium	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days
Zinc	LTM-MET-3040	Metals in Waters by ICP-MS	µg/L	5	180 days

* Limit of Reporting
**For total and carbonate alkalinity
Other abbreviations:
APHA: American Public Health Association

2.5 SURFACE WATER MANAGEMENT AND TREATMENT

2.5.1 Water Management Infrastructure

Rainfall runoff is diverted to the SRO, the Browns Pit, and several sumps near the surface ore stockpiles (see Table 2-6 and Map 2 for locations). Water is pumped from each location to the processing plant for treatment. Pit water from the Browns does slightly exceed trigger values and as such must be treated. The pit water is pumped to the processing plant as the main feed sources to the Water Treatment Plant (WTP) and is used to blend the stockpile contact water. Further details on surface water flows are provided in Section 5.5.

2.5.2 Water Treatment and Effluent Release to EBFR

The Browns Project site has a small network of open and underground drains, bunded containment areas and concrete sumps to collect contact water. This contact water is pumped from the containment

areas to the water treatment circuit (or 'WTP') within the plant facility. Contact water is captured and pumped to the feed pump box in the WTP. The pipe configuration allows for the feed water input lines to be operated individually or at the same time depending on site requirements. In March 2017, the DPIR approved a change from sodium carbonate to hydrated lime as the key reagent for the precipitation of dissolved metals (see Appendix B for further details). In October 2017, NTR began reconfiguring the processing plant to facilitate this transition and the new circuit was commissioned in December 2017.

Feed water enters the treatment system via Tank #1 and then flows by gravity through Tank #3, Tank #5 and then Tank #7. These three tanks have agitators in place to facilitate the circulation of the lime through the water column. Flocculant is introduced into Tank #7 via a distribution pipeline at a constant flow rate. The flocculant aggregates the precipitated metal particles while gently agitating the water to keep the particles in suspension. This water is then gravity fed into CCD1 and LTT Tanks concurrently. These tanks provide no agitation. This enables the metal precipitate to settle to the bottom of the tanks where it collects as a metal precipitate slurry.

Treated water flows over the launders at the top of the tanks where it collects in each of the respective overflow tanks. From these overflow tanks the water is then pumped to the CCD2 Tank. This tank represents the 'clean' (treated) water which is then piped via the underflow pump to the Pre-Settlement Ponds within the Main Sediment Dam facility. There is a water quality sampling point (TREAT1) under CCD2 Tank. This sampling point is a WDL 177-06 monitoring site and is sampled fortnightly.

Water released from the Pre-Settlement Ponds meanders through a series of vegetated ponds connected via vegetated channels that facilitate the natural filtration of the water. Water from the Main Sediment Dam is discharged by a valve-controlled pipeline to a naturally-vegetated wetland area that also receives unimpacted flows from Middlebrook Creek. The compliance point (Site 5) for WDL177-06 is about 200 m downstream of the wetland near the fence line that separates the Browns Site from the former Rum Jungle mine site (see Section 2.6.2).

WDL177-06 authorizes wastewater discharge to the EBFR. Wastewater is defined as water containing a contaminant or waste, e.g. dissolved metals. Wastewater released from the site is a mixture of unimpacted storm water (rainfall runoff) from the site that reports to the Main Sediment Dam and treated effluent from the water treatment system. Only water from these two sources can be discharged. Wastewater discharge is only authorized by WDL177-06 when the following criteria are satisfied:

- The river height at the gauge board adjacent to station GS8150200 is 1.56 m or higher.
- The pH of wastewater in the Main Sediment Dam at Site 2 is between pH 6.5 and pH 8.0.

The 1.56 m river height on the gauge board equates to a flow rate of 1 m^3/s in the EBFR at station GS8150200. Station GS8150200 is located downstream of the bridge at the former Rum Jungle mine site. It records the combined flow from the East Finniss Diversion Channel (EFDC) and EBFR flows through the Main Pit and Intermediate Pit. Together, these flows comprise the total flow in the EBFR

downstream of the central mining area at the former Rum Jungle mine site. Water quality in the EFDC is routinely monitored at Site 1 as part of WDL177-06.

Water released when the stream flow in the EBFR exceeds 1 m^3/s is referred to as a 'controlled discharge event'. An hourly flow-duration curve for EBFR at Station GS8150200 is provided in Figure 2-2. There are normally several controlled discharge events each Wet Season, although the number depends on the amount of rainfall that the EBFR catchment receives. Uncontrolled discharge may enter Middlebrook Creek from an emergency spillway at the southwest corner of the Main Sediment Dam at DAMOUT2 as authorised by the DPIR under Authorisation 0919-01. Uncontrolled discharge can occur during periods of intense rainfall when the water level in the Main Sediment Dam exceeds 5 m depth (or 66.3 m AHD) (GHD, 2016a). The spillway is located upstream of Site 5.

Table 2-5. Summary of Surface Water Monitoring Stations

Site ID	Easting, m	Northing, m	Description	Monitoring Status or Purpose	Monitoring Frequency		
					Field Measurements	Metals and Major Chemistry	Radiological
Monitoring sites for WDL177-06							
SITE1	717263	8562948	East Branch of the Finniss River (EBFR) Upstream	Active	F / U	F / U	-
SITE2	716810	8562738	Main Sediment Dam	Active	F / U	F / U	-
SITE3	716639	8562366	Main Sediment Dam	No longer monitored	n/a	n/a	-
SITE4	717109	8562080	Middlebrook Creek upstream of boundary discharge	Active	F / U	F / U	-
SITE5	717009	8562888	Middlebrook Creek ~0.2 km downstream of boundary discharge	Active	D / U	F / U	-
TREAT1	715751	8562533	Treated effluent discharging to the Main Sediment Dam	Active	F	F / U	-
DAMOUT1	716855	8562729	Main Sediment Dam at the discharge pipe outlet	Active	U	U	-
DAMOUT2	716560	8562364	Main Sediment Dam emergency spillway (when flowing)	Active	U	U	-
Other surface water monitoring sites (pits, creeks, and effluent)							
WAND1	717140	8562796	Wandering Creek upstream of Middlebrook Creek	Active	F / U	F / U	-
GS200	717003	8563107	EBFR ~0.4 km downstream of discharge	Active	F / U	F / U	-
GS097	713425	8566009	EBFR ~7 km downstream of discharge	Active	M	M	-
RUMWHITE	718065	8563345	Main (Whites) Pit at Rum Jungle	Active	M	B	-
RUMINTER	717128	8563036	Intermediate Pit at Rum Jungle	Active	M	B	-
Rainwater collection ponds							
RW_TSF	715628	8562366	TSF Stormwater Collection Pond	Active	F	Q	-
RW_SRO	715112	8562411	Small Sediment Dam	Active	F	Q	-
RW_PAF	716077	8562383	PAF Stockpile Pond	Active	F	Q	-
RW_SP3	716334	8562245	Low Grade Ore Pond	Active	F	Q	-
RW_BSS	716308	8562695	Intermediate Stockpile Pond	Active	F	Q	-
RW_POND	715410	8562432	Process water storage pond	Active	F	B	-
RW_PIT	716710	8562941	Oxide pit	Active	F	B	-

Abbreviations:
Field measurements: water level (m), pH, EC (µS/cm), DO (% sat.), turbidity (NTU), and water temperature (°C)
Metals and metalloids (total and filtered, i.e. < 0.45 um): Al, Cd. Co, Cu, Fe, Pb, Mn, Ni, U, and Zn
D = Daily (when discharging)
F = Fortnightly (when flowing)
U = Upon discharge
M = Monthly
Q = Quarterly (Jan, Apr, Jul, Oct)
B = Biannual (Jan and Jul)

2.6 WDL177-06 MONITORING AND REPORTING REQUIREMENTS

2.6.1 Licensee and Administering Agency

NTR is the licensee and the NT EPA is the administering agency for WDL177-06 (Appendix A).

2.6.2 Surface Water Monitoring Program

SITE5 (at the eastern site boundary) is the compliance point for WDL177-06. Further details on Site 5 and other monitoring sites for WDL177-06 are provided in Table 2-6. Water levels and field measurements of pH, EC, DO, turbidity, and temperature are recorded daily at Site 5 during controlled discharge events. WDL177-06 stipulates the following be measured and recorded at Site 5 during these events:

- The time discharge commenced and the duration of discharge.
- The discharge flow rate.
- The discharge volume.

Samples for total and dissolved metals are collected every two weeks (fortnightly) at Site 5 and additional samples taken upon opening of the discharge valve. Samples are analyzed for Al, Cd, Co, Cu, Fe, Pb, Mn, Ni, U, and Zn. Other stipulations regarding the condition of wastewater are listed in WDL177-06 (see Appendix A).

2.6.3 Trigger Values for Boundary Discharge at Site 05

Trigger values for boundary discharge at Site 05 are summarized in Table 2-6. Trigger values are only applicable to wastewater at Site 5. The trigger values represent either the 80% or 90% species protection trigger level from ANZECC/ARMCANZ (2000). Trigger values apply to filtered samples, i.e. dissolved metal concentrations, and are not to be modified to account for hardness.

Table 2-6 Trigger Values for Surface Water at SITE5

Parameter	Abbreviation	Units	Trigger Value (WDL 177-06)
Aluminum	Al	µg/L	80[a]
Cadmium	Cd	µg/L	0.4[a]
Cobalt	Co	µg/L	13
Copper	Cu	µg/L	2.5[b]
Lead	Pb	µg/L	5.6[a]
Manganese	Mn	µg/L	2500[a]
Nickel	Ni	µg/L	13[a]
Zinc	Zn	µg/L	15[a]

[a] 90% species protection trigger level, ANZECC/ARMCANZ (2000)

[b] 80% species protection trigger level, ANZECC/ARMCANZ (2000)

Note: trigger values apply to filtered samples and are not to be modified to account for hardness

2.6.4 Annual Reporting Requirements

WDL177-06 stipulates that the NT EPA must be notified when:

- A concentration at Site 5 exceeds a trigger value on three consecutive occasions.
- A concentration that is greater than or equal to two times the trigger value is observed on a single occasion.

Condition 42 of WDL177-06 stipulates that the Monitoring Report include:

- A tabulation of all monitoring data required as a condition of WDL177-06, i.e. groundwater and surface water quality data (Sections 4.2 and 4.3).
- Spatial images of contaminated groundwater (i.e. contaminant plumes) generated by activities on the mine lease at differing depths/aquifer. (Section 5.4.1)
- Long-term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available). (Section 5.4.2).
- An estimate of the volume of contaminated groundwater leaving the mine lease, including estimates of individual contaminant volumes, e.g. metal and metalloids.
- An assessment of environmental impact from the activity (Section 5.6.2).

The current report satisfies each of the requirements but does not provide an estimate of volume of contaminated groundwater leaving the mine lease. This estimate will be provided in a pending report on the Phase I remediation strategy to be completed after the 2018 hydrogeology drilling program is complete (see Section 6.2).

2.7 COMMITMENTS FROM MMP

A site water balance model and Water Account for care and maintenance activities are to be developed for inclusion in the Water Management Plan. Commitment AR49 of the MMP requires NTR to conduct water balance modelling to assess the impacts to site water management of a 1 in 100-year average recurrence interval event.

3 METHODS AND APPROACH

3.1 DATA RECEIVED

3.1.1 Pit Water and Groundwater Levels

Depth-to-water (DTW) measurements for each bore on site were supplied in an Excel file 'Groundwater Data Sep 2017_Depth'. DTW measurements for the Thompson and Thompson-Mango bores were also provided in this file. Pit water levels are not routinely monitored. The groundwater level at bore TPB5 (which is routinely monitored) is considered a proxy for the water level in the Browns Pit (see RGC, 2016a).

Geodetic groundwater levels were calculated by subtracting the DTW from the Top-of-Casing (TOC) elevation for each bore. If a bore was 'dry', the total depth of the bore is subtracted from the TOC elevation, indicating that the geodetic water level is below this elevation. TOC elevations are provided in the spreadsheet mentioned above. RGC is not aware of the survey date or the company that completed the survey and has recommended that each TOC elevation be re-surveyed after the 2018 drilling investigation has been completed (see Section 6.2).

For some bores, e.g. BH13A/B, there was a substantial discrepancy between the TOC elevation in the spreadsheet and ground elevations taken from a regional topography map. In some cases, the discrepancy is due to an obvious transcription error that was corrected so a preliminary groundwater flow field could be inferred (see Section 5.2).

3.1.2 Surface Water Flows

Hourly flows and gauge heights for the EBFR at gauge GS8150200 from December 1981 to December 2017 were provided by the DPIR on January 19th, 2018 (A. Brandis, personal communication). A scatter diagram of hourly flows against corresponding gauge heights was created.to provide a coarse check on the quality of the data collected at this station, particularly for the period since the Browns Project has been under care and maintenance. The scatter diagram revealed that at least three different rating curves have been used since 2009 to convert measured water levels to estimated discharge rates. These rating curves were found to be reasonably consistent throughout the full range of flows experienced by the stream, thus providing some evidence that the flow data from 2009 onwards is of good quality.

3.1.3 Water Quality

Groundwater quality data collected until the end of September 2017 were supplied by NTR in an Excel file ('Groundwater Data Sept 2017_Chemistry'). Data collected in January 2018 were sent separately. Surface water quality monitoring data were supplied by NTR in an Excel file 'Surface water_ALL' on January 31st, 2018. The file contains data collected until January 19th, 2018. The reliability of the

groundwater and surface water quality collected since 2008 was evaluated as per the procedures outlined in Section 3.2.

3.2 INITIAL DATA VERIFICATION (QA/QC)

3.2.1 Initial Screening and Transcription Error Corrections

Groundwater level time trends were prepared in Excel and initially reviewed to identify erroneous measurements. DTW measurements that were several meters different than previously-collected data were removed from time trends.

Groundwater and surface water quality data were initially screened to ensure that the proper units were assigned to major ions and metal concentrations. For some years, metal concentrations were erroneously reported in mg/L instead of µg/L, or vice versa. These errors were corrected as part of the initial screening process. There were no unit errors in 2016 and 2017.

3.2.2 Additional QC/QC Procedures

Dissolved metal concentrations for most years are available from the database. For some years, samples were not analyzed for alkalinity, Fe, SO_4, Cl, Ca, Mg, Na, or K. Groundwater and surface water samples with a complete set of major ion concentrations were assessed with a Charge Balance Analysis (CBA).

The CBA involved converting the concentrations of major cations (including metals) and major anions to milliequivalents per L (meq/L), summing the cations and anions, and then comparing the sums for each sample via a Relative Percent Difference (RPD value). The RPD value was calculated as the absolute value of the difference between the sum of cations and anions divided by the average of the two values.

The CBA was done in Excel for historic samples to identify transcription errors and/or potential lab errors. A CBA for a composite set of data was also done in The Geochemist's Workbench while preparing the Piper plots and Durov plots provided in Section 5. Duplicate samples or field blanks were not routinely collected in the past so RPD values for duplicate samples could not be calculated.

3.2.3 QA/QC Results

RPD values for groundwater and surface water quality data are summarized in Figure 3-1 and Figure 3-2, respectively. RPD values for groundwater samples are often very high and often indicate an under-estimate of major ions, i.e. HCO_3 or SO_4. Erroneous SO_4 and/or HCO_3 concentrations (from alkalinity) do not necessarily imply that metal concentrations are unreliable, so none of the historic samples with high RPD values were excluded from this report. It should, however, be acknowledged that many of the data that appear in groundwater quality time trends in Section 4 are unreliable. Correcting these

data or commenting on individual errors was beyond RGC's scope of work and the inclusion of some unreliable samples from past years does not detract from the key findings of this report.

Many of the historic groundwater samples are characterized by elevated TSS and turbidity. High TSS and turbidity affect total metal concentrations in unfiltered groundwater because some particulate matter is digested when the sample is acidified. High TSS does not affect dissolved metal concentrations in groundwater and it is only these concentrations that are interpreted in this report. Groundwater should, however, be characterized by no appreciable TSS and the elevated TSS reflects inadequate development and/or improper installation. Only dissolved concentrations in surface water are reviewed in this report because trigger values at Site 5 apply only to dissolved metal concentrations in wastewater.

Many of the groundwater samples collected in 2017 and in January 2018 were characterized by low turbidity and TSS and RPD values of less than 10%. These RPD values suggest the data are more reliable than some of the historic data and can be interpreted with more confidence. However, some of the samples collected in 2017 and 2018 still had high RPD values, possibly due to lab error. Data from 2017 and 2018 that are considered reliable appear on the maps and in the summary table provided in Section 4. If the data collected in 2017 and 2018 were considered unreliable then a previously-collected reliable sample with a lower RPD was selected for further interpretation of current impacts to groundwater.

3.3 STATISTICAL TREND ANALYSIS

The stability of time trends of metal concentrations in groundwater were analyzed using the Mann-Kendall trend analysis. This section describes the statistical methods used to evaluate stability. The results of the statistical evaluation, including an explanation of the significance of any trends identified, are discussed in Section 5.

3.3.1 Parameter Selection

Dissolved Cu was selected for Mann-Kendall trend analysis. Cu was selected because it appears to be representative of trends for other metals. Trends for other metals and SO_4 were analyzed to confirm this assumption but the trend analyses are not provided.

3.3.2 Non-Detect Values

A value equal to the detection limit for Cu (1 µg/L Cu) was assigned to data reported as below the detection limit in a time series that included detectable and non-detectable Cu concentrations. Time series that were predominated by non-detect values were not evaluated with the Mann-Kendall trend analysis because the data reflect unimpacted groundwater, i.e. there is no source to cause a trend.

3.3.3 Seasonally-Adjusted Trend Plots

As discussed below, the Mann-Kendall trend analysis requires data that are not influenced by seasonal effects. This is required so potential intra-annual variations caused by dilution do not detract from the longer term, monotonic trend that is being analyzed. For sites at higher latitudes, preparing a seasonally-adjusted time series could involve selecting concentrations observed during winter low flow conditions or during the spring freshet, thereby ensuring that samples collected under similar conditions each year are represented in the time series.

For this report, seasonally-adjusted trend plots were prepared by selecting samples collected only during the Dry Season. Most of the samples were collected July, August, or September, but an analysis of Wet Season data was also completed to confirm the results from the Mann-Kendall trend tests. Seasonally-adjusted trend plots were prepared in Excel and are not provided. The data do, however, appear in the time trends presented in Section 4.

3.3.4 Mann-Kendall Trend Tests

The Mann-Kendall test is a non-parametric test for identifying trends in time series data. It is a widely-accepted approach to environmental time series and is often used, if not required, at EPA Super Fund sites in the U.S.A. The test compares the relative magnitudes of data, e.g. concentrations, rather than the data values themselves (Gilbert, 1987), and thereby avoids some of the issues associated with a parametric statistical procedure such as a linear regression analysis. The Mann-Kendall test is particularly useful for determining the stability of a contaminant plume and whether there has been a change in the flux of contaminants in groundwater, and if any commensurate change in the frequency of future routine monitoring is warranted (see Section 3.3.5).

The Mann-Kendall trend test does not require data to be distributed normally, nor does it require that data be collected at a consistent interval. The test does require that data not fluctuate seasonally. i.e. in response to dilution, etc., so seasonally-adjusted trend plots are a prerequisite. A minimum of four independent sampling events and no more than ten sampling events can be analyzed. The key term for the test is the Mann-Kendall statistic, S. The first step in calculating S is to list the data in the order in which they were collected: x_1, x_2,… to x_n where x_i is the value at time i. Then determine the sign of all n(n-1)/2 possible differences where $x_j - x_k$, where j > k. Let $Sign(x_j - x_k)$ be an indicator function that takes the value of 1, 0, or -1 as described below:

- $Sign(x_j - x_k) = 1$ if $x_j - x_k > 0$
- $Sign(x_j - x_k) = 0$ if $x_j - x_k = 0$
- $Sign(x_j - x_k) = -1$ if $x_j - x_k < 0$

Then compute S:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} Sign(x_j - x_k)$$

A high positive value of S is an indicator of an increasing trend and a high negative value indicates a decreasing trend. The degree of confidence or 'confidence level' in a trend is the statistical probability that a value is increasing (S > 0) or decreasing (S < 0). Confidence level can be expressed as a percentage by subtracting the probability (*p*) from 1, i.e. 1 – *p*). A confidence level of 90% represents a significance level of α = 0.1 and a 95% confidence interval corresponds to α = 0.05. The probability associated with S is determined by comparing S and the number of samples in a time series, n, to determine if the trend is statistically significant. This is done with a Kendall probability table that compares S and n to determine the probability of rejecting the null hypothesis for a given level of significance.

The null hypothesis (H_o) for the Mann-Kendall trend test is that there is no trend in a time series. H_o is rejected for a confidence level above 90%, meaning there is either an increasing or decreasing trend. If S > 0, the trend is 'increasing' if the confidence in the trend is greater than 95% and it is 'probably increasing' if the confidence in the trend is 90 – 95%. If S < 0, the trend is 'decreasing' if the confidence in the trend is greater than 95% and it is 'probably decreasing' if the confidence in the trend is 90 – 95%. Increasing trends suggest increased flux or an expanding plume boundary that may warrant an increased sampling. Conversely, a decreasing trend suggests a decreased flux or a diminishing plume and may support reducing monitoring (see Section 5.3).

3.3.5 Stability Evaluation for "No Trend" Determinations

Concentration trends with less than 90% confidence are either stable or are identified as having 'no trend', implying that that the null hypothesis, H_o, cannot be rejected. The Coefficient of Variation (COV) for a time series is used to differentiate a 'stable' trend from a times series with 'no trend' in concentration over time. COV is a statistical measure of how individual data points vary about the mean, and it is defined as the standard deviation (s) divided by the mean ($\bar{x}$).

COV values less than or near 1 indicate the data point form a relatively close group about the mean. Values greater than 1 indicate the data show more scatter about the mean. If S ≤ 0 and there is less than 90% confidence in the trend, a COV < 1 indicates a stable trend whereas a COV ≥ 1 suggests no trend. A stable trend suggests no change in flux and/or a stable plume, and usually supports reduced monitoring. A 'no trend' determination implies there is too much scatter in the data for any trend to be identified and supports maintaining the same frequency of monitoring if that frequency adequately reflects future monitoring objectives. The assumption is that scatter will be reduced over time if the reliability of data improves or the influence of a certain value (possibly an error) is lessened over time, thereby allowing a trend to be identified.

4 RESULTS (DATA REVIEWED)

4.1 GROUNDWATER AND PIT WATER LEVELS

4.1.1 Recent Water Level Surveys

Table 4-1 summarizes several site-wide groundwater level surveys completed in 2017 and 2018. The survey completed in November 2017 was used to infer a preliminary groundwater flow field for the site (see Section 5.2). Water levels in the Browns Pit are not routinely monitored.

Table 4-1. Selected Groundwater Level Survey Data, 2017/2018

Bore ID	Screened Lithology	TOC, m AHD	Survey Date	DTW, m	GWL, m AHD	Survey Date	DTW, m	GWL, m AHD	Survey Date	DTW, m	GWL, m AHD	Survey Date	DTW, m	GWL, m AHD
TSF1 Bores														
BH2A	Laterite/saprolite	74.8	17-Aug-17	Dry	-	1-Nov-17	Dry	-	29-Dec-17	Dry	-	23-Jan-18	Dry	-
BH2B	Laterite/saprolite	75.4	17-Aug-17	15.15	60.2	1-Nov-17	15.15	60.2	29-Dec-17	Dry	-	23-Jan-18	15.70	59.7
BH3A	Laterite/saprolite	76.9	17-Aug-17	5.77	71.2	1-Nov-17	5.77	71.2	29-Dec-17	Dry	-	23-Jan-18	Dry	-
BH3B	Whites Formation	77.4	17-Aug-17	6.23	71.1	1-Nov-17	6.23	71.1	29-Dec-17	8.69	68.7	23-Jan-18	5.62	71.8
BH4A	Laterite/saprolite	78.0	17-Aug-17	5.47	72.5	1-Nov-17	5.47	72.5	29-Dec-17	Dry	-	23-Jan-18	Dry	-
BH4B	Whites Formation	78.4	17-Aug-17	6.50	71.9	1-Nov-17	6.50	71.9	29-Dec-17	8.82	69.6	23-Jan-18	6.25	72.1
BH4D	Whites Formation	78.0	17-Aug-17	6.05	72.0	1-Nov-17	6.05	72.0	29-Dec-17	8.69	69.4	23-Jan-18	4.93	73.1
BH4E	Whites Formation	74.7	17-Aug-17	5.67	69.1	1-Nov-17	5.67	69.1	29-Dec-17	7.77	67.0	23-Jan-18	4.22	70.5
BH4F*	Whites Formation	78.3	17-Aug-17	6.03	72.3	1-Nov-17	6.03	72.3	29-Dec-17	8.29	70.0	23-Jan-18	5.02	73.3
BH4G**	Whites Formation	78.8	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	10.72	-	23-Jan-18	8.94	69.9
BH4H*	Whites Formation	78.0	17-Aug-17	5.97	72.0	1-Nov-17	5.97	72.0	29-Dec-17	8.22	69.7	23-Jan-18	3.86	74.1
BH5A	Laterite/saprolite	75.1	17-Aug-17	3.49	71.6	1-Nov-17	3.49	71.6	Buried in sediment		-	Buried in sediment		-
BH5B	Whites Formation	75.9	17-Aug-17	4.08	71.8	1-Nov-17	4.08	71.8	29-Dec-17	5.02	70.9	23-Jan-18	1.24	74.7
BH12A	Laterite/saprolite	75.6	17-Aug-17	9.05	66.6	1-Nov-17	-	-	29-Dec-17	Dry	-	23-Jan-18	7.49	68.1
BH12B	Whites Formation	75.6	17-Aug-17	9.25	66.4	1-Nov-17	12.87	62.7	29-Dec-17	12.80	62.8	23-Jan-18	7.80	67.8
BH12C**	Coomalie Dolostone	75.0	17-Aug-17	-	-	1-Nov-17	12.02	63.0	29-Dec-17	12.86	62.2	23-Jan-18	7.90	67.1
BH13A	Coomalie Dolostone	75.1	17-Aug-17	Dry	-	Abandoned		-	Abandoned		-	Abandoned		-
BH13B	Laterite/saprolite	75.2	17-Aug-17	8.92	66.3	1-Nov-17	11.51	63.7	29-Dec-17	12.29	62.9	23-Jan-18	8.02	67.2
BH14A	Coomalie Dolostone	74.8	17-Aug-17	10.97	63.9	Abandoned		-	Abandoned		-	Abandoned		-
BH14B	Laterite/saprolite	74.7	17-Aug-17	23.56	51.2	1-Nov-17	13.33	61.4	29-Dec-17	14.05	60.7	23-Jan-18	12.92	61.8
BH15A	Whites Formation	74.8	17-Aug-17	9.63	65.2	1-Nov-17	10.86	63.9	29-Dec-17	10.20	64.6	23-Jan-18	8.10	66.7
BH15B	Whites Formation	74.8	17-Aug-17	9.38	65.4	1-Nov-17	10.60	64.2	29-Dec-17	9.86	65.0	23-Jan-18	8.02	66.8
BH16B	Rum Jungle Complex	76.3	17-Aug-17	6.15	70.1	1-Nov-17	8.00	68.3	29-Dec-17	7.92	68.4	23-Jan-18	6.65	69.6
BH17B	Coomalie Dolostone	78.2	17-Aug-17	14.54	63.7	1-Nov-17	14.53	63.7	29-Dec-17	14.54	63.7	23-Jan-18	14.54	63.7
BH18A	Laterite/saprolite	77.6	17-Aug-17	13.44	64.2	1-Nov-17	15.19	62.4	29-Dec-17	15.19	62.4	23-Jan-18	15.20	62.4
BH18B	Laterite/saprolite	77.7	17-Aug-17	13.63	64.1	1-Nov-17	16.07	61.6	29-Dec-17	16.78	60.9	23-Jan-18	15.33	62.4
TSF2 Bores														
BH7A	Whites Formation	80.8	17-Aug-17	7.66	73.2	1-Nov-17	-	-	29-Dec-17	Dry	-	23-Jan-18	6.6	74.2
BH7B	Whites Formation	81.0	17-Aug-17	7.88	73.1	1-Nov-17	9.42	71.6	29-Dec-17	10.08	70.9	23-Jan-18	6.7	74.3
BH8A	Laterite/saprolite	75.0	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	Dry	-	23-Jan-18	10.7	64.2
BH8B	Whites Formation	74.9	17-Aug-17	-	-	1-Nov-17	12.77	62.1	29-Dec-17	13.77	61.1	23-Jan-18	11.7	63.2
BH9A	Laterite/saprolite	73.6	17-Aug-17	4.52	69.1	1-Nov-17	6.30	67.3	29-Dec-17	6.70	66.9	23-Jan-18	2.6	71.0
BH9B	Whites Formation	74.5	17-Aug-17	4.69	69.8	1-Nov-17	6.51	68.0	29-Dec-17	6.90	67.6	23-Jan-18	2.7	71.8
BH10	Laterite/saprolite	78.6	17-Aug-17	-	-	1-Nov-17	10.39	68.2	29-Dec-17	10.90	67.7	23-Jan-18	6.2	72.4
BH11	Laterite/saprolite	70.5	17-Aug-17	-	-	1-Nov-17	10.54	60.0	29-Dec-17	11.14	59.4	23-Jan-18	8.2	62.3
Other Bores														
TPB4	Coomalie Dolostone	61.5	17-Aug-17	5.55	56.0	1-Nov-17	5.61	55.9	29-Dec-17	5.99	55.6	23-Jan-18	5.1	56.4
TPB5	Coomalie Dolostone	59.9	17-Aug-17	3.78	56.1	1-Nov-17	3.90	56.0	29-Dec-17	4.23	55.6	23-Jan-18	3.3	56.6
RN023137	Whites Formation	66.0	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	3.78	62.2	23-Jan-18	2.2	63.8
RN022085	Coomalie Dolostone	73.8	17-Aug-17	-	-	1-Nov-17	-	-	29-Dec-17	-	-	23-Jan-18	12.7	61.1

* Recovery bore, ** Operational recovery bore
Values in red denote a concentration lower than the indicated detection limit
Shaded values are higher than groundwater trigger values (see Table 5)
TOC: Top of Casing
DTW: Depth-to-Water
GWL: Geodetic Water Level

4.1.2 Groundwater Level Time Trends

Groundwater level time trends for each bore on site are provided in Figures 4-1 to 4-19. Some key features of the time trends are summarized here:

- Bores BH2A, BH13A and BH14A are typically dry and do not appear to have been installed properly or were not properly developed (purged) (see Figures 4-1, 4-13 and 4-14). The low geodetic water levels on the time trends correspond to the bottom elevation of the bore where some water likely accumulates between manual water level measurements. These water levels are provided here for completeness but they are erroneous and neither of these bores should be monitored in the future.
- Groundwater levels for most bores fluctuate seasonally by 5 to 10 m. The highest groundwater levels are typically observed in March or April before water levels recede to minimum levels in November or December immediately prior to the Wet Season. The largest fluctuations in groundwater levels occur to the south of the Browns site, i.e. up to 15 m at bores BH8A and BH8B (see Figure 4-8) and near the western end of the TSF at bores BH12A and BH12B (see Figure 4-12).
- Groundwater levels in bores BH2B, BH3A/B, and BH4A/B mounded by up to 6 m in 2008 and 2009 when there was standing water in the nearby TSF. Historic water level trends indicated a gradual recovery of this groundwater mounding over the next 2-5 years. Limited (and delayed) mounding was observed at bores BH5A and BH5B. At present, there is little evidence of mounding in the TSF area, except for some small inferred mounding near the southwestern portion of the TSF (Map 3).
- Groundwater levels near the TSF berm are not substantially affected by pumping from bores BH4G and BH12C because the flow rates for these recovery bores are too low. Groundwater levels observed at bore BH4G have gradually declined (Figure 4-5), possibly due to pumping directly from this bore since 2009. Groundwater levels from the shallower of two bores at the same location are often higher than the groundwater level in the deeper bore. This suggests a downward vertical gradient, i.e. from weathered laterite/saprolite to the bedrock aquifer.
- Groundwater levels at TPB5 are a proxy for the water level in the pit due to a strong hydraulic connection between the bore and the nearby pit (see RGC, 2016a). This is consistent with groundwater levels around 35 m AHD in 2008 when the pit was de-watered to allow the oxide deposit to be mined (see Figure 4-19).

4.2 GROUNDWATER QUALITY

4.2.1 Representative (Verified) Data

Selected groundwater quality results for each bore on site and regional bores are provided in Table 4-2. Most of the samples were collected in 2017 and 2018 when the reliability of data appears to have improved. Previously-collected data were selected for bores without reliable data for 2017 and 2018

(see Section 3). The median RPD value (CBA) for the samples in Table 4-2 is 4.7%. Samples from bores BH4A, BH4B, and BH4E with high RPD values (up to 30%) are included because they are the most reliable data collected over the last three years and the only recent samples for which there are complete results available, i.e. Fe, major ions, etc. The data in Table 4-2 are reasonably representative of current conditions at the site and are discussed further in Section 5.

Table 4-2. Representative Groundwater Quality Data

Bore ID	Screened Lithology	Sampling Date	Field pH, -	Field EC, µS/cm	Total Alkalinity, mg/L as $CaCO_3$	Ca, mg/L	Mg, mg/L	Na, mg/L	K, mg/L	HCO_3, mg/L	SO_4, mg/L	Cl, mg/L	Al-d, µg/L	Cd-d, µg/L	Co-d, µg/L	Cu-d, µg/L	Fe-d, µg/L	Mn-d, µg/L	Ni-d, µg/L	Pb-d, µg/L	U-d, µg/L	Zn-d, µg/L	RPD (CBA) %
TSF1 Bores																							
BH3A	Laterite/saprolite	14-Jan-15	4.2	102	5	0.5	0.9	7.4	0.9	6	3	10	60	0.1	15	150	50	43	13	2	0.4	57	1.7%
BH3B	Whites Formation	14-Jan-15	3.8	137	5	1	1	10	2	0	11	12	250	0.2	20	300	50	63	16	13	1.2	89	4.5%
BH4A	Laterite/saprolite	8-Jul-17	2.8	1,527	5	150	84	28	7	0	1,400	8	22,000	8.9	10,000	29,000	780	24,000	4,900	48	200	2,700	17.4%
BH4B	Whites Formation	17-Aug-16	3.3	1,201	5	70	69	33	3	0	1,300	17	19,000	7	13,000	27,000		36,000	6,000	11	140	2,900	27.4%
BH4D	Whites Formation	5-Jan-18	3.6	381	20	9	12	25	3	0	120	7	1,200	1	1,400	1,200	80	3,700	640	9	5	370	5.4%
BH4E	Whites Formation	5-Jan-18	5.7	327	40	12	16	22	3	49	88	31	50	1	990	19	9,600	2,800	460	1	5	220	1.5%
BH4F*	Whites Formation	28-Dec-17	7.3	147	69	4	4	11	5	84	5	32	50	0.2	1	1	2900	220	1	1	5	6	29.7%
BH4G**	Whites Formation	9-Jan-18	3.8	877	5	43	40	24	4	0	370	15	6,900	3	5,400	7,700	1,800	15,000	2,100	43	39	1,100	2.4%
BH4H*	Whites Formation	5-Jan-18	7.2	103	24	3	1	9	1	29	2	7	10	0.1	3	2	50	1600	1	1	5	12	1.0%
BH5A	Laterite/saprolite	8-Jul-17	6.3	265	70	8	10	13	1	85	20	3	50	0.2	210	17	60	3000	83	2	5	27	1.1%
BH5B	Whites Formation	2-Aug-17	5.9	98	29	5	7	5	0.5	35	5	16	50	0.2	1	4	50	35	21	1	5	43	3.5%
BH12A	Laterite/saprolite	10-Jul-17	5.9	486	86	5	56	10	0.5	105	150	3	50	0.2	78	1	50	5	1	1	7	21	3.7%
BH12B	Whites Formation	2-Aug-17	6.4	889	280	18	120	7	0.5	342	290	15	50	0.2	1	1	50	14	10	1	5	17	4.1%
BH12C**	Coomalie Dolostone	9-Jan-18	7.6	454	94	6	56	3	0.5	115	140	8	50	0.2	1	1	50	24	1	1	5	5	0.6%
BH13A	Coomalie Dolostone	1-Sep-16	-	2,100	550	90	170	210	6	671	940	13	10	0.1	1	3		9	4	1	38	5	5.4%
BH13B	Laterite/saprolite	9-Jan-18	5.7	1,180	66	17	170	6	1	81	580	8	50	2	15	380	50	170	150	1	5	140	5.3%
BH14A	Coomalie Dolostone	18-Apr-17	6.5	1,816	260	10	270	4	0.5	317	790	6	50	0.2	1	1	50	72	4	1	5	5	2.5%
BH14B	Laterite/saprolite	11-Jan-18	6.6	474	120	4.4	96	6.7	0.5	146	230	4	50	0.2	6	3	110	420	9	1	5	19	7.2%
BH15A	Whites Formation	11-Jan-18	5.1	55	5	0.5	2	5.7	0.5	0	5	8	50	4	16	10	50	10	50	180	5	980	16.6%
BH15B	Whites Formation	18-Jan-18	6.6	196	79	10	7	16	3.5	96	10	16	50	0.2	10	6	1200	150	50	180	5	540	7.4%
BH16B	Dolerite	29-Apr-17	6.0	2,797	37	260	260	14	1	45	1600	17	50	0.7	1	1	50	120	53	1	5	18	0.7%
BH17B	Coomalie Dolostone	21-Apr-10	6.8	2,056	298	68	82	11	1	364	187	4	10	0.1	74	3	50	927	51	1	5	38	3.3%
BH18A	Laterite/saprolite	10-Jul-17	5.7	332	73	2	36	10	1	89	76	5	50	0.2	2	15	50	10	21	2	5	190	5.0%
BH18B	Laterite/saprolite	11-Jan-18	5.7	1,924	88	77	290	12	1	107	1200	4	50	0	220	74	50	1,900	240	1	5	70	2.7%
TSF2 Bores																							
BH7B	Whites Formation	5-Jan-18	6.3	145	77	7	12	5	1	94	5	7	50	0.2	1	1	60	13	2	1	5	5	8.7%
BH8A	Laterite/saprolite	13-May-14	6.6	147	30	2	5	2	1	37	2	2	20	0.1	2	1	50	72	1	1	0.1	6	4.7%
BH8B	Whites Formation	4-Jan-18	6.9	291	170	19	25	4	2	207	2	4	50	0.2	1	1	50	5	1	2	5	9	4.5%
BH9A	Laterite/saprolite	16-Jun-14	6.5	398	200	12	44	15	3	244	2	3	10	0.100	1	3	50	1	1	1	0.2	8	9.1%
BH9B	Whites Formation	19-Nov-14	7.0	506	190	9	40	15	3	232	2	3	10	0.100	1	1	50	5	1	1	0.5	5	6.8%
BH10	Laterite/saprolite	4-Jan-18	7.3	485	290	6	67	2	1	354	5	4	50	0.2	1	1	50	5	4	1	5	11	0.7%
BH11	Laterite/saprolite	13-May-14	7.0	201	60	7	8	2	1	73	2	2	10	0.200	1	1	50	1	2	1	0.1	5	5.9%
Other Bores																							
TPB4	Coomalie Dolostone	9-Jan-18	7.4	455	260	17	46	3	1	317	5	8	50	0.2	2	2	1,500	100	1	1	5	7	6.6%
TPB5	Coomalie Dolostone	8-Jul-17	7.6	1,004	88	55	120	15	2	107	570	12	50	0.2	1	1	50	35	4	1	5	5	2.4%
RN023137	Whites Formation	9-Oct-17	6.5	568	190	64	30	7	3	232	130	12	50	0.2	1	1	450	550	3	1	5	11	5.9%
RN022085	Coomalie Dolostone	23-Apr-09	7.4	508	190	35	34	2	1	232	1	2	2	0.02	0.7	1	20	415	0.2	0.03	2	2	8.7%
Thompson	Whites Formation	7-Jul-17	6.7	336	170	24	22	8	1	207	2	3	50	0.2	1	1	370	56	1	1	5	5	1.3%
Thompson-Mango	Whites Formation	7-Jul-17	6.1	140	48	3	9	10	3	59	4	3	50	0.2	2	1	7200	130	6	1	5	6	21.3%

* Recovery bore, ** Operational recovery bore

Values in red denote a concentration lower than the indicated detection limit

4.2.2 Groundwater Quality Time Trends

Groundwater monitoring data collected in 2016, 2017, and 2018 are tabulated in Appendix D and the complete record is available digitally upon request. Groundwater quality time trends for field pH, SO_4, and Cu are provided in Figures 4-20 to 4-38. Time trends for these parameters and alkalinity, Al, Cd, Co, Fe, Mn, Ni, Pb, and Zn are also provided in Appendix D. The data for pairs of bores, e.g. BH4A and BH4B, or two or three bores very close to one another are plotted together in the time trends to illustrate the condition of groundwater in a certain area. The data are plotted on a log scale to more clearly show the range of concentrations observed in groundwater.

Some key observations from the groundwater quality time trends are summarized here and discussed further in Section 5:

- Groundwater quality results for the TSF2 bores to the south of the TSF reflect background conditions for the site (see Section 5.1). Most of the groundwater quality time trends for bores within the Browns site show some impact by ARD. Groundwater quality for most bores is either stable or there is no statistically significant trend over time due to the scatter in the historic data (see Section 5.3 for further details and trend analysis).
- The time trends for bores BH4A and BH4B are characterized by a step trend with peak concentrations of SO_4 and dissolved metals and depressed pH values observed in January 2009 (see Figures 4-28 to 4-31). Water quality impacts are related to undiluted liquor from the TSF that likely displaced groundwater from these bores in 2008. This is consistent with water level mounding in 2008 and 2009. After the initial increase in SO_4 and metal concentrations, concentrations decreased exponentially (R^2 = 0.86) from 2009 to 2012. For the last 5 years, concentrations appear to be relatively stable and groundwater levels have returned to near the levels observed in 2007, i.e. before acidic liquor was discharged to the TSF.
- Groundwater from bore BH4D, about 50 m southwest of bores BH4A and BH4B, is impacted by liquor stored in the TSF in 2008 (see Figure 4-32 to 4-35). This bore is screened relatively deep (16.5 to 38.5 m bgs) in Whites Formation shale, so samples collected in 2009 (with 10,000 µg/L Cu) could reflect a mixture of liquor and unimpacted groundwater from the deeper aquifer in this area. Bores BH3A/B and BH5A/B may also have been characterized by diluted liquor from the TSF.
- Liquor from the TSF appears to have impacted groundwater to the west of the TSF at bore BH13B. This bore is screened in laterite/saprolite from 15 to 21 m bgs. The very low pH and high metal concentrations observed at bores BH4A and BH4B were not observed in this area but 30,000 µg/L Cu was observed in groundwater in 2009. Groundwater from bore BH13A was not impacted to the same extent, as it was only characterized by a few hundred mg/L SO_4 and up to 13 µg/L Cu in 2009. Bore BH13A is screened from 34.4 to 40.4 m bgs in the Coomalie Dolostone and therefore appears to be too deep to be affected by liquor from the TSF.

- Recovery bore BH12C was installed near the southwestern TSF berm to intercept the impacted groundwater identified at bore BH13B. Bore BH12C is screened in Coomalie Dolostone from 13.9 to 22.6 m bgs, or about the same interval that is screened by bore BH13B. Bore BH12C intercepted the type of groundwater identified in the Coomalie Dolostone at bore BH13A, i.e. elevated SO_4 and no metals, from 2010 to December 2017 when the pump became clogged and was removed from the bore.
- Metal concentrations in groundwater from bore BH13B have decreased since 2009 and there is some evidence of a seasonal trend in metals that could be related to larger loads from the TSF when water levels in the pond increase each year (see Figure 4-81 to 4-83). This cannot be confirmed without a detailed record of the pond extent(s) within the TSF. The long-term decrease suggests some dilution/dispersion and/or attenuation and is unrelated to pumping from bore BH12C.

4.3 SURFACE WATER FLOWS

4.3.1 EBFR Flows

Hourly flows in the EBFR from 2009 to 2017 are shown in Figure 4-39 and a statistical summary of monthly flows is provided in Table 4-3. The table provides mean, minimum, and maximum monthly flows in the EBFR and the number of months for which there are data available.

On average, EBFR flows exceed the 1 m3/s threshold for controlled discharge about 55 days per year or about 15% of the time. The historic flow record for gauging station GS8150200 indicates that the number of days when flow exceeds 1 m^3/s varies substantially from year to year.

In 2010/2011, which included Cyclone Carlos, the flow was greater than 1 m^3/s for 109 days or almost 30% of the year. In the extreme drought recorded in 1985/1986, the river's flow was greater than 1 m3/s for only 14 days or less than 4% of the year.

Table 4-3. Summary of EBFR Flows, 2009 to 2017

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean flow, m^3/s	2.7	4.6	2.5	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6
Minimum flow, m^3/s	0.2	0.9	0.6	0.1	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Year recorded	2013	2013	2016	2016	2015	Multiple	Multiple	Multiple	Multiple	Multiple	2017	Multiple	2016
Maximum flow, m^3/s	5.7	11.8	5.9	5.2	0.4	0.2	0.03	0.05	0.02	0.02	0.03	2.2	0.7
Year recorded	2011	2011	2012	2011	2013	2013	2012	2013	2012	2012	2014	2015	2015
No. of months	8	9	9	9	7	6	6	6	6	6	7	6	4

4.3.2 Controlled (Licensed) Discharge Events

Table 4-4 summarizes the licensed discharge events for the 2016/2017 Wet Season and the 2017/2018 Wet Season as of January 31st, 2017. In 2016/2017, there were 13 licensed discharge events and a total of 470 ML of water was discharged from the Main Sediment Dam. There have been two licensed discharge events during the 2017/2018 Wet Season. 32.4 ML was discharged during the first event. The valve was opened again on January 22nd and it remained opened on January 31st. A total of 167.8 ML of water had been discharged by January 31st via the main outlet, while an ungauged volume of water flowed over the emergency spillway for two days.

Table 4-4. Controlled Discharge Events from Main Sediment Dam, December 2016 to January 31st, 2018

Valve Opened		Valve Closed		Duration open, hours	Volume discharged, ML	Notification ID
Date	**Time**	**Date**	**Time**			
2016/2017 Wet Season						
30-Dec-16	10:02	06-Jan-17	8:00	166.0	53.6	170106-L
13-Jan-17	7:50	14-Jan-17	23:35	39.6	12.8	170113-L
20-Jan-17	8:00	23-Jan-17	10:00	50.0	23.9	NTR-ENV-LET-002
24-Jan-17	10:38	27-Jan-17	7:08	70.0	22.1	NTR-ENV-LET-003
31-Jan-17	10:40	31-Jan-17	18:20	7.7	2.5	NTR-ENV-LET-005
02-Feb-17	7:20	02-Feb-17	18:12	11.0	3.5	NTR-ENV-LET-006
05-Feb-17	8:48	11-Feb-17	11:00	146.5	47.2	NTR-ENV-LET-008
16-Feb-17	11:20	17-Feb-17	22:00	32.5	27.1	NTR-ENV-LET-012
22-Feb-17	10:20	22-Feb-17	18:50	8.5	7.4	NTR-ENV-LET-013
05-Mar-17	7:40	09-Mar-17	18:10	82.5	73.1	NTR-ENV-LET-018
12-Mar-17	7:15	25-Mar-17	8:10	312.0	83.2	NTR-ENV-LET-021
11-Apr-17	13:10	13-Apr-17	18:05	77.0	49.5	NTR-ENV-LET-023
18-Apr-17	7:40	21-Apr-17	7:15	96.0	63.6	NTR-ENV-LET-025
TOTAL:				**1099.2**	**469.6**	
2017/2018 Wet Season						
18-Jan-18	16:55	20-Jan-18	7:20	37.5	32.4	NTR-ENV-LET-042
22-Jan-18	0:32	Valve still open on January 31st		216.0	167.6	Pending notification
TOTAL:				**253.5**	**200.0**	

4.4 SURFACE WATER QUALITY

4.4.1 Water Quality Trends

Surface water quality monitoring data collected from 2007 to January 19th, 2018, are provided in Appendix D. Time trends for Site 5 are provided in Figures 4-40 to 4-44. Time trends for Site 1, Site 2, Site 4, DAMOUT1, and DAMOUT2 are provided in Appendix F. The stations are ordered from upstream to downstream for ease of reference.

Selected surface water quality data for the WDL177-06 stations and others, i.e. the Rainwater Collection Ponds (RW) stations, are summarized in Table 4-5 and shown in Map 6. The data provided had the lowest RPD values of any samples collected in 2017 and are considered reasonably representative of Wet Season conditions on site.

Table 4-5. Selected Surface Water Quality Results, 2017

Location Code	Sampling Date	Field pH	Field EC	SO4	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
Monitoring sites for WDL177-06 (upstream to downstream)															
TREAT1	4/27/2017	9.6	810	140	50	0.2	3	3	50	5	5	2	5	5	15%
SITE2	2/22/2017	7.7	326	98	50	0.3	89	30	50	97	43	1	5	38	19%
DAMOUT1	2/22/2017	7.1	317	98	50	0.2	11	15	50	90	31	1	5	18	1%
SITE4	4/14/2017	7.2	41	2	50	0.2	1	1	50	6	1	1	5	5	4%
SITE5	6/15/2017	6.7	643	75	50	0.2	1	20	50	730	6	1	5	5	6%
SITE1	5/29/2017	4.6	2,392	1,800	4,000	13	2,000	4,400	17,000	7,800	3,600	1	38	11,000	13%
Other surface water monitoring sites (pits, creeks, and effluent)															
RW_PIT	7/31/2017	7.6	644	240	50	0	10	75	50	290	67	4	5	45	0.1%
RUMWHITE	1/12/2017	6.1	157	48	50	0	33	37	-	230	34	1	5	8	1%
RUMINTER	1/12/2017	6.3	158	49	50	0	55	35	-	240	36	1	5	10	7%
Rainwater collection ponds															
RW_TSF	4/27/2017	4.6	703	280	3,700	2	13,000	2,100	50	990	1,500	590	50	530	14%
RW_SRO	4/27/2017	6.3	42	8	50	0.2	45	19	50	130	11	70	5	22	8%
RW_PAF	4/27/2017	3.8	670	330	18,000	23	66,000	8,800	260	7,800	7,400	3,200	92	7,200	6%
RW_SP3	4/27/2017	-	-	170	340	5	8,600	1,500	50	3,200	1,000	1,400	6	1,300	3%
RW_BSS	4/27/2017	4.1	545	110	4,000	3	55,000	5,300	110	4,100	2,700	2,300	150	990	63%
RW_POND	7/31/2017	7.2	7	240	50	0	19	51	50	210	64	6	5	36	1%

Key observations from the surface water stations monitored for WDL177-06 are summarized here:

- Treated effluent at TREAT1
    - Treated effluent released to the Main Sediment Dam from the water treatment system is typically alkaline (pH 9.6) and characterized by elevated bicarbonate and carbonate alkalinity. Effluent is characterized by elevated SO4 and low metal concentrations, i.e. 3 µg/L Cu, 3 µg/L Co, and non-detectable Zn concentrations in April 2017.
- Main Sediment Dam at SITE2.

  - The pH of water in the Main Sediment Dam is typically neutral to slightly alkaline due to inflows of alkaline effluent from the processing plant (pH 9 to 10).
  - Water contains some alkalinity and elevated SO_4, e.g. 98 mg/L in February 2017.
  - Cu, Co, and Zn concentrations are often elevated, whereas other metals are near or below detection limits.
- Controlled discharge from the Main Sediment Dam at DAMOUT1
  - Controlled discharge water quality from the Main Sediment Dam is comparable to water quality at SITE2, except Cu, Co, and Zn concentrations are noticeably lower at DAMOUT1. DAMOUT1 is across the pond from SITE2, so the lower concentrations are likely related to the precipitation of metals within the pond as the concentration of SO_4 (which behaves conservatively) are identical at both stations.
- Middlebrook Creek at SITE4 (upstream of boundary discharge)
  - Unimpacted surface water flows at SITE4 are characterized by near neutral pH values, low alkalinity and EC, and non-detectable concentrations of SO_4 and most dissolved metals, i.e. all except Mn.
- Middlebrook Creek at SITE5 (downstream of boundary discharge)
  - Boundary discharge from the site, wastewater is characterized by circum-neutral to slightly acidic pH, elevated EC and alkalinity, and metal concentrations that can exceed trigger values under some circumstances (see Section 6.1 for further discussion of Site 5 exceedances).
- EFDC at SITE1 (upstream of SITE5 at the former Rum Jungle mine site)
  - Water samples collected from the EFDC at SITE1 are acidic (pH 3 to 5, depending on the time of year) and characterized by no appreciable alkalinity. SO4 and dissolved metal concentrations are high, i.e. 2000 µg/L Cu in May 2017, due to ARD from the Intermediate WRD (immediately upstream of SITE1) and additional flows of seepage and ARD-impacted groundwater from the Main WRD, Dyson's WRD, and Dyson's (backfilled) Pit.
  - Downstream of SITE1 and SITE5, relatively clean flows from the Intermediate Pit (Rum Jungle) report to the EFDC during the Wet Season when the water level in the pit is 57.53 m AHD or higher (see RGC, 2016b). Water quality at gauge GS8150200 reflects the combined impact to the EBFR from the majority of the former Rum Jungle mine site and outflow from the Browns site. Flows from the former Rum Jungle mine site account for more than 99% of the SO_4 and metals in the EBFR (See Section 5.5).

A few key observations from other surface water monitoring stations are summarized here:

- TSF Pond at RW_TSF
  - TSF pond water is acidic and characterized by elevated metal concentrations. This water is a mixture of liquor released to the TSF in 2008, rainfall to the TSF, water from the SRO

pond during high rainfall periods, and groundwater pumped from recovery bores BH4G and BH12C to the TSF (see RGC, 2017, and Section 5.2 for further discussion).

- Browns Pit at RW_PIT
  - Pit water from the Browns Pit is slightly alkaline and characterized by appreciable alkalinity and low metal concentrations. The sample included in Table 4-5 was collected in July 2017 (Dry Season) and likely represents an intra-annual maximum due to evapo-concentration.
  - Metal concentrations in the Browns Pit are lower than observed in the Main Pit (Rum Jungle) and the Intermediate Pit at the former Rum Jungle mine site during the Wet Season when EBFR flows through the pits and dilutes shallow pit water.
- Rainfall runoff from the existing ore stockpiles (RW_SP3, RW_PAF, and RW_BSS)
  - Rainfall runoff from the existing stockpiles is often acidic (pH 3 to 4) and characterized by no appreciable alkalinity. SO_4 concentrations are elevated, i.e., 100 to 400 mg/L SO_4, and up to 66,000 µg/L Cu is observed in some samples. Metal concentrations are highest in runoff from the PAF (RW_PAF) ore stockpile and the Black Shale Stockpile (RW_BSS).

Further discussion of surface water flows and impacts and simulated loads to the water treatment system and the EBFR is provided in Section 5.5.

4.4.2 Boundary Discharge Exceedances at Site 5

Table 4-6 summarizes trigger value exceedances at SITE5 from January 2016 to January 2018. Exceedances of the WDL177-06 trigger values for this period and previous monitoring periods are shown in Figures 4-134 to 4-136. There were 8 instances from January 2016 to January 2018 when the trigger value (2.5 µg/L) for Cu was exceeded on three consecutive occasions. Cu and Co are the two metals that exceeded their respective trigger values most frequently. The Cu concentration at SITE5 was higher than 5 µg/L, i.e. twice the trigger value, on 19 separate occasions (or 45% of the sampling events).

In November and December, the highest metal concentrations on record were observed at Site 5, i.e. up to 2100 µg/L Cu (see Table 4-6). The exceedances on November 22nd, 2017, occurred after the first substantial (73 mm) rain event of the 2017/2018 Wet Season. An additional 42 mm of rain occurred between November 22nd and the second exceedance event on November 30th. These rainfall events may have caused a pulse of existing contaminants to be flushed to the wetland.

This may occur each year, but in November 2017, samples from SITE5 were collected during the first flush (N. Rodwell, personal communication). This has not been done in the past and likely explains the elevated metal concentrations observed. Further discussion of potential causes and the environmental implications of the exceedances in the context of contaminant loads in the EBFR is provided in Section 5.6.2.

Table 4-6. Trigger Value Exceedances at SITE5, December 2016 to February 2018

Location Code	Sampling Date	Field pH	Field EC	Hardness	Al-f	Cd-f	Cu-f	Co-f	Mn-f	Ni-f	Pb-f	Zn-f
		-	uS/cm	mg/L as CaCO3	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L
WDL177-06 Trigger Value					**80**	**0.4**	**2.5**	**13**	**2,500**	**13**	**5.6**	**15**
NTR-ENV-LET-001												
SITE5	12/29/2016	6.5	328	88	**410**	0.2	**15**	**41**	96	**31**	1	**56**
SITE5	12/30/2016	6.9	285	95	**120**	0.2	**6**	**14**	110	10	1	**15**
NTR-ENV-LET-006												
SITE5	1/12/2017	6.7	79	88	50	0.2	**16**	12	38	**20**	1	**19**
SITE5	1/13/2017	7.2	231	29	50	0.2	**16**	5	18	10	1	13
SITE5	1/20/2017	7.1	99	49	-	0.2	**10**	3	15	9	1	7
NTR-ENV-LET-007												
SITE5	1/26/2017	7.0	471	32	-	0.2	**3**	2	7	6	1	6
NTR-ENV-LET-009												
SITE5	1/30/2017	6.2	80	23	-	0.2	**9**	3	21	9	1	10
NTR-ENV-LET-010												
SITE5	2/2/2017	6.9	95	29	-	0.2	**8**	2	19	7	1	8
NTR-ENV-LET-011												
SITE5	2/5/2017	7.8	45	9	-	0.2	**3**	1	9	1	1	7
NTR-ENV-LET-015												
SITE5	2/16/2017	6.8	151	49	-	0.2	**7**	2	17	8	2	7
NTR-ENV-LET-017												
SITE5	2/22/2017	6.8	227	570	50	0.2	**6**	3	32	10	1	7
NTR-ENV-LET-019												
SITE5	3/1/2017	7.2	103	27	50	0.2	**7**	5	63	6	1	5
NTR-ENV-LET-020 and -022												
SITE5	3/5/2017	7.2	194	63	50	0.2	**6**	9	100	9	1	5
SITE5	3/12/2017	6.9	74	26	50	0.2	**9**	2	14	4	1	13
SITE5	3/14/2017	6.9	162	65	50	0.2	**31**	9	23	11	3	8
SITE5	3/28/2017	6.3	261	26	50	0.2	1	2	20	4	1	5
NTR-ENV-LET-026												
SITE5	4/11/2017	6.5	253	88	50	0.2	**7**	**15**	260	8	1	5
SITE5	4/14/2017	7.1	175	47	50	0.2	1	2	38	3	1	5
SITE5	4/18/2017	6.7	107	31	50	0.2	2	2	20	2	1	5
NTR-ENV-LET-029												
SITE5	4/27/2017	7.2	246	46	50	0.2	**4**	4	92	4	1	5
NTR-ENV-LET-031												
SITE5	5/16/2017	6.9	351	140	50	0.2	**7**	**47**	1,500	12	1	5
NTR-ENV-LET-032												
SITE5	5/30/2017	6.8	525	220	50	0.2	**5**	**48**	1,800	**13**	1	6
NTR-ENV-LET-035												
SITE5	6/15/2017	6.7	643	250	50	0.2	1	**20**	730	6	1	5
NTR-ENV-LET-040												
SITE5	11/22/2017			320	**90**	**1.4**	**210**	**340**	780	**190**	2	**290**
SITE5	11/30/2017	3.6	2,396	1,600	**2,500**	**13**	**2,100**	**3,800**	**11,000**	**2,000**	**380**	**3,100**
NTR-ENV-LET-041												
SITE5	12/29/2017			1,900	**1,900**	**9.5**	**1,800**	**2,900**	**8,100**	**1,800**	**390**	**2,400**
NTR-ENV-LET-045												
SITE5	1/17/2018	6.7	157	61	50	0.3	**33**	**61**	230	**52**	1	**70**

Concentration higher than trigger value

Concentration greater than or equal to two times the trigger value

Note: The reference ID for each exceedance event is specified above the relevant data for each event

5 DISCUSSION

5.1 BACKGROUND WATER QUALITY

5.1.1 Groundwater Quality

Groundwater quality data for bores RN022085 and RN023140 at the former Rum Jungle mine are representative of background conditions in the Coomalie Dolostone near the Browns site, i.e. groundwater that is unimpacted by ARD or liquor lost from the TSF in 2008. Groundwater samples from the TSF2 bores and groundwater collected from bores BH4A and BH4B before December 2008 reflect background conditions in Whites Formation and the overlying laterite/saprolite. Unimpacted groundwater from Whites Formation is characterized by circum-neutral to slightly acidic pH values and EC values that range from 100 to 500 µS/cm.

Figures 5-1 illustrates the major ion composition of unimpacted groundwater at the Browns site or in the surrounding area. Unimpacted groundwater from the Coomalie Dolostone and Whites Formation is Mg-HCO_3 type water that is characterized by less than 2 mg/L SO_4. Groundwater from Whites Formation can be slightly more acidic (i.e. pH 5 to 6) than groundwater from the Coomalie Dolostone because fewer carbonates are present to buffer pH values for groundwater. Metal concentrations in groundwater from the Coomalie Dolostone and Whites Formation are often low (i.e. 1 to 5 µg/L) or non-detectable. Fe and Mn are exceptions, as both can be elevated in unimpacted groundwater.

5.1.2 ML/ARD Indicators and Contaminants of Concern (CoC)

Groundwater characterized by more than 5 mg/L SO_4 is likely impacted by ARD or the acidic liquor lost from the TSF in 2008. For most metals, concentrations higher than 10 µg/L likely imply some impact, but it is important to recall that many of the historic data are not reliable and some elevated metal concentrations could be related to cross-contamination during sampling. Most groundwater quality impacts at the Browns site are not ambiguous however and there is little uncertainty regarding which bores are impacted given the high concentrations in contaminant sources (See Section 5.3).

5.2 CONTAMINANT SOURCES TO GROUNDWATER

5.2.1 Acidic Liquor in TSF

In August 2008, Compass Resources began discharging tailings and liquor to the TSF. Pumping records indicate that ~530 ML of liquor and 200,000 t of tailings were discharged to the TSF between August 2008 and January 12th, 2009, when discharge ceased. Approximately 75% of the liquor was discharged to a western pond within the TSF and the remainder was discharged to an eastern pond[1]. The two ponds were

[1] NTR also provided several emails that pertain to the 2009 incident report and an Excel spreadsheet summarizing water quality data for the liquor discharged to the TSF in December 2008. The spreadsheet also contains estimates of the volume of liquor that was discharged to the TSF from August 2008 to December 2008 and later recovered by pumping from January 12th to February 17th, 2009.

separated by an un-engineered bund that was built with Potentially Acid Forming (PAF) waste rock (see ATC Williams, 2009).

The liquor discharged to the TSF in 2008 was acidic (pH 3) and characterized by high concentrations of dissolved metals, i.e. up to 1,574,000 µg/L Cu and 105,000 µg/L Zn. A sample from the western pond within the TSF was characterized by concentrations that were comparable to those observed in liquor, whereas concentrations in the eastern pond were slightly lower by comparison (Table 5-1). Since 2009, pond water quality has improved but water samples have only been collected routinely since 2016 so the long-term trend cannot be determined.

On December 30th, 2008, elevated Electrical Conductivity (EC) and low pH values were observed while purging monitoring bores BH4A and BH4B prior to routine sampling. These bores are located south of the TSF near the current mine lease boundary. Lab testing later confirmed that water samples from these bores were characterized by metal concentrations that were comparable to concentrations in liquor in the TSF ponds (see Table 5-1). The high concentrations are attributed to undiluted liquor lost from the western and/or eastern TSF ponds (see Section 5.4 for further discussion).

Table 5-1. Condition of Liquor Released in 2008 and Concentrations in BH4A/B in 2009

Bore ID or Sampling Location	Analysis Date	pH	EC	SO_4, mg/L	Mg, mg/L	Al-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Zn-d, mg/L
Liquor discharged to TSF at decant													
Western side of bund	5-Jan-09	3.4	3,900	-	-	638	243	1,550	1,450	439	120	4	40
Water samples collected within the TSF													
Western pond	5-Jan-09	3.1	3,270	-	-	638	243	1,550	1,450	439	120	4	40
Eastern pond (NW corner)	5-Jan-09	5.5	75	-	-	1,142	254	1,146	2,920	382	146	5	88
Eastern pond (NW corner)	5-Jan-09	5.3	75	-	-	1,129	261	1,169	2,943	378	150	5	91
Eastern pond (NE corner)	5-Jan-09	3.1	5,530	-	-	1,176	273	1,164	3,126	401	156	6	105
Eastern pond (NE corner)	5-Jan-09	3.0	-	-	-	1,157	268	1,143	3,108	393	153	6	103
Samples from bores BH4A and BH4B, January 2009													
Bore BH4A	14-Jan-09	2.7	8,256	8,370	507	703	110	609	177	296	52	0.1	24
Bore BH4B	13-Jan-09	2.2	12,460	15,200	689	1,130	169	1,000	458	453	80	0.04	7

5.2.2 Seepage from Existing Ore and Waste Rock Stockpiles

There are no surface expressions of seepage from the existing stockpiles that are routinely sampled (if any occur at all). Table 5-2 summarizes the condition of seepage from waste rock excavated from the trial mine pit in 2002. The trial mine pit was excavated when Compass Resources intended to mine the sulphide ore deposit by open pit. Water samples were collected by site staff for EGI (2002) and further described in RGC (2018c).

Table 5-2. Seepage Water Quality (Trial Mine Pit Samples), 2002

Dump/Stockpile	Field pH	Field EC, µS/cm	Mg, mg/L	SO_4, mg/L	Al-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Zn-d, mg/L
Seepage from Sulphide Ore Dump												
Sulphide Ore Dump	2.2	20,000	539	39,448	435	966	17,335	1,441	60	771	10	632
Sulphide Ore Dump	2.4	19,700	427	29,600	342	821	15,128	748	59	609	0.3	423
Sulphide Ore Dump	1.5	17,100	80	18,945	317	697	5,997	1,672	3	405	4	927
Sulphide Ore Dump	1.6	14,500	72	14,123	206	473	4,116	1,354	2	313	3	495
Sulphide Ore Dump	1.8	10,500	256	10,762	330	238	3,249	722	45	176	2	271
Sulphide Ore Dump	1.9	8,290	147	8,241	173	130	1,952	465	7	107	3	146
Seepage from Waste Rock Dump												
Waste Rock Dump	2.2	11,800	1,926	15,961	-	-	-	-	-	-	-	-
Waste Rock Dump	2.4	10,800	1,633	14,381	1,004	11	16	79	25	18	1	300
Waste Rock Dump	1.9	10,500	988	13,928	1,008	14	15	952	20	21	1	285
Waste Rock Dump	2.7	10,300	2,056	12,161	604	9	2	31	94	22	0.2	7
Waste Rock Dump	1.6	10,800	465	11,757	741	16	17	1,761	12	22	3	454
Waste Rock Dump	2.4	7,020	842	7,608	658	8	6	47	24	11	1	178
Waste Rock Dump	3.3	3,050	408	2,357	15	1	0.2	1	7	2	1	1
Waste Rock Dump	3.2	2,280	325	1,704	10	1	0.2	1	5	2	1	0
Seepage from Oxide Ore Dump												
Oxide Ore Dump	3.2	910	58	481	17	5	34	1	3	4	5	22
Oxide Ore Dump	3.4	670	51	356	8	4	26	0.2	3	3	4	13
Oxide Ore Dump	4.9	80	4.0	27	-	-	-	-	-	-	-	-
Oxide Ore Dump	5.6	90	3.0	18	0.0006	0.3	4	0.02	0.1	0.3	2.5	0.1
Oxide Ore Dump	5.5	30	1.3	12	0.0030	0.1	0.3	-	0.0	0.1	3.5	0.2
Oxide Ore Dump	5.5	80	1.1	8	0.0030	0.1	0.2	0.02	0.0	0.1	2.3	0.1

Notes: Numbers in red denote a concentration below the indicated detection limit

5.2.3 TSF Berm

ATC Williams (2007) indicates that PAF waste rock was used to construct the TSF berm. However, an as-built report is not available, and there are no known expressions of seepage along the berm. Groundwater near the berm (where there are no other known sources) can be characterized by elevated SO4 and some metals. Seepage from the TSF is therefore considered a potential (if not secondary) contaminant source to groundwater that may explain localized water quality impacts in some areas (see Section 5.4.1).

5.3 SITE-WIDE GROUNDWATER FLOW REGIME

5.3.1 Recharge Areas

RGC developed a conceptual groundwater budget that includes recharge rates to groundwater from the Main Sediment Dam, the TSF pond, and the ore stockpiles. Also provided are recharge rates for undisturbed land areas and estimated flow rates to the Browns Pit from the surrounding aquifer. Undisturbed areas provide the majority of recharge to the model domain. This recharge, and potential recharge from the flooded pits at the former Rum Jungle mine site, may dilute contaminant loads in groundwater.

Recharge rates for the ore stockpiles, Main Sediment Dam, and the TSF pond are used to estimate contaminant loads to groundwater in Section 5.4.3. The ore stockpiles are considered preferential recharge

areas because the infiltration rates to groundwater for the coarse ore that is stockpiled are higher than infiltration rates for undisturbed land areas. Recharges from the Main Sediment Dam and TSF pond are also relatively high because a strong vertical hydraulic gradient is caused by the standing water in these ponds.

5.3.2 Inferred Flow Field

Map 3 shows geodetic groundwater levels in January 2018 and the inferred flow field and groundwater flow directions. The inferred flow field to the south of the TSF and along then northern property boundary i.e. north of the offices and processing plant, are still rather uncertain due to the lack of monitoring bores in these areas,. Additional information from the monitoring bores to be installed in 2018 is needed to refine the local groundwater flow field for these areas and determine groundwater flow directions with more certainty (see Section 6.2 for proposed drilling locations).

Key observations from the preliminary flow field provided here are summarized below:

- Groundwater levels are highest to the south of the TSF near bores BH7A/B where ground elevations naturally increase to ~88 m AHD. High groundwater levels in this area suggest that the gradient in this area is weak and that groundwater may currently flow towards the TSF from the south at certain times of the year. A gradient towards the south could have occurred in 2008 when there was standing water in the TSF but there is no evidence that liquor from the TSF impacted bores BH7A or BH7B or any other TSF2 bores.
- Some mounding is observed along the southern TSF berm from bore BH3A to bore BH5B near the eastern end of the TSF. These elevated water levels could reflect a hydraulic connection between the TSF pond and groundwater beyond the TSF berm. This mounding suggests ongoing seepage to groundwater from the TSF pond and could explain impacts to groundwater from bores BH3B, BH13B, and BH4D.
- Groundwater generally flows across the Browns site from the TSF area towards the Browns Pit. This flow pattern is related to the low water level in the pit (56 to 57 m AHD since 2012), which depresses groundwater levels nearby and causes the pit to act as a local sink for groundwater throughout the year.

5.3.3 Potential Groundwater Fluxes

Table 5-3 summarizes a conceptual groundwater budget for the Browns site. RGC developed a 3D numerical groundwater flow model for Doe Run Australia. The model was developed using the finite-element code FEFLOW to support Doe Run Australia's PFS of the Browns Sulphide Mine. The model was developed to simulate groundwater inflow rates to the de-watered underground workings at the end of the proposed mine life.

Shallow (< 30 m depth), unconfined aquifers near ground surface, i.e. laterite, saprolite, and bedrock units, are grouped together as a single unit in RGC's PFS flow model. The simplified representation of shallow

aquifer units as a single unit in the model precluded the use of the numerical model for this report. Instead, groundwater flows from the conceptual groundwater budget from RGC (2018b) are used in this report to estimate annual contaminant loads to groundwater (see Section 5.4.3).

Table 5-3. Estimated Seepage Flows to Groundwater

Source	Flow Rate*		Comment
	L/s	Contribution	
*Loads to Groundwater**			
TSF pond	5	51%	Estimated from K and 0.1 m/m gradient over pond
Main Sediment Dam	2.6	26%	Estimated from K for base of pond and 10% vertical hydraulic gradient
Small Sediment Dam	0.3	3%	10% of Main Sediment Dam recharge assumed
PAF Ore Stockpile	0.7	7%	50% of MAP assumed, as per RGC (2016a)
Low Grade Ore Stockpile	0.3	3%	50% of MAP assumed, as per RGC (2016a)
Intermediate Ore Stockpile	1.1	11%	50% of MAP assumed, as per RGC (2016a)
TOTAL:	**9.9**	**100%**	

5.4 GROUNDWATER QUALITY IMPACTS AND CONCEPTUAL LOAD BALANCE

5.4.1 Seepage and Liquor-Related Water Quality Impacts

Map 4 and Map 5 shows groundwater quality results that are reasonably representative of current conditions. These are the same (verified) data provided in Table 4-2. The major ion composition of groundwater at the Browns site is illustrated in Figure 5-2 (Piper plot) and Figure 5-3 (Durov plot). Figure 5-4, Figure 5-5, and Figure 5-6 are conceptual cross-sections that show how SO_4 and Cu concentrations vary with depth near the southern and western TSF berms. Geodetic groundwater levels from the January 2018 survey are plotted in the cross-sections. Cross-section alignments are shown in Map 4 with site features shown and with surficial geology in Map 5.

Key observations regarding current impacts to groundwater are summarized here:

- Approximately 530 ML of liquor was discharged to the TSF from September 2008 to December 2008. This volume is about three times higher than the average annual rainfall volume to the TSF (167 ML). By December 2008, a pond within the TSF was likely 5 to 6 m deep based on the EAV curve from GHD (2016a). Internal records indicate that 75% of the liquor was discharged to the western pond and 25% was discharge to an eastern pond. After pumping in January 2009, there was a single pond near the western end of the TSF (see Figure 5-7).
- For several months in 2008, groundwater level data for bores BH4A and BH4B indicate substantial, if not localized, mounding near the southern TSF due to the increased seepage (recharge) from the TSF pond. The groundwater flow field would have been radial, but still skewed towards the de-watered pit (~35 m AHD during mining). Some localized mounding near the southern perimeter of the TSF is inferred to occur today but it is not widespread as often observed near TSFs at other

sites that are filled with more water and tailings, or which are underlain by less permeable aquifer materials than Whites Formation shales and the Coomalie Dolostone.

- In December 2008 and January 2009, undiluted liquor was identified during sampling bores BH4A and BH4B. Liquor was likely be lost from the western pond and/or the eastern pond in 2008 via a fracture zone(s) or some other disturbance within the foundation. Prior to liquor being discharged to the TSF, groundwater quality at bores BH4A and BH4B was unimpacted (see Table 5-4).
- Liquor from the TSF was likely lost via two fault zones running beneath the TSF. One of the faults runs north-to-south and dips to the west. The other fault is oriented roughly northeast-to-southwest and runs beneath the former eastern pond. URS (2009) identified the fault that runs from east-to-west as the likely pathway for liquor from the eastern pond to the bores BH4A and BH4B (see Figure 5-7).
- Since peak concentrations were observed in December 2008 and January 2009, metal concentrations in groundwater samples from bores BH4A and BH4B have decreased by at least an order of magnitude. Cu concentrations in water from bore BH4B, for instance, decreased from 1,106,000 µg/L Cu in January 2009 to ~30,000 µg/L Cu in 2017. SO_4 concentrations have decreased by an order-of-magnitude since 2009, i.e. from 12,320 mg/L SO_4 in 2009 to 1,201 mg/L SO_4 in 2016.
- Metal concentrations in groundwater from bores BH4A and BH4B are now comparable, if not lower than, concentrations in TSF water (see Table 5-4). Water in the TSF consists of residual liquor from 2008 that has been diluted by rainfall during each subsequent wet season and by small volumes of impacted groundwater pumped from recovery bores BH4G and BH12C since 2010. Comparable water quality in the pond and bores BH4A and BH4B suggests there is still a direct connection between the western TSF pond and the sub-surface near these bores. These bores likely received undiluted liquor from the former eastern pond for several months in 2008 (until it was drained) and have continued to receive water from the western pond since 2009. This is supported by preliminary simulations of the Cu concentrations in TSF pond with the Goldsim model (see Figure 5-8).
- The decrease in metal concentrations at bores BH4A and BH4B appears to be unrelated to the minimal pumping rates achieved by seepage recovery bores BH4G and BH12C. Groundwater from recovery bore BH12C is also characterized by nearly non-detectable Cu concentrations, so it does not intercept any appreciable metal load. RGC (2017) recommended that it no longer be operated and the pump was removed in December 2017 because it was clogged.
- South of the TSF, elevated Cu concentrations can occur in bores other than bores BH4A and BH4B. However, only concentrations in groundwater from monitoring bore BH4D and recovery bore BH4G are characterized by Cu concentrations higher than 1,000 µg/L Cu (see Map 4). Elevated Cu in bores BH4D and BH4G is likely related to a diluted, possibly localized plume that is sustained by ongoing seepage from the TSF pond.

- SO_4 and metal concentrations in the other TSF1 bores, i.e. to the west and north of the TSF, are much lower than in groundwater from bores BH4A and BH4B. Lower concentrations indicate that most of the bores around the TSF are not connected to the fracture or other preferential flow path(s) between the TSF pond and bores BH4A and BH4B. The modest impact observed in bores to the east of the TSF, e.g. BH16B and BH17B, is likely related to seepage from the ore stockpiles and/or a TDS (SO_4) plume that originates beneath the TSF and is migrating towards the Browns Pit.

Table 5-4. Selected Water Quality Observations for Bores BH4A and BH4B, 2009 to 2017

Bore ID	Sampling Date	Field pH	Field EC	SO4	Mg	Al-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	
BH4A	28-Aug-08	5.3	86	1	0.1	165	0.2	1	100	14	0.4	0.3	4	3%
BH4A	30-Dec-08	4.5	6,649	5,000	320	-	75,800	431,000	78,100	213,000	34,900	116	16,400	-
BH4A	7-Jan-09	5.3	8,138	-	490	626,300	119,300	715,400	161,800	289,800	58,550	330	23,060	-
BH4A	14-Jan-09	2.7	8,256	8,370	507	703,000	110,000	609,000	177,000	296,000	52,000	91	24,400	2%
BH4A	30-Apr-09	3.3	8,049	8,200	516	474,000	107,000	440,000	399,000	324,000	49,000	193	25,600	3%
BH4A	1-Jul-09	3.5	6,191	5,480	398	235,000	88,000	267,000	265,000	260,000	36,800	125	18,500	0.2%
BH4A	31-Aug-09	3.7	5,554	4,370	378	127,000	77,700	157,000	148,000	189,000	33,600	115	15,800	0.4%
BH4A	15-Jan-10	3.4	3,380	2,610	243	68,600	47,800	94,800	2,660	114,000	20,900	94	10,800	7%
BH4A	8-Jul-17	2.8	1,527	1,400	84	22,000	10,000	29,000	780	24,000	4,900	48	2,700	35%
BH4B	28-Aug-08	5.8	60	0.6	0.3	91	1	1	60	62	1	0.3	9	17%
BH4B	30-Sep-08	5.3	55	0.5	0.3	390	0.3	1	160	13	1	0.4	5	43%
BH4B	7-Nov-08	5.4	54	0.6	0.2	16	0.2	1	60	8	0.3	0.1	2	22%
BH4B	9-Dec-08	6.3	59	3.1	0.3	79	11	40	40	48	6	1	10	29%
BH4B	30-Dec-08	4.5	6,057	4,850	301	370,000	73,900	-	78,100	226,000	33,500	94	16,000	-
BH4B	8-Jan-09	4.9	12,320	-	612	970,200	168,900	1,106,000	432,600	433,300	81,760	340	31,940	-
BH4B	13-Jan-09	2.2	12,460	15,200	689	1,130,000	169,000	1,000,000	458,000	453,000	80,400	38	37,600	11%
BH4B	30-Apr-09	3.2	8,067	8,670	507	490,000	107,000	450,000	424,000	321,000	49,800	124	25,800	6%
BH4B	1-Jul-09	3.4	6,327	5,370	382	232,000	88,100	256,000	265,000	253,000	37,100	81	18,500	1%
BH4B	31-Aug-09	3.6	5,548	4,380	387	119,000	78,600	150,000	142,000	185,000	34,500	81	16,300	0.3%
BH4B	15-Jan-10	3.3	4,520	3,800	315	85,000	70,000	106,000	95,600	179,000	29,300	73	13,900	9%
BH4B	17-Aug-16	3.3	1,201	1,300	69	19,000	13,000	27,000	-	36,000	6,000	11	2,900	-
TSF Pond	**17-Jan-18**	**4.2**	**1,146**	**580**	**49**	**12,000**	**6,100**	**32,000**	**80.0**	**1,700**	**4,100**	**620**	**1,100**	**4%**

5.4.2 Statistical Trends

Table 5-5 summarizes the results of the Mann-Kendall trend analysis for 22 bores on site or to the south of the TSF. Five bores at the Browns site had insufficient data for a trend analysis because these bores have been damaged or could not be routinely sampled because they are typically dry. Descriptive statistics for the Dry Season samples selected for the trend analysis are provided in the table to provide an indication of the degree of water quality impact for each bore and the range of concentrations included in the trend analysis. Descriptive statistics are also provided for the bores that that were not included in the Mann-Kendall trend analysis for reference.

50% of the seasonally-adjusted time trends analyzed were identified as stable and the other 50% had no trend, i.e. concentrations are not increasing or decreasing but there is too much scatter in the data to be

classified as stable. The trends for bores BH4A, BH4B, BH4D, and BH4G were each identified as stable[2]. S values are negative, suggesting a possible decrease over time, but the downward trend was not statistically significant. This is important because it indicates that the Cu concentration in groundwater impacted by liquor from the TSF has been consistent for five years. This implies that the current seepage recovery strategy is not effective and that groundwater quality will not likely improve unless additional recovery measures are implemented.

Bores identified as having no trend are characterized by a large degree of scatter in the historic data and hence a high COV. Should these bores continue to be sampled routinely, it is likely that many of these bores would eventually be classified as stable given the improving reliability of routine monitoring data at the site. It would take years to collect the additional data and it does not seem warranted given the low metal concentrations (see Section 6.2 for the recommended scope of future routine groundwater monitoring).

[2] RGC fit an exponential curve (R^2 = 0.86) to data collected from January 2009 to January 2012 to characterize the initial decline in Cu concentrations that occurred after liquor was lost. An exponential curve could not be fit to the data collected from 2009 to 2017 because concentrations have not been decreasing in recent years.

Table 5-5. Summary of Mann-Kendall Trend Analysis for Selected Bores

Bore ID	Series	Descriptive Statistics				Mann-Kendall Trend Analysis			
		n	Median [Cu], µg/L	Mean [Cu], µg/L	SD	COV	S	Confidence Factor	Concentration Trend
Cu concentrations predominantly non-detectable (no trend analysis completed)									
BH4H	Recovery	5	1	2	1	-	-	-	-
BH7A	TSF2	5	1	1	0	-	-	-	-
BH7B	TSF2	5	6	5	2	-	-	-	-
BH8A	TSF2	5	1	1	0	-	-	-	-
BH8B	TSF2	5	1	2	3	-	-	-	-
BH9A	TSF2	5	1	1	2	-	-	-	-
BH9B	TSF2	5	1	2	1	-	-	-	-
BH10	TSF2	5	2	2	1	-	-	-	-
BH11	TSF2	5	1	1	0	-	-	-	-
BH12C	Recovery	5	1	1	0	-	-	-	-
TPB4	Regional	5	1	1	0	-	-	-	-
TPB5	Regional	5	1	1	0	-	-	-	-
Thompson	Regional	5	1	3	5	-	-	-	-
Thompson-Mango	Regional	5	1	1	1	-	-	-	-
Detectable Cu concentrations									
BH3A	TSF1	5	14	18	19	0.5	-8	75.8%	Stable
BH3B	TSF1	5	150	157	137	0.9	-6	88.3%	Stable
BH4A	TSF1	5	34,000	34,800	8,757	0.3	-2	59.2%	Stable
BH4B	TSF1	5	32,000	31,000	8,573	0.2	-6	81.5%	Stable
BH4D	TSF1	5	2,100	2,335	1,510	0.4	-2	59.2%	Stable
BH4G	Recovery	5	8,700	8,655	2,440	0.2	-4	75.8%	Stable
BH13B	TSF1	5	320	382	210	0.6	0	40.8%	Stable
BH14B	TSF1	5	26	26	26	1.0	-4	75.8%	Stable
BH15A	TSF1	5	17	22	15	0.7	-4	75.8%	Stable
BH15B	TSF1	5	9	7	5	0.6	0	40.8%	Stable
BH16B	TSF1	5	14	18	16	0.9	-4	75.8%	Stable
BH2B	TSF1	5	7	22	26	1.2	-6	88.3%	No Trend
BH4E	TSF1	5	79	88	30	0.4	4	75.8%	No Trend
BH4F	Recovery	5	1	13	22	1.8	-3	67.5%	No Trend
BH5A	TSF1	5	18	45	66	1.5	4	75.8%	No Trend
BH5B	TSF1	5	5	7	9	1.2	-2	53.5%	No Trend
BH12A	TSF1	5	2	5	6	1.3	1	50.0%	No Trend
BH12B	TSF1	5	1	4	6	1.5	-10	86.2%	No Trend
BH17B	TSF1	4	2	14	25	1.8	-4	83.3%	No Trend
BH18A	TSF1	5	13	14	4	0.2	2	59.2%	No Trend
BH18B	TSF1	5	125	130	96	0.8	6	88.3%	No Trend
RN023137	Regional	5	3	5	5	1.2	6	66.8%	No Trend

5.4.3 Conceptual Load Balance for Groundwater

Table 5-6 provides a conceptual load balance for the shallow groundwater system at the Browns site, i.e. up to 30 m bgs. Flows from the conceptual groundwater budget provided by RGC (2018b) and summarized in Table 5-3 are assumed for the load calculations. The average SO_4, Cu, and Zn concentration in surface runoff from the existing ore stockpiles were used as source terms. Other concentrations, i.e. for the TSF pond and Main Sediment Dam, are median concentrations for the routine surface water quality monitoring. Water balance modeling indicates that there is no loss of water from the ponds that receive runoff from the existing ore stockpiles so these ponds are not considered sources to groundwater (see Section 5.5 for further discussion).

Table 5-6. Conceptual Load Balance for Groundwater

Source	Flow Rate*		SO_4, mg/L	Cu, mg/L	Zn, mg/L	SO_4 Load		Cu Load		Zn Load	
	L/s	Contribution				t/year	Contribution	kg/year	Contribution	kg/year	Contribution
*Loads to Groundwater**											
TSF pond	5	51%	280	13	1	44	66%	2,050	38%	84	29%
Main Sediment Dam	2.6	26%	120	0.01	0.02	10	15%	1	0.02%	2	1%
SRO	0.3	3%	25	0.4	0.08	0.2	0.31%	3	0.06%	1	0%
PAF Ore Stockpile	0.7	7%	330	66.0	7	7	11%	1,457	27%	159	56%
Stockpile 3	0.3	3%	170	8.6	1	2	2%	81	2%	9	3%
Black Shale Stockpile	1	10%	110	55.0	1	3	5%	1,734	33%	32	11%
TOTAL (IN):	**9.9**	**100%**	-	-	-	**67**	**100%**	**5,327**	**100%**	**286**	**100%**
*Recovered from Groundwater***											
Bore BH4G	1.9	50%	370	7.7	1.1	22	73%	461.4	100%	65.9	14%
Bore BH12C	1.9	50%	140	0.001	0.005	8	27%	0.1	0%	0.3	0%
TOTAL (OUT):	**3.8**	**100%**	-	-	-	**31**	**100%**	**461.4**	**100%**	**66.2**	**14%**

* From RGC (2018b)
** Assuming flows from GHD (2016), likely upper bound estimates based on observations by RGC in July 2017

The contaminant load balance is intended to provide an indication of the potential magnitude of loads to groundwater and how they compare to surface water loads that report to the water treatment system. The load balance is not calibrated because there are too few reliable data to develop calibration targets. Moreover, groundwater quality near the existing stockpiles is not characterized to the extent that the concentrations inferred from estimated loads in Table 5-5 can be compared to observed concentrations in groundwater. The model is, however, instructive and suggests that most of the annual Cu load to groundwater is related to seepage from the western TSF pond whereas seepage from the existing ore stockpiles accounts for the majority of annual SO_4 and Zn loads to groundwater.

The large loads from the TSF pond are consistent with the severity of groundwater quality impacts due to liquor losses from the TSF in 2008. However, it should be acknowledged that the nature of the connection between the pond and the aquifer near bores BH4A and BH4B is not yet well-understood. Additional information from pump testing a new recovery bore is needed to determine the volume of impacted groundwater that still resides near the southern TSF and how it compares to the volume of liquor released in 2008. The pumping test will also allow the hydraulic connection between the pond and the aquifer near bores BH4A and BH4B to be assessed (see Section 6.2 for further details).

5.4.4 Seepage Recovery System Performance

Key aspects of the current seepage recovery strategy are summarized here:

- Groundwater recovered from recovery bore BH4G is characterized by ~370 mg/L SO_4 and elevated Cu, i.e. 7,700 µg/L Cu in January 2018. These concentrations are much lower than in groundwater from bores BH4A and BH4B. Recovery bore BH4G has a long (12-m) screen from 6 to 18 m bgs. This bore likely captures a mixture of the severely-impacted groundwater observed at bores BH4A and BH4B and less impacted groundwater from other depths in the aquifer. These concentrations suggest the plume is likely confined to discrete zones within a fractured and/or heterogeneous aquifer.
- Recovery bore BH4G may recover about 460 kg/year Cu. This assumes a pumping rate of 1.9 L/s and the 7,700 µg/L Cu observed in January 2018. This load is less than 0.5% of the mass of Cu that remained in the TSF pond(s) after pumping liquor back in February 2009. Moreover, it is unlikely that bore BH4G has consistently yielded 1.9 L/s since 2009. More likely is that bore BH4G currently recovers no appreciable load due to the minimal flow rates achieved, i.e. ~0.1 L/s. This recovery bore could be of use if future well testing supports the installation of a larger pump, as it does intercept groundwater with substantial Cu and other metals.
- Pumping the residual liquor and/or impacted groundwater that has been identified at bores BH4B cannot be achieved by continued pumping from recovery bore BH4G. A new, 150 to 200 mm diameter recovery bore that can achieve the higher (~5 L/s) flow rates observed during a short-term pumping test by URS in 2009 is therefore recommended. If this flow rate is achieved from the new recovery bore, it is unlikely that bore BH4G and the new recovery bore can be operated together in this area without some interference unless the aquifer yield is much higher than expected.
- Groundwater pumped from recovery bore BH12C is characterized by 140 mg/L SO_4 and less than the 1 µg/L detection limit for Cu. The SO_4 concentration likely represents a small seepage load to the area from the TSF pond that has been buffered and/or attenuated in the Coomalie Dolostone. Continued pumping from recovery bore BH12C is therefore not expected to capture liquor lost from the TSF in 2008 and is unlikely to improve groundwater quality to the west near bore BH13B.
- Recovery bores BH4F and BH4H are not currently operated. Groundwater from bore BH4F is unimpacted, as it appears to be screened too deep in the aquifer to be affected by liquor from the TSF (see Figure 5-4). Recovery bore BH4H is located ~100 m south west of bores BH4A and BH4B and likely beyond the area affected by TSF liquor. Neither of these bores is useful for future seepage recovery but they could be retained to monitor drawdown near a new seepage recovery bore.
- Bores BH4A and BH4B may receive water directly from the TSF pond that has remained since 2009. This implies that water from bores BH4A and BH4B is essentially pond water that

continues to be lost to the sub-surface and that the long-term decrease in contaminants likely reflects the dilution of pondwater by rainfall each year. Reducing concentrations at bores BH4A and BH4B may require eliminating the source of contaminants (pond water) and then pumping the impacted groundwater ("residual plume") that currently resides in the aquifer near this bore. The former could be achieved by sealing the TSF floor near bores BH4A and BH4B and/or treating the existing (contaminated) pond so only clean rainfall accumulates in the pond in future years.

5.5 SURFACE WATER FLOWS AND SITE WATER BALANCE

5.5.1 Model Inputs and Structure

RGC developed a water balance model (WBM) in Goldsim to simulate the current, 'care and maintenance' configuration of the water management infrastructure on site, including the pumps, pipelines, and drainage ditches that convey surface water to and from water treatment system in the processing plant and the seepage recovery bores near the TSF (BH4G and BH12). The following storage reservoirs are represented in the model (see Figure 5-9 and Figure 5-10):

- Browns Pit.
- TSF.
- SRO.
- PAF ore stockpile pond.
- Black Shale Stockpile.
- Stockpile 3.
- Processing water storage ponds (or PLS ponds).
- Pre-Settlement Ponds.
- Main Sediment Dam.

Controlled discharge from the Main Sediment Dam to the EBFR and flows in the EBFR at gauging station GS8150200 are simulated by the model. The model was operated on a daily time step to capture the highly transient hydrological regime of the region. Daily flows from the ungauged catchments were estimated using the Australian Water Balance Model (AWBM).

The structure of the model represents the main pipeline systems that operate at the mine. Most of these pipelines direct impacted rainfall runoff to the water treatment system. The model does not contain any temporary pump or pipeline, including those deployed to manage the flooding caused by Cyclone Carlos in February 2011 because modeling objectives for the PFS could be achieved without them. The installations were not added to the WBM for this report because the focus of the water balance modeling is the 2016/2017 Wet Season that is mostly within the current monitoring period (December 2016 to January 2018).

The boundaries of the WBM encompass the Browns site (~1 km^2) and the 71 km^2 of the EBFR catchment that drains to Station GS8150097. This station is about 8 km downstream of the Browns site and is the most downstream point in the model domain. It was selected as the most downstream point to facilitate the calibration of the runoff routine in the WBM and allow realistic simulations of controlled releases from the mine to the receiving environment as per WDL177-06.

The WBM was run for the 10.5-year period from October 1st, 2006, to April 30th, 2017, to assess how the present configuration of the mine would behave under a wide range of climatic conditions. The first 4.5 years of simulation were used as a warm-up period to eliminate the need for an accurate assessment of initial conditions, such as initial reservoir volumes. The results of the modelling should not be considered a strict reconstruction of how the mine behaved historically because the water management infrastructure has changed over the years. The latest substantive changes were in in late 2011 when the Pre-Settlement Ponds were excavated and the safety berm around the open pit was raised after Cyclone Carlos.

5.5.2 Simulated Water Balance for 2016/2017 Wet Season

Figure 5-11 illustrates the movement and storage of water within the boundaries of the Browns site and the linkages between the mine site and the EBFR that were simulated in the model. One symbol represents the EBFR and the other symbols denote key mine elements, such as the Browns Pit, the TSF, and the rainwater collection ponds downstream of the existing ore stockpiles. The water treatment system in the processing plant is abbreviated as WTP for 'Water Treatment Plant'. The broad, coloured[3] arrows represent inputs to or outputs from the model domain. The inputs are:

- Direct rainfall to a pond surface.
- Runoff from the catchment upstream.
- Groundwater inflows.

Outputs are:

- Direct evaporation from a pond surface.
- Infiltration losses to the groundwater system.

ΔS in Figure 5-11 indicates the difference in storage (in millions of litres, ML) from July 2016 to July 2017. A positive ΔS indicates that more water was stored at the end of the simulation was greater than at the beginning and a negative ΔS value indicates the opposite. The thin, black lines indicate flows between the model elements, such as the water pumped from the Browns Pit or the water collection ponds to the WTP or water discharged from the Main Sediment Dam to the EBFR. The values in

[3] The colours of the arrows and the WTP conform to the Water Accounting Framework (WAF) from the Minerals Council of Australia (see Appendix X).

parentheses next to the flowlines in Figure 5-11 are simulated flows (in ML) for the 2016/2017 Wet Season.

Each of the flowlines except the line that represents controlled discharge from the Main Sediment Dam to the EBFR are ungauged. Daily flows from the ungauged flowlines were estimated using the AWBM. To apply the AWBM, the model parameters that dictate the overall magnitude and shape of the hydrographs simulated by the model must be estimated. These parameters were estimated by calibrating the model against the daily flow record for the EBFR at GS8150097 from 1965 to 2009. The assumption is that the model parameters adopted for the EBFR catchment apply to constituent areas of that catchment. Figure 5-12 shows an example of the fit obtained between modelled and observed flows in the EBFR at GS8150097 for 1990/1991 Wet Season.

5.5.3 Model Validation

The accuracy of the simulated runoff at the mine site could be partially validated using the record of controlled releases of water from the Main Sediment Pond to the EBFR. Figure 5-13 presents cumulative controlled releases of water from the Main Sediment Pond over six wet seasons from 2011 to 2017. The blue line is the observed volume and the red line is the simulated release from the WBM. The observed volume (2009 to mid-2017) was calculated from detailed records of the times when the valve on the outlet structure from the Main Sediment Dam was opened to allow releases to the river. These time records were converted to records of annual volumes by taking the product of valve opening duration and an estimate of the average release rate (typically 200 L/s).

Since mid-February 2017, the releases from the Main Sediment Pond have been measured directly by an electromagnetic flow sensor installed on the outlet pipeline. The close match between the observed and simulated releases suggests that the AWBM simulates reasonably well the runoff volume generated by the mine site catchments. Observed discharge for the 2016/2017 Wet Season was 6% lower than the simulated discharge for this wet season (see Section 5.5.3).

5.5.4 Simulated Flows to Water Treatment System and EBFR

Table 5-7 summarizes simulated flows to and from the water collection ponds, the TSF, and the Browns Pit for the 2016/2017 Wet Season. This is the only near-complete wet season (water year) since the electronic sensor was installed at the outlet pipeline from the Main Sediment Dam and most of the flows occurred during the current monitoring period for WDL177-06 (December 2016 to January 2018). Table 5-8 summarizes flows to and from the Main Sediment Dam for the 2016/2017 Wet Season.

Table 5-7. Simulated Flows to the Water Treatment System, 2016/2017 Wet Season

Source	INPUTS			OUTPUTS		ΔS, ML	Pumped to WTP, ML
	Direct Rainfall, ML	Runoff from Upstream Catchment, ML	Groundwater Inflow, ML	Evaporation, ML	Infiltration to Groundwater, ML		
Browns Pit	122.0	86.7	158.0	147.0	0.0	-0.7	252.0
TSF	170.0	74.3	119.0	208.0	110.0	-45.2	0.0
SRO	5.8	54.0	54.0	6.8	0.0	-3.3	56.2
PLS Ponds	16.4	0.0	0.0	13.0	0.0	-3.5	0.0
PAF Ore Stockpile Pond	6.3	22.0	0.0	4.3	0.0	0.0	24.1
Black Shale Stockpile	6.9	26.0	0.0	4.5	0.0	0.0	28.4
Stockpile 3	7.9	41.1	0.0	6.2	0.0	-0.2	43.0
TOTAL:	**335**	**304**	**331**	**390**	**110**	**-53**	**404**

Table 5-8. Simulated Flows to the Water Treatment System, 2016/2017 Wet Season

Source	INPUTS			OUTPUTS		ΔS, ML	Controlled Discharge to EBFR, ML
	Direct Rainfall, ML	Runoff from Catchment Upstream, ML	Flows from Pre-Settlement Ponds*, ML	Evaporation, ML	Infiltration to Groundwater, ML		
Main Sediment Dam	**90.7**	**45.0**	**520.6**	**98.0**	**71.0**	**-9.7**	**497.0**

Notes:
Flows to Pre-Settlement Ponds: 404 ML from WTP, 48.5 ML from Processing Plant area, and 68.1 ML of runoff
Simulated controlled discharge (497 ML) from the Main Sediment Dam is 1.5% of the flow in the EBFR during 2016/2017 Wet Season (31,864 ML)
Observed controlled discharge volume for 2016/2017 Wet Season was 469 ML (6% lower than the simulated controlled discharge volume)

Some key observations from these tables are summarized here:

- 404 ML was simulated to flow to the WTP during the 2016/2017 Wet Season. This is 81% of the simulated volume of controlled discharge (497 ML) from the Main Sediment Dam during the 2016/2017 Wet Season. The observed volume of controlled discharge from the Main Sediment Dam during the 2016/2017 Wet Season was 469 ML, or 6% lower than the simulated volume.
- Simulated flows to the WTP (404 ML) were 36% higher than the average simulated flow to the water treatment system for the 6-year calibration period. These higher flows are related to higher rainfall during the 2016/2017 Wet Season than in previous wet seasons except the 2010/2011 Wet Season (the wettest season of the calibration period).
- Simulated flows from the Browns Pit account for 62% of the simulated flows to the WTP. Pit water is pumped to the processing plant as the main feed sources to the WTP and is used to blend the stockpile contact water. Substantial groundwater inflows to the Browns Pit (158 ML) are simulated by the model to ensure that pit water could be directed to the water treatment system while maintaining the constant pit water level that was inferred from bore TPB5 for the 2016/2017 Wet Season[4]. These groundwater flows (5 L/s annualized) are equivalent to annual

[4] No records are maintained of the volumes of water withdrawn from the pit so a definitive assessment of groundwater inflows could not be made. Groundwater inflows were therefore inferred by assuming that groundwater levels at bore TPB5 are a proxy for the water level in the pit. The groundwater/pit water level remains reasonably constant during the Dry Season when the only significant loss from the pit is direct evaporation from the pond surface. For the pit pond level to remain roughly constant while it is subject to large evaporation losses, an inflow of nearly equal magnitude would be required to offset the losses. This inflow stream was assumed to be the result of a net positive groundwater inflow to the pit.

evaporation from the pit and are consistent with RGC's CSM for the site (see RGC, 2018b). Flows are also consistent with substantial withdrawals of water from the pit for use as the main feed water to the WTP (N. Rodwell, personal communication).

- The TSF is simulated to be an enclosed basin because it has sufficient empty storage to full capture any direct rainfall. This is true for each wet season of the 6-year calibration period, including the 2010/2011 Wet Season (2500 mm rainfall). Flows from the TSF to the WTP are therefore not simulated by the model. Instead, water stored in the TSF is simulated to be lost by evaporation (which is estimated by the AWBM) and infiltration to groundwater. In the model, infiltration to groundwater was increased until simulated flows to the water treatment were not required to maintain a closed system. For the 2016/2017 Wet Season, 110 ML of water from the TSF pond was simulated to infiltrate to groundwater. Annualized, this is 3.5 L/s, which is within the 1 to 10 L/s range estimated in RGC (2018b).
- 24% of the simulated flows to the WTP are related to water pumped from the PAF ore stockpile pond, the Black Shale Stockpile pond, and the Stockpile 3 pond. Flows from the SRO account for the other 14% of the simulated flows to the WTP.

5.5.5 WDL Constraints on Controlled Discharge

Figure 5-14 provides simulated results from the GoldSim model that illustrate how opportunities for controlled releases from the mine development differ between wet and dry years. Owing to the intermittent nature of the EBFR flow regime, the WDL has a profound influence on water management activities at the mine. For example, adherence to conditions in WDL177-06 periodically causes a chain reaction that forces a temporary shutdown of the WTP, which in turn forces a temporary shutdown in de-watering of the various ponds used to manage contact water, including the Browns Pit.

This disruption is particularly likely in drought years when the opportunity to release water from the Main Sediment Dam to the EBFR is very restricted by the few number of days in which the flow is above 1.0 m^3/s. The WTP (circuit) is commissioned at the beginning of the wet season when the Main Sediment Pond is in a drawn-down state. If the opportunity to release water is limited, then a point may be reached when the pond becomes nearly full. The WTP would then have to be halted, or otherwise the pond would continue to fill, potentially spilling at a time when the river flow is very low or zero.

For the six-year period from May 1st, 2011, to April 30th, 2017, the average annual release from the Main Sediment Pond was estimated to be 10.4 L/s. In comparison, the estimated average annual flow of the EBFR just upstream of the Browns Project was 712 L/s. The model results indicate that most of the surplus water accumulating on site is released to the river in the same year that it was generated.

In other words, there is no need to carry over a portion of surplus water from one year to the next, despite the strict release limitations posed by WDL177-06.

5.5.6 Surface Water Management During 1-in-100 Year, 72-Hour Rainfall Event

Flows in February 2011 during Cyclone Carlos were simulated during the development of the WBM (not shown here). During Cyclone Carlos, the site received 330 mm (recorded at Batchelor Airport) over a 3-day period from February 15th to February 17th, 2011, or about 70% of the 1-in-100 year. 72-hour rainfall event. Some spillage of untreated water to the receiving environment was simulated by the WBM, which is consistent with the requirement for additional pumping from the mine's collection ponds during the storm.

In January 2018, 1107.6 mm of rainfall was recorded in the site rain gauge at SITE2 with the wettest 72-hour period recording 460 mm. During this event, Stockpile 3 and the SRO overflowed and runoff from the Black Shale Stockpile was directed to the Browns Pit. Controlled discharge from the Main Sediment Dam began on February 22nd, 2018, and there was overflow from the Main Sediment Dam via the emergency spillway for a period of two days.

These observations suggest the current water management facilities in their current configuration are not adequate and that more storage capacity on site or increased treatment capacity is required. More storage could be achieved by (i) drawing down the Browns Pit prior to each Wet Season and/or (ii) releasing more water from the Main Sediment Dam when permitted to maximize available storage prior to periods of intense rainfall. It may also be prudent to evaluate whether controlled discharge could begin when EBFR flows are less than 1 m^3/s (see Section 6.2).

5.6 SURFACE WATER QUALITY IMPACTS AND CONTAMINANT LOADS

5.6.1 Contaminant Load Balance for Surface Water

Table 5-9 summarize simulated annual loads of SO_4 and Cu in surface water. Loads were calculated by multiplying representative source term concentrations by simulated annual flows from the WBM. SO_4, Cu, and Zn concentrations in rainfall runoff and in the water released from the Main Sediment Dam (see Table 4-4). For recovered groundwater, the average concentrations in groundwater from bores BH12C and BH4G in January 2018 were used.

The objective of the contaminant load balance model is to identify key sources to the WTP. A reduction in Cu and Zn loads within the WTP is represented by applying a solubility limit that simulates the removal of Cu and Zn prior to water release to the Main Sediment Dam. SO_4 is assumed to behave conservatively so no reduction in the WTP is simulated. A further reduction in loads within the Pre-Settlement Pond and/or the Main Sediment Dam is not represented.

Table 5-9. Simulated SO_4 and Cu Loads in Surface Water

Source	Flow Rate*			SO_4,	Cu,	Zn,	SO_4 Load		Cu Load	
	L/s	ML/year	Contribution	mg/L	mg/L	mg/L	t/year	Contribution	kg/year	Contribution
Flows and Loads to WTP										
From Browns Pit	8.0	252	62%	240	0.01	0.05	60	77%	3	0%
From TSF pond	0.0	0	0%	280	13	0.5	0	0%	0	0%
SRO	1.8	56	14%	8	0.05	0.02	0	1%	3	0%
PAF Ore Stockpile Pond	0.8	24	6%	330	66.0	7.2	8	10%	1,591	38%
Black Shale Stockpile	0.9	28	7%	170	8.6	1.3	5	6%	244	6%
Stockpile 3	1.4	43	11%	110	55.0	1.0	5	6%	2,365	56%
TOTAL:	**12.8**	**404**	**100%**	**-**	**-**		**78**	**100%**	**4,205**	**100%**
Removed by water treatment										
To PLS ponds	9.4	296	136%	-	-	-				
Loads in the EBFR										
From Main Sediment Dam	15.8	497	2%	120	0.013	0.021	60	1.3%	6	0.2%
From upstream/Rum Jungle	1,010	31,864	98%	140	0.128	0.172	4461	98.7%	4079	99.8%
TOTAL:	**1,026**		**100%**	**-**	**-**		**4521**	**100%**	**4085**	**100%**

The reduction in Cu and Zn loads by the WTP is simulated for completeness and does not represent the treatment process in a meaningful way. Annual Cu and Zn loads to the EBFR are also provided for completeness but the simulated loads are intended to be predictive of when or if wastewater will comply with WDL177-06.

Some key observations from the SO_4 load balance for surface water are summarized here:

- 78 t/year SO_4 is simulated to report to the WTP. About 77% of this load is related to flows pumped from the Browns Pit and the other 23% is related to rainfall runoff from the SRO and ore stockpile ponds.
- The TSF is a closed system, meaning combined inflows from runoff and flows of recovered groundwater from bores BH4G and BH12C are balanced by losses by infiltration to groundwater and evaporation. This implies that the TSF pond does not contribute a SO_4 load (or a Cu or Zn load) to the water treatment system.
- SO_4 is assumed to behave conservatively, so 78 t/year reports to the Main Sediment Dam from the processing plant. About 24% of the SO_4 load to the Main Sediment Dam is assumed to enter the groundwater system beneath the pond due to seepage. The other 76% reports to the EBFR via controlled discharge.
- The SO_4 load that reports to the EBFR from the Main Sediment Dam represents about 1.5% of the SO_4 load to the EBFR from the portion of the former Rum Jungle mine site that affects the EFDC at Site 1, i.e. the entire site except for the Old Tailings Dam area.

Some key observations from the Cu load balance for surface water are summarized here:

- ~4200 kg/year Cu is simulated to report to the WTP. 90% of this load is related to water pumped from PAF Ore Stockpile pond and the Black Shale Stockpile pond. The other 10% is from the Stockpile 3 pond. Other surface water flows, e.g. from SRO, do not contribute an appreciable Cu load.
- The simulated Cu load to the EBFR from Main Sediment Dam for the 2016/2017 Wet Season is ~6 kg/year Cu. This load roughly corresponds to a concentration that is at or below the trigger

value for Cu. To achieve this load, 99.9% of the Cu load that reports to the water treatment system is removed from wastewater.

- The annual Cu load to the EBFR from the Main Sediment Dam represents about 1.3% of the load to the EBFR from the former Rum Jungle mine site.

5.6.2 Environmental Implications of Contaminant Loads to EBFR

Water quality in the Main Sediment Dam often deteriorates after the first rainfall event each year. This is referred to as the 'first flush', as it reflects a flushing of oxidation products that likely accumulated during the later stages of the previous Wet Season and during the Dry Season. The first flush was particularly evident in November and December 2017, when concentrations that were several orders of magnitude higher than the trigger value for Cu were observed at SITE5 and comparable to Cu concentrations in the EFDC at Site 5 (see Figure 5-15 and 5-16). This is an unusual occurrence, as concentrations at SITE1 are typically much higher than at Site 5 because of the much larger loads contributed to the EFDC by ARD from the former Rum Jungle mine site.

Samples from November 22nd, 2017, were collected within hours of a 73-mm rainfall event and an additional 43-mm was received by the site between November 22nd and November 30th, 2017, when the second set of samples were collected. According to the non-compliance notification (NTR-ENV-LET-040) (see Appendix E), Middlebrook Creek began flowing around this time, contributing additional flows to the wetland. These flows are not associated with an appreciable load, but may have contributed enough water to re-dissolve accumulated oxidation products.

Further discussion of these elevated concentrations is speculative without additional information about the conditions within the Main Sediment Dam prior to the flushing event. The environmental impact of the small loads to the EBFR from the Main Sediment Dam was likely relatively minor compared to impacts by the former Rum Jungle mine site despite the unusually high concentrations of Cu and other metals in November and December 2017. This is consistent with findings from the surface water load balance, which suggests that controlled discharge from the Main Sediment Dam accounts for about 0.2% of the Cu load in the EBFR downstream of SITE5 and SITE1 at the former Rum Jungle Mine Site.

6 KEY FINDINGS AND RECOMMENDATIONS

6.1 KEY FINDINGS

Key findings from this report that pertain to groundwater are summarized here:

1. SO_4 and metal concentrations in water samples from bores BH4A and BH4B have decreased by an order-of-magnitude since 2009. Concentrations of most metals are now comparable to concentrations observed in the TSF pond, i.e. 30 mg/L Cu. The TSF pond consists of residual liquor from 2008 that has been diluted by rainfall and flows of less impacted groundwater from two recovery bores installed in 2009 and 2010.
2. Groundwater quality is not being improved by the minimal contaminant loads recovered by pumping from bores BH4G and BH12C. Instead, the MK trend analysis indicates that groundwater quality at bores BH4A and BH4B has been stable for the last five years. Previous consultants have reported 120 ML/year pumped from bores BH4G and BH12C. This flow rate (3.8 L/s annualized) could not be verified due to the lack of flow records for these bores.
3. Elevated SO_4 and metal concentrations in samples from bores BH4A, BH4B, and BH4D suggest some impacted groundwater and/or undiluted liquor has migrated beyond the southern lease boundary. The extent of contamination downgradient of bores BH4A and BH4B and the mass of contaminants that may have migrated beyond the southern lease boundary cannot be determined until additional monitoring bores and a new recovery bore have been installed in this area and appropriately monitored and pump tested.
4. Liquor lost from the TSF has impacted bores BH4A and BH4B, BH4D, BH5A and BH5B, and BH13B. Each of these bores is located within 100 m of the outer TSF berm. Groundwater from the 'TSF2' bores to the south of the TSF are not impacted by liquor losses from the TSF in 2008 or seepage from any other on-site sources, e.g. the ore stockpiles or PAF waste rock in the TSF berm.
5. A preliminary, un-calibrated load balance suggests that ~67 t/year SO_4 and 5,300 kg/year Cu may report to groundwater at the Browns site. Loads from the TSF pond account for two-thirds of the estimated SO_4 and Cu loads to groundwater. The other one-third is primarily related to seepage to groundwater from the PAF ore stockpile and the Black Shale Stockpile.
6. The current routine monitoring program does not seem appropriate given the extent of groundwater quality impacts and a program that is more focused on conditions near bores BH4A and BH4B is recommended (see Section 6.2).

Key findings from this report that pertain to surface water flows and quality are summarized here:

1. A water balance model (WBM) was developed to simulate ungauged flows to the WTP and flows from the Main Sediment Dam during controlled discharge events. The WBM simulates 404 ML of pit water and rainfall runoff to the water treatment plant (WTP) during the 2016/2017 Wet Season. The simulated annual controlled discharge volume from the Main Sediment Dam

for the 2016/2017 Wet Season was 497 ML, or approximately 6% higher than the observed volume (469 ML).

2. Flows from the Browns Pit account for two-thirds of the simulated flow to the WTP during the 2016/2017 Wet Season. The other one-third of simulated flows is related to flows from the Site Run Off (SRO) pond and the ponds that collect rainfall runoff from the existing ore stockpiles. The TSF is an enclosed basin that does not contribute any flows to the WTP.
3. A contaminant load balance for surface water indicates that flows from the Browns Pit account approximately 80% of the simulated annual SO_4 load to the WTP. Rainfall runoff from the ore stockpiles accounts for the other 20% of the SO_4 load and 100% of the simulated Cu load to the WTP.
4. At Site 5, Cu and Co are the metals that exceed their respective trigger values most frequently. There were eight occasions from December 2016 to mid-January 2018 when the Cu concentration at Site 5 was greater than or equal to a value that is two times the trigger value for Cu. There were 19 instances when the trigger value (2.5 µg/L Cu) was exceeded.
5. The highest concentrations of Cu, Co, and other metals since routine monitoring at Site 5 began were observed in November and December 2017. The high concentrations, e.g. ~2000 µg/L Cu, are attributed to a large 'first flush' event during the build up to the 2017/2018 Wet Season. Environmental impacts to the EBFR were likely minor because high concentrations in the EBFR related to seepage from the former Rum Jungle mine site also occurred at the time.
6. The WBM simulated some spillage from the water collection ponds during Cyclone Carlos in February 2011. Water management facilities and infrastructure on site have since been improved and additional changes are planned for 2018. In RGC's opinion, the Browns site may be able manage surface water flows associated with the 1 in 100-year, 72-hour rainfall event if rainfall runoff is directed to the Browns Pit and the Main Sediment Dam is used effectively to regulate water releases to the EBFR via Middlebrook Creek. Further assessment and hydrological modeling is needed to evaluate the performance of the water management system on site during this event.
7. In January 2018, the site received 460 mm of rainfall over three days. This is less than the 1 in 100-year design event as the largest one-day precipitation (225 mm) had a return period of 30 years. Some flooding occurred on site during the event but there were no water quality impacts to the EBFR and a strategy has been developed to prevent future flooding.

6.2 RECOMMENDATIONS

RGC recommends the following with respect to routine groundwater monitoring:

1. Reduce the frequency of water quality sampling for most monitoring bores to annual and continue to collect quarterly samples from bores BH4A and BH4B and the new bores recommended to support seepage remediation monitoring (see Table 6-1). The recommended

program is commensurate with current groundwater quality impacts on site and involves sampling few bores containing unimpacted groundwater, e.g. the TSF2 bores. It also better reflects the future focus on groundwater remediation monitoring.

2. Collect manual groundwater level and pit water level measurements monthly in the Dry Season and fortnightly in the Wet Season and place pressure transducers in selected bores to continuously monitor changes in groundwater levels (see Table 6-1).
3. Discontinue the analysis of groundwater samples for total metal concentrations and include a gravimetric analysis of the Total Dissolved Solids (TDS) content in the future suite of water quality parameters that are analyzed.
4. Implement a QA/QC program to check the reliability of each groundwater sample collected and re-sample groundwater if a sample is flagged as suspect, i.e. RPD (CBA) > 10%.
5. Survey the gauge height and creek bottom elevation at Station GS8150200, the staff gauge near the Browns Pit, and the TOC elevation of each bore on site after the 2018 drilling program is complete.
6. Investigate site-specific trigger values for groundwater that are supported by a statistical analysis of water quality and historic time trends and a list of specific remedial actions and/or additional monitoring that will be undertaken if a trigger value is exceeded.

RGC recommends a phased approach to the remediation of groundwater near the TSF. The Phase I objective is to further delineate the extent of impacted groundwater near the TSF and refine the local groundwater flow field near bores BH4A and BH4B. The following is recommended for the Phase I (interim) remediation strategy:

1. Complete a 24-hour pumping test of recovery bore BH4G before the next hydrogeology drilling program commences.
2. Install additional monitoring bores and a new, 150 to 200 mm diameter seepage recovery bore screened from 3 to 21 m bgs near bore BH4B.
3. Operate the new seepage recovery bore and bore BH4G as per pending recommendations in RGC's Task 2 report
4. Collect quarterly water quality samples from the new recovery bore and other new bores near bores BH4A and BH4B.
5. Deliver recovered groundwater from bore BH4G and the new recovery bore to the processing plant for treatment (not to the TSF pond) if yields exceed 1 L/s.

RGC understands that the new recovery bore and six new monitoring bores (PMB18-3A/B, PMB18-4A/B, PMB18-5, and PMB18-6) will be installed in 2018 as part of a staged implementation of the Phase I remediation strategy. The Phase II objective is to develop a final remediation strategy for impacted groundwater near the TSF. A site-wide groundwater flow model is recommended to support the Phase II remediation strategy. The model would be calibrated to current conditions since 2016 and

be used to simulate the performance of the Phase I recovery strategy and, if required, assess additional seepage recovery options, i.e. additional recovery bores, treatment of the TSF pond, etc.

Recommendations for Surface Water Management

RGC recommends the Browns Pit be used as the prime storage reservoir for contact water during periods of intense rainfall, including the 1-in-100 year, 72-hour rainfall event, and that the release of controlled discharge from the Main Sediment Dam be optimized to ensure sufficient storage capacity in this reservoir to receive treated water from the WTP. The factors that affect the live storages of the Browns Pit and the Main Sediment Dam include the following:

1. The rate that pit water can be pumped to the WTP.
2. The capacity of the WTP and when it operates.
3. The discharge threshold in the WDL, i.e. currently 1 m^3/s.
4. The rate of controlled discharge from the Main Sediment Dam.
5. Potential inflows to the pit from the EBFR if the safety berm overtops.

RGC recommends these factors be assessed to ensure the site can manage the 1-in-100 year, 72-hour rainfall event and that lesser events can be managed efficiently, i.e. with fewer pumps.

Table 6-1. Recommended Routine Groundwater Monitoring Program

Bore ID	Water Quality	Water Level Surveys	Comment/Rationale
TSF2 Monitoring Bores			
BH7A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH7B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH8A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH8B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH9A	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH9B	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH10	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
BH11	Annual	Monthly and Fortnightly (Wet Season)	Background water quality
TSF1 Monitoring Bores			
BH2A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH2B	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Improperly installed or not developed, contains 'slime' (possibly drilling mud)
BH3A	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH3B	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH4A	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly sampling for seepage recovery assessment
BH4B	Quarterly*	Monthly and Fortnightly (Wet Season)	Quarterly sampling for seepage recovery assessment
BH4D	Quarterly	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to delineate capture zone around new recovery bore
BH4E	Quarterly	Monthly and Fortnightly (Wet Season)	Impacted, may be influenced by future seepage recovery
BH5A	Annual	Monthly and Fortnightly (Wet Season)	Stable water quality, modest impact
BH5B	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to delineate capture zone around new recovery bore
BH12A	Annual	Monthly and Fortnightly (Wet Season)	Routine monitoring of bore BH12C sufficient for this area
BH12B	Annual	Monthly and Fortnightly (Wet Season)	Routine monitoring of bore BH12C sufficient for this area
BH13A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH13B	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly monitoring for seepage recovery assessment
BH14A	Not routinely monitored	Monthly and Fortnightly (Wet Season)	Typically dry, improperly installed or not developed
BH14B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH15A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH15B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH16A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH16B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH17A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH17B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH18A	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
BH18B	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
TSF1 Recovery Bores			
BH4F	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Unimpacted groundwater
BH4G	Quarterly	Monthly and Fortnightly (Wet Season)	Quarterly monitoring for seepage recovery assessment
BH4H	Annual	Monthly and Fortnightly (Wet Season)	Unimpacted groundwater
BH12C	Quarterly	Monthly and Fortnightly (Wet Season)	Not operated as recovery bore (only monitoring)
Regional Monitoring Bores or Other 'On-Site' Bores			
TPB4	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
TPB5	Annual	Monthly and Fortnightly (Wet Season) + pressure transducer	Pressure transducer to continuously monitor pit water level
RN023137	Annual	Monthly and Fortnightly (Wet Season)	Low-priority, long-term monitoring
Thompson	Annual	Quarterly	Low-priority, long-term monitoring
Thompson-Mango	Annual	Quarterly	Low-priority, long-term monitoring
Proposed bores			
New recovery bore	Monthly	Monthly and Fortnightly (Wet Season)	Seepage recovery
PMB18-3A	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring
PMB18-3B	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring
PMB18-4A	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring
PMB18-4B	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring
PMB18-5	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring
PMB18-6	Quarterly	Monthly and Fortnightly (Wet Season)	Seepage recovery monitoring

* Repairs to PVC required

7 CLOSURE

Robertson GeoConsultants Inc. (RGC) is pleased to submit this report. We trust that the information provided in this proposal meets your current requirements.

Should you have any questions, or if we can be of further assistance, please do not hesitate to contact the undersigned.

Respectfully Submitted,

ROBERTSON GEOCONSULTANTS INC.

Prepared by:

Paul Ferguson, Ph.D.

Principal Geochemist

Pat Bryan, P. Eng.

Water Resources Engineer

Reviewed by:

Christoph Wels, Ph.D., P. Geo

Principal Hydrogeologist

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MAPS

713000 714000 715000 716000 717000 718000 719000 720000 721000 722000

8566000 8565000 8564000 8563000 8562000 8561000

GS8150097

GS8150327

GS8150200

East Branch of Finniss River

West Branch of Finniss River

Old Tailings Creek

East Branch of Finniss River

Rum Jungle Mine Site

GIANT'S REEF FAULT

Upper East Branch of Finniss River

Fitch Creek

Browns Mine Site

West Branch of Finniss River

Lithology

- Whites Formation
- Geolsec Formation
- Coomalie Dolostone
- Crater Formation
- Quartz Vein
- Rum Jungle Complex

- Drainage
- Fault
- Mine Site Boundary
- Gauge

Regional Geology and Flow Gauge Locations near the Browns Mine Site

Geology adapted from Lally (2003) 1:100,000 Scale Geology Map, NT Geological Survey

N W E S

Scale 1:25,000

0 500 1,000 2,000 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 1**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 06, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map1_RegionalGeology_Feb2018.mxd	

715000
716000
717000
8563000
8562000

White's (Main) Pit
Intermediate Pit
TPB4
TPB5
GS200
RUMINTER
Browns Pit (oxide deposit)
RW_PIT
SITE1
SITE5
Intermediate WRD
WAND1
DAMOUT1
RW_BSS
RN023137
Black Shale Stockpile (BSS)
Pre-Settlement Ponds
Main Sediment Dam
White's (Main) WRD
Processing Plant Area
Offices and Car Park
TREAT01
BH17B
BH15A/B
RW_POND
BH18A/B
RW_SRO
Site Run Off (SRO) Pond
BH14A/B
BH2A/B
RWTSF
PAF Ore Stockpile
RW_PAF
DAMOUT2
SITE2
RN022085
Tailings Storage Facility (TSF)
Stockpile 3 (SP3)
BH16B
RW_SP3
BH13A/B
BH12A/B/C
BH3A/B
BH4F
BH4G
BH4A
BH4D
BH4B
BH4E
BH4H
BH5A/B
SITE4
Thompson (RN031479)
Thompson-Mango
BH9A
BH9B
BH7A
BH7B
BH8A/B

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Mine Site Boundary

N
W
E
S

Site Layout and Water Monitoring Networks

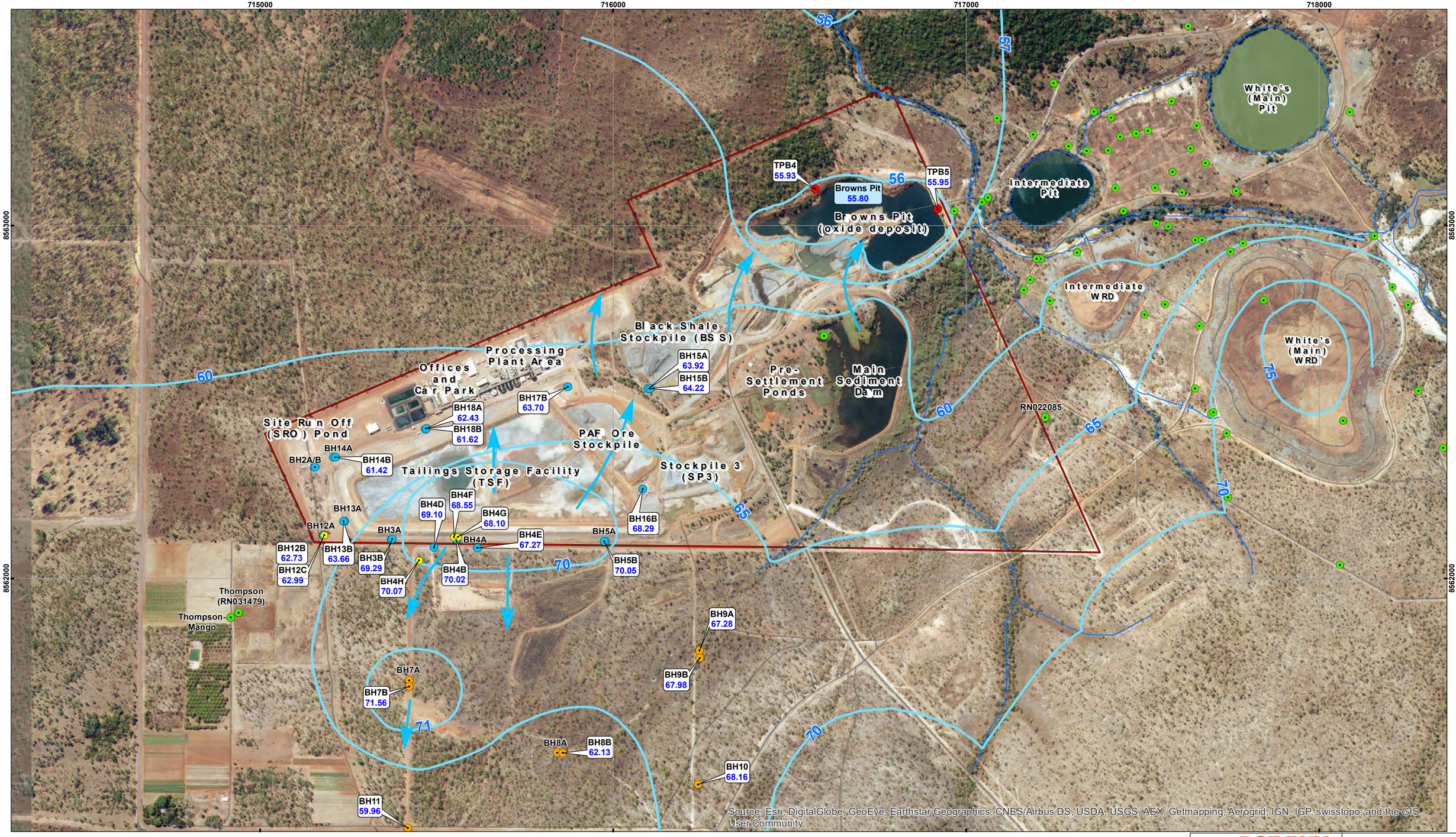
Scale 1:8,000

0 100 200 400 600 800 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 2**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map2_Browns_MonitoringNetwork_Feb2018.mxd	



Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Mine Site Boundary
- Groundwater Level
- 2017 VWP
- 2017 Monitoring Bore
- Flow Direction
- Groundwater Level (m AHD) — BH7A 73.8

N W E S

Geodetic Groundwater Levels and Inferred Contours, November 2017

Scale 1:10,000

0 50 100 200 300 400 500 600 700 800 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 3**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map3_GWL_forNov2017_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

Browns Pit (oxide deposit)

Intermediate Pit

Intermediate WRD

Processing Plant Area

Offices and Car Park

Black Shale Stockpile (BSS)

Pre-Settlement Ponds

Main Sediment Dam

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

PAF Ore Stockpile

Stockpile 3 (SP3)

Fault

Fault

RW_SRO RW_POND RWTSF RW_PAF RW_BSS RW_PIT RW_SP3 TREAT01 DAMOUT1 DAMOUT2 GS200 RUMINTER SITE1 SITE5 WAND1 SITE2 SITE4

B B' A A' C C'

BH2A/B BH7A

BH12A (12.0 m)
10-Jul-17
pH 5.9
EC, µg/L 486
SO_4, mg/L 150
Cu, µg/L 1

BH12B (21.0 m)
2-Aug-17
pH 6.4
EC, µg/L 889
SO_4, mg/L 290
Cu, µg/L 1

BH12C (22.9 m)
9-Jan-18
pH 7.6
EC, µg/L 454
SO_4, mg/L 140
Cu, µg/L 1

Thompson (40 m)
7-Jul-17
pH 6.7
EC, µg/L 336
SO_4, mg/L 2
Cu, µg/L 1

Thompson-Mango
7-Jul-17
pH 6.1
EC, µg/L 140
SO_4, mg/L 4
Cu, µg/L 1

BH13A (40.4 m)
1-Sep-16
pH -
EC, µg/L -
SO_4, mg/L 940
Cu, µg/L 3

BH13B (21.0 m)
9-Jan-18
pH 5.7
EC, µg/L 1,180
SO_4, mg/L 580
Cu, µg/L 380

BH14A (25.4 m)
18-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 790
Cu, µg/L 1

BH14B (21.4 m)
11-Jan-18
pH 6.6
EC, µg/L 474
SO_4, mg/L 230
Cu, µg/L 3

BH18A (15.0 m)
10-Jul-17
pH 5.7
EC, µg/L 332
SO_4, mg/L 76
Cu, µg/L 15

BH18B (27.4 m)
11-Jan-18
pH 5.7
EC, µg/L 1,924
SO_4, mg/L 1,200
Cu, µg/L 74

BH17B (15.3 m)
21-Apr-10
pH 6.8
EC, µg/L 2,056
SO_4, mg/L 187
Cu, µg/L 3

BH15A (24.0 m)
11-Jan-18
pH 5.1
EC, µg/L 55
SO_4, mg/L 5
Cu, µg/L 10

BH15B (50.0 m)
18-Jan-18
pH 6.6
EC, µg/L 196
SO_4, mg/L 10
Cu, µg/L 6

BH4F (50.0 m)
28-Dec-17
pH 7.3
EC, µg/L 147
SO_4, mg/L 5
Cu, µg/L 1

BH4G (24.0 m)
9-Jan-18
pH 3.8
EC, µg/L 877
SO_4, mg/L 370
Cu, µg/L 7,700

BH4A (5.8 m)
8-Jul-17
pH 2.8
EC, µg/L 1,527
SO_4, mg/L 1,400
Cu, µg/L 29,000

BH16B (15.4 m)
29-Apr-17
pH 6.0
EC, µg/L 2,797
SO_4, mg/L 1,600
Cu, µg/L 1

BH3A (5.8 m)
14-Jan-14
pH 4.2
EC, µg/L 102
SO_4, mg/L 3
Cu, µg/L 150

BH3B (20.0 m)
14-Jan-15
pH 3.8
EC, µg/L 137
SO_4, mg/L 11
Cu, µg/L 300

BH4H (23.5 m)
5-Jan-18
pH 7.2
EC, µg/L 103
SO_4, mg/L 2
Cu, µg/L 2

BH4B (20.0 m)
17-Aug-16
pH 3.3
EC, µg/L 1,201
SO_4, mg/L 1,300
Cu, µg/L 27,000

BH4D (38.5 m)
5-Jan-18
pH 3.6
EC, µg/L 381
SO_4, mg/L 120
Cu, µg/L 1,200

BH4E (40.0 m)
5-Jan-18
pH 5.7
EC, µg/L 327
SO_4, mg/L 88
Cu, µg/L 19

BH5A (5.7 m)
8-Jul-17
pH -
EC, µg/L -
SO_4, mg/L 20
Cu, µg/L 17

BH5B (20.0 m)
8-Jul-17
pH 6.3
EC, µg/L 265
SO_4, mg/L 20
Cu, µg/L 17

BH7B (30 m)
5-Jan-18
pH 6.3
EC, µg/L 145
SO_4, mg/L 5
Cu, µg/L 1

BH8A (10 m)
13-May-14
pH 6.6
EC, µg/L 147
SO_4, mg/L 2
Cu, µg/L 1

BH8B (30 m)
4-Jan-18
pH 6.9
EC, µg/L 291
SO_4, mg/L 2
Cu, µg/L 1

BH11 (24.1 m)
5-Jan-18
pH 6.7
EC, µg/L 213
SO_4, mg/L 5
Cu, µg/L 1

TPB4 (71.5 m)
9-Jan-18
pH 7.4
EC, µg/L 455
SO_4, mg/L 5
Cu, µg/L 2

TPB5 (27.0 m)
8-Jul-17
pH 7.6
EC, µg/L 1004
SO_4, mg/L 570
Cu, µg/L 1

RN023137 (40 m)
9-Oct-17
pH 6.5
EC, µg/L 568
SO_4, mg/L 130
Cu, µg/L 1

RN022085 (32 m)
23-Apr-09
pH 7.4
EC, µg/L 508
SO_4, mg/L 1
Cu, µg/L 1

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

BH10 (23.8 m)
4-Jan-18
pH 7.3
EC, µg/L 485
SO_4, mg/L 5
Cu, µg/L 1

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Mine Site Boundary
- Section Line
- Inferred Plume (High Impact)
- Inferred Plume (Moderate Impact)

Bores screened in bedrock

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

Bores screened in laterite/saprolite

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

N W E S

Selected Groundwater Quality and Cross-Section Alignments with Site Features

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 4**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map4_Browns_WQandSectionLines_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

Browns Pit (oxide deposit)

Intermediate Pit

Intermediate WRD

Black Shale Stockpile (BSS)

Processing Plant Area

Offices and Car Park

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

PAF Ore Stockpile

Pre-Settlement Ponds

Main Sediment Dam

Stockpile 3 (SP3)

Fault

RW_SRO RW_POND RWTSF RW_PAF RW_BSS RW_PIT RW_SP3

TREAT01 DAMOUT1 DAMOUT2 SITE1 SITE2 SITE4 SITE5 WAND1 RUMINTER GS200

A A' B B' C C'

BH2A/B

BH12A (12.0 m)
10-Jul-17
pH 5.9
EC, µg/L 486
SO_4, mg/L 150
Cu, µg/L 1

BH12B (21.0 m)
2-Aug-17
pH 6.4
EC, µg/L 889
SO_4, mg/L 290
Cu, µg/L 1

BH12C (22.9 m)
9-Jan-18
pH 7.6
EC, µg/L 454
SO_4, mg/L 140
Cu, µg/L 1

Thompson (40 m)
7-Jul-17
pH 6.7
EC, µg/L 336
SO_4, mg/L 2
Cu, µg/L 1

Thompson-Mango
7-Jul-17
pH 6.1
EC, µg/L 140
SO_4, mg/L 4
Cu, µg/L 1

BH14A (25.4 m)
18-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 790
Cu, µg/L 1

BH14B (21.4 m)
11-Jan-18
pH 6.6
EC, µg/L 474
SO_4, mg/L 230
Cu, µg/L 3

BH13A (40.4 m)
1-Sep-16
pH -
EC, µg/L -
SO_4, mg/L 940
Cu, µg/L 3

BH13B (21.0 m)
9-Jan-18
pH 5.7
EC, µg/L 1,180
SO_4, mg/L 580
Cu, µg/L 380

BH18A (15.0 m)
10-Jul-17
pH 5.7
EC, µg/L 332
SO_4, mg/L 76
Cu, µg/L 15

BH18B (27.4 m)
11-Jan-18
pH 5.7
EC, µg/L 1,924
SO_4, mg/L 1,200
Cu, µg/L 74

BH17B (15.3 m)
21-Apr-10
pH 6.8
EC, µg/L 2,056
SO_4, mg/L 187
Cu, µg/L 3

BH15A (24.0 m)
11-Jan-18
pH 5.1
EC, µg/L 55
SO_4, mg/L 5
Cu, µg/L 10

BH15B (50.0 m)
18-Jan-18
pH 6.6
EC, µg/L 196
SO_4, mg/L 10
Cu, µg/L 6

BH4F (50.0 m)
28-Dec-17
pH 7.3
EC, µg/L 147
SO_4, mg/L 5
Cu, µg/L 1

BH4G (24.0 m)
9-Jan-18
pH 3.8
EC, µg/L 877
SO_4, mg/L 370
Cu, µg/L 7,700

BH4A (5.8 m)
8-Jul-17
pH 2.8
EC, µg/L 1,527
SO_4, mg/L 1,400
Cu, µg/L 29,000

BH16B (15.4 m)
29-Apr-17
pH 6.0
EC, µg/L 2,797
SO_4, mg/L 1,600
Cu, µg/L 1

BH3A (5.8 m)
14-Jan-14
pH 4.2
EC, µg/L 102
SO_4, mg/L 3
Cu, µg/L 150

BH3B (20.0 m)
14-Jan-15
pH 3.8
EC, µg/L 137
SO_4, mg/L 11
Cu, µg/L 300

BH4H (23.5 m)
5-Jan-18
pH 7.2
EC, µg/L 103
SO_4, mg/L 2
Cu, µg/L 2

BH4B (20.0 m)
17-Aug-16
pH 3.3
EC, µg/L 1,201
SO_4, mg/L 1,300
Cu, µg/L 27,000

BH4D (38.5 m)
5-Jan-18
pH 3.6
EC, µg/L 381
SO_4, mg/L 120
Cu, µg/L 1,200

BH4E (40.0 m)
5-Jan-18
pH 5.7
EC, µg/L 327
SO_4, mg/L 88
Cu, µg/L 19

BH5A (5.7 m)
8-Jul-17
pH -
EC, µg/L -
SO_4, mg/L 20
Cu, µg/L 17

BH5B (20.0 m)
8-Jul-17
pH 6.3
EC, µg/L 265
SO_4, mg/L 20
Cu, µg/L 17

BH7A

BH7B (30 m)
5-Jan-18
pH 6.3
EC, µg/L 145
SO_4, mg/L 5
Cu, µg/L 1

BH11 (24.1 m)
5-Jan-18
pH 6.7
EC, µg/L 213
SO_4, mg/L 5
Cu, µg/L 1

BH8A (10 m)
13-May-14
pH 6.6
EC, µg/L 147
SO_4, mg/L 2
Cu, µg/L 1

BH8B (30 m)
4-Jan-18
pH 6.9
EC, µg/L 291
SO_4, mg/L 2
Cu, µg/L 1

TPB4 (71.5 m)
9-Jan-18
pH 7.4
EC, µg/L 455
SO_4, mg/L 5
Cu, µg/L 2

TPB5 (27.0 m)
8-Jul-17
pH 7.6
EC, µg/L 1004
SO_4, mg/L 570
Cu, µg/L 1

RN023137 (40 m)
9-Oct-17
pH 6.5
EC, µg/L 568
SO_4, mg/L 130
Cu, µg/L 1

RN022085 (32 m)
23-Apr-09
pH 7.4
EC, µg/L 508
SO_4, mg/L 1
Cu, µg/L 1

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

BH10 (23.8 m)
4-Jan-18
pH 7.3
EC, µg/L 485
SO_4, mg/L 5
Cu, µg/L 1

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Fault

Lithology

- White's Formation
- Coomalie Dolostone
- Rum Jungle Complex

Bores screened in bedrock

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

Bores screened in laterite/saprolite

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

N W E S

Selected Groundwater Quality and Cross-Section Alignments with Surficial Geology

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 5**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map5_Browns_WQandSectionLines_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

White's (Main) Pit

Intermediate Pit

Browns Pit (oxide deposit)

Intermediate WRD

White's (Main) WRD

Processing Plant Area

Offices and Car Park

Black Shale Stockpile (BSS)

Pre-Settlement Ponds

Main Sediment Dam

PAF Ore Stockpile

Stockpile 3 (SP3)

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

Thompson (RN031479)

Thompson-Mango

RUMINTER
12-Jan-17
pH 6.3
EC, µg/L 158
SO_4, mg/L 49
Cu, µg/L 55
Zn, µg/L 10

SITE1
29-May-17
pH 4.6
EC, µg/L 2,392
SO_4, mg/L 1,800
Cu, µg/L 2,000
Zn, µg/L 11,000

SITE5
15-Jun-17
pH 6.7
EC, µg/L 643
SO_4, mg/L 75
Cu, µg/L 1
Zn, µg/L 5

RW_PIT
31-Jul-17
pH 7.6
EC, µg/L 644
SO_4, mg/L 240
Cu, µg/L 10
Zn, µg/L 45

RW_BSS
27-Apr-17
pH 4.1
EC, µg/L 545
SO_4, mg/L 110
Cu, µg/L 55,000
Zn, µg/L 990

RW_SRO
27-Apr-17
pH 6.3
EC, µg/L 42
SO_4, mg/L 8
Cu, µg/L 45
Zn, µg/L 22

RW_POND
31-Jul-17
pH 7.2
EC, µg/L 7
SO_4, mg/L 240
Cu, µg/L 19
Zn, µg/L 36

TREAT1
27-Apr-17
pH 9.6
EC, µg/L 810
SO_4, mg/L 140
Cu, µg/L 3
Zn, µg/L 5

RW_PAF
27-Apr-17
pH 3.8
EC, µg/L 670
SO_4, mg/L 330
Cu, µg/L 66,000
Zn, µg/L 7,200

RW_TSF
27-Apr-17
pH 4.6
EC, µg/L 703
SO_4, mg/L 280
Cu, µg/L 13,000
Zn, µg/L 530

RW_SP3
27-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 170
Cu, µg/L 8,600
Zn, µg/L 1,300

DAMOUT1
22-Feb-17
pH 7.1
EC, µg/L 317
SO_4, mg/L 98
Cu, µg/L 11
Zn, µg/L 18

SITE2
22-Feb-17
pH 7.7
EC, µg/L 326
SO_4, mg/L 98
Cu, µg/L 89
Zn, µg/L 38

SITE4
14-Apr-17
pH 7.2
EC, µg/L 41
SO_4, mg/L 2
Cu, µg/L 1
Zn, µg/L 5

RN023137

RN022085

TPB4

TPB5

BH17B

BH15A/B

BH18A/B

BH14A/B

BH2A/B

BH16B

BH13A/B

BH12A/B/C

BH3A/B

BH4F

BH4G

BH4D

BH4A

BH4B

BH4E

BH5A/B

BH4H

BH9A

BH9B

BH7A

BH7B

BH8A/B

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Section Line
- Mine Site Boundary

N W E S

Selected Surface Water Quality Data, 2017

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 6**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map6_Browns_SWS-WQ_Feb2018.mxd	

715000 715500 716000 716500

8562500 8562000

Processing Plant Area
Offices and Car Park
Black Shale Stockpile (BSS)
Main Sediment Dam
Pre-Settlement Ponds
Site Run Off (SRO) Pond
PAF Ore Stockpile
Stockpile 3 (SP3)
Tailings Storage Facility (TSF)
New Recovery Bore

PMB18-11
PMB18-10
PMB18-9A/B
PMB18-8A/B
PMB18-5
PMB18-6
PMB18-7A/B
PMB18-4A/B
PMB18-1A/B
PMB18-3A/B
PMB18-2A/B

BH17B
BH15A/B
BH18A/B
BH14A/B
BH2A/B
BH16B
BH13A/B
BH12A/B/C
BH3A/B
BH4G
BH4F
BH4B
BH4A
BH4E
BH4D
BH4H
BH5A/B

RN023137
Thompson (RN031479)
Thompson-Mango

Bore ID	Easting GDA 1994 MGA Zone 52	Northing GDA 1994 MGA Zone 52
New Recovery Bore	715556	8562112
PMB18-1A/B	715708	8562013
PMB18-2A/B	715513	8561907
PMB18-3A/B	715531	8561985
PMB18-4A/B	715545	8562051
PMB18-5	715471	8562114
PMB18-6	715623	8562109
PMB18-7A/B	715827	8562100
PMB18-8A/B	715650	8562189
PMB18-9A/B	715656	8562303
PMB18-10	715416	8562567
PMB18-11	715814	8562734

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AE... User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Proposed Recovery Bore
- Proposed Monitoring Bore
- Fault

Lithology

- White's Formation
- Coomalie Dolostone
- Rum Jungle Complex

N W E S

Proposed Drilling Locations

Scale 1:5,000

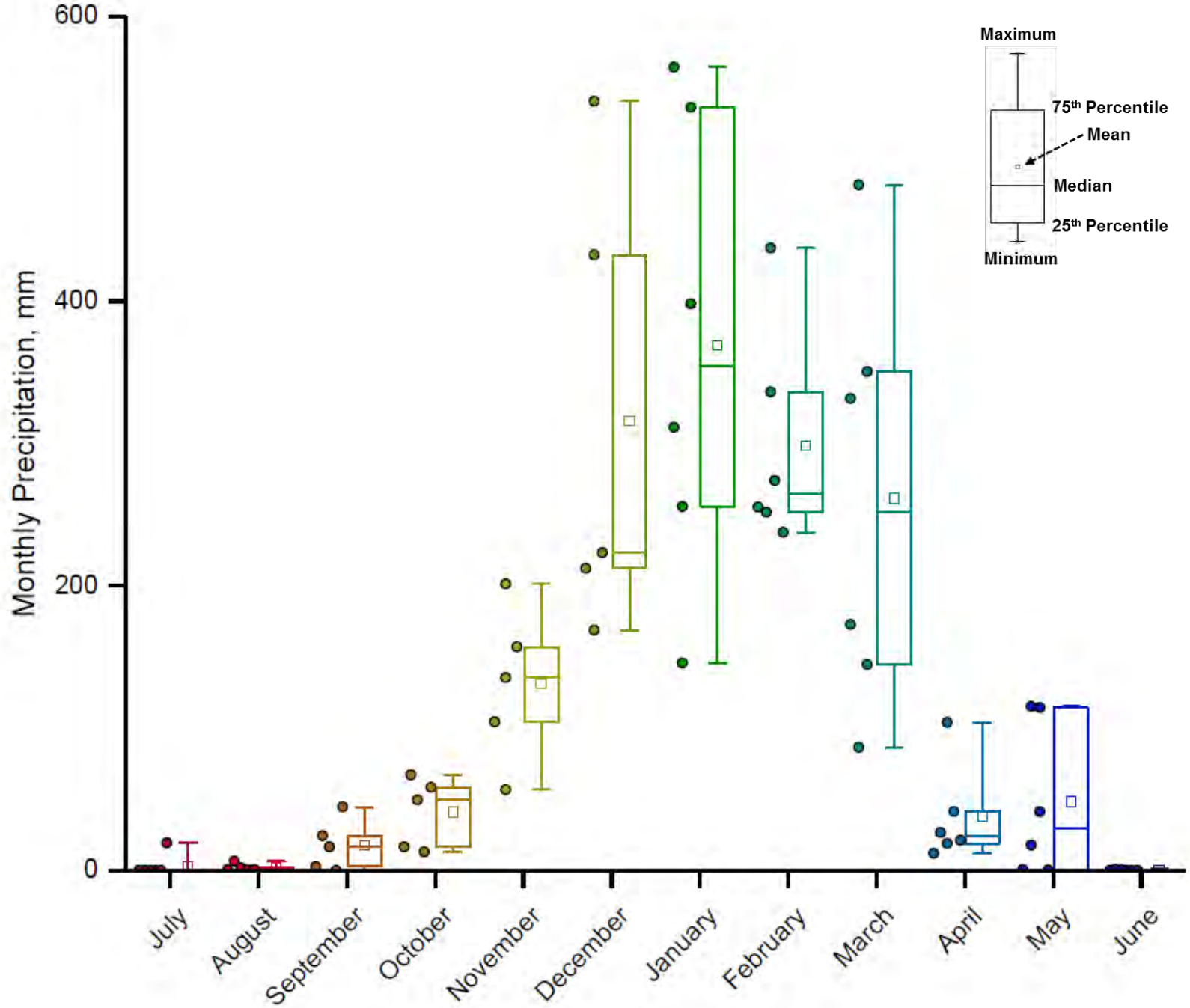
0 50 100 200 300 400 500 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 7**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map7_ProposedDrillingLocations_Feb2018.mxd	

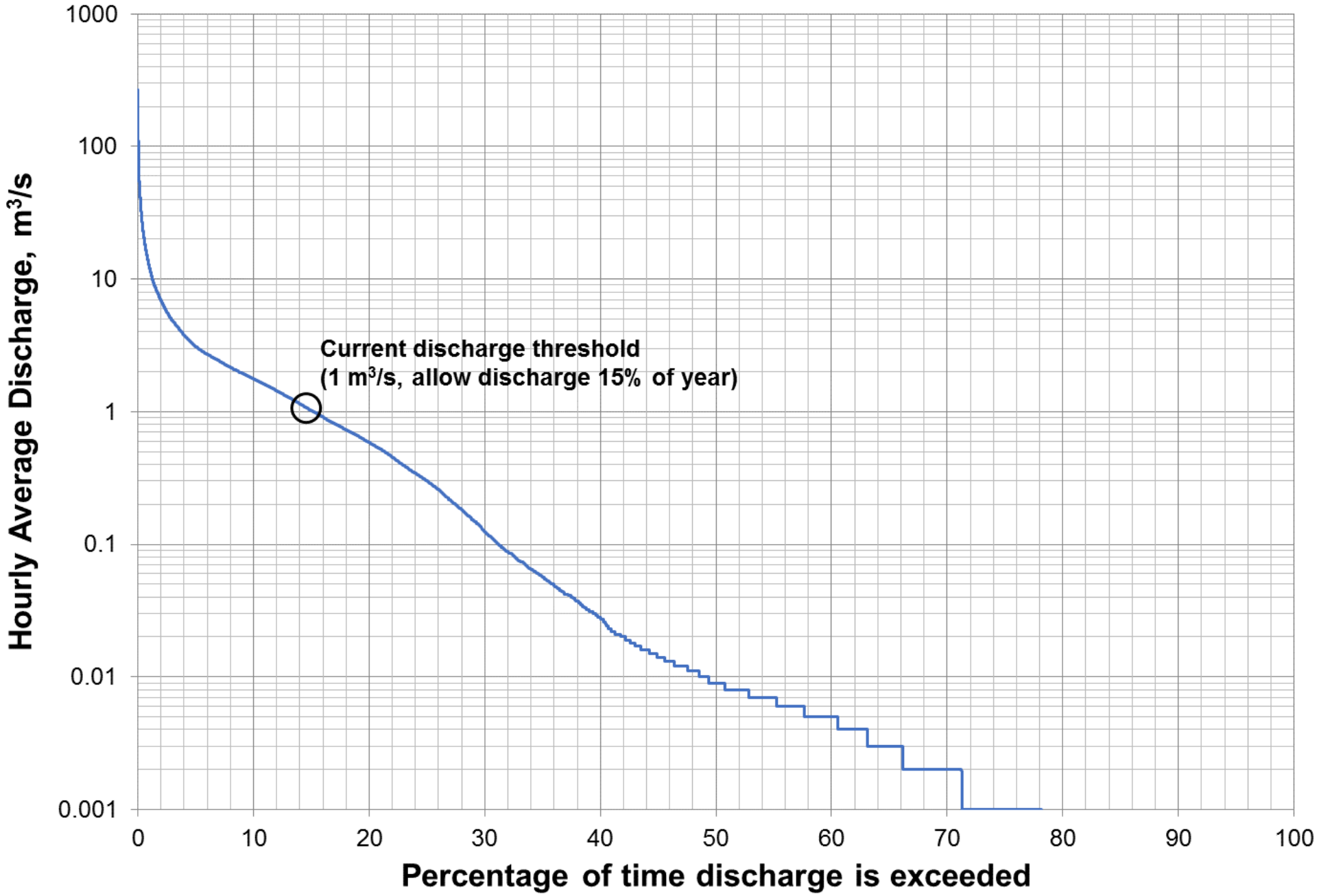
FIGURES



Box Plots of Monthly Rainfall, 2012 to 2017

Client: DOE RUN AUSTRALIA NL	**Figure: 2-1**
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

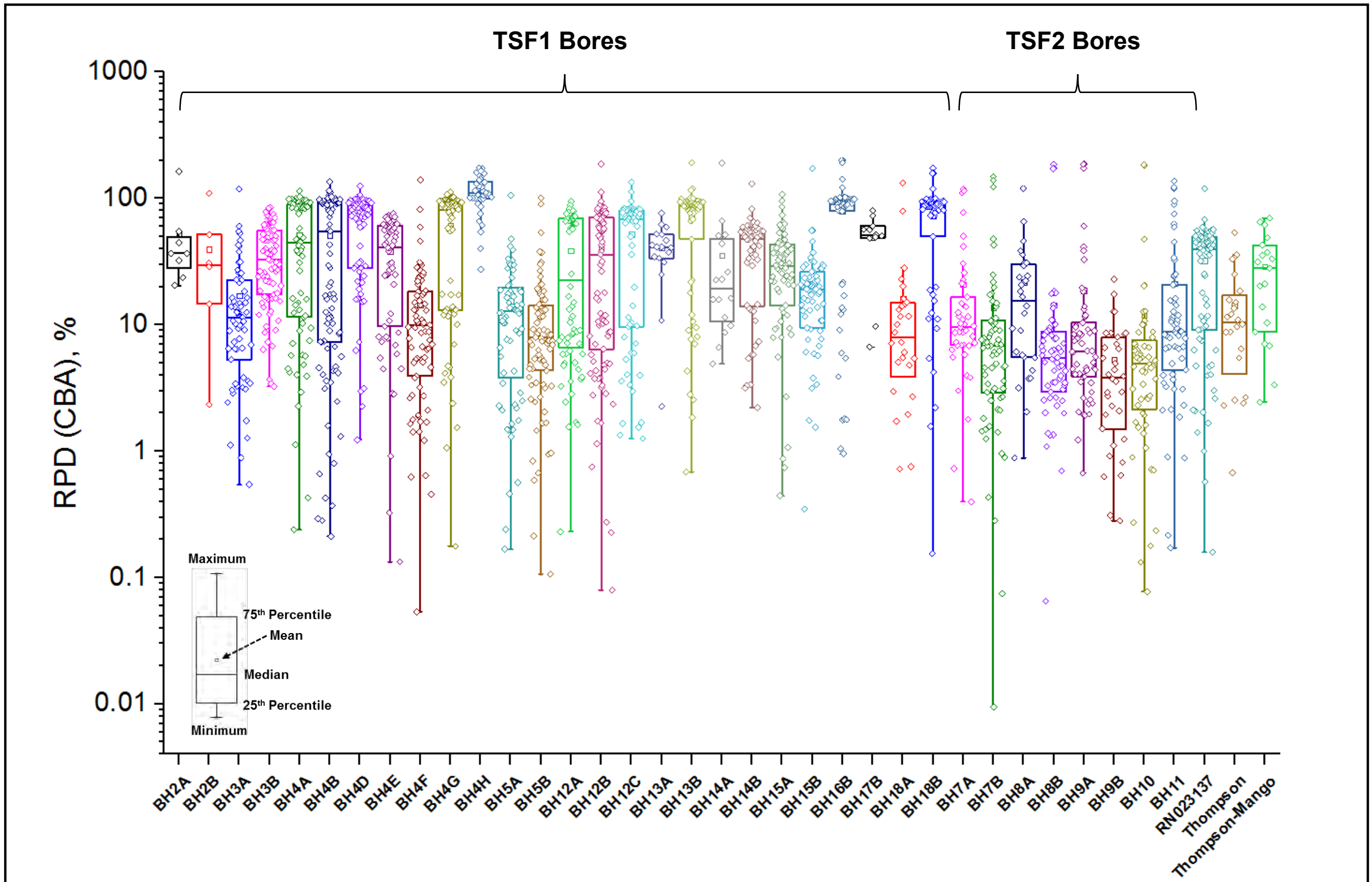
Robertson GeoConsultants Inc.



Hourly Flow-Duration Curve for EBFR at Station GS8150200

Client: DOE RUN AUSTRALIA NL	**Figure: 2-2**
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

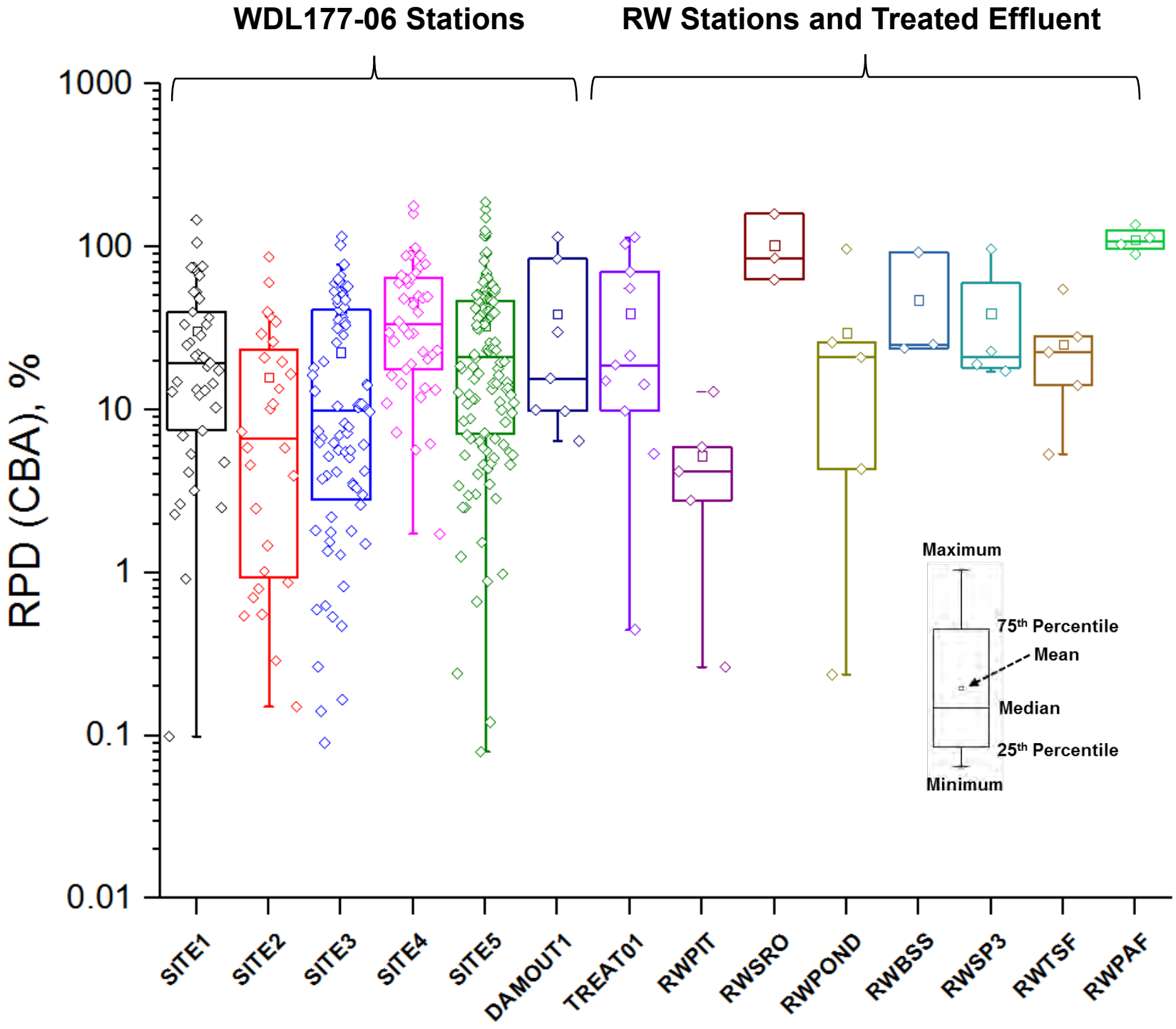
Robertson GeoConsultants Inc.



Box Plots – RPD Values for Charge Balance Analysis (CBA) for Groundwater Samples, 2008 to 2018

Client: DOE RUN AUSTRALIA NL	Figure: 3-1
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

Robertson GeoConsultants Inc.



Box Plot – RPD Values for Charge Balance Analysis (CBA) for Surface Water Samples, 2008 to 2018

Client: DOE RUN AUSTRALIA NL	Figure: 3-2
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

Robertson GeoConsultants Inc.

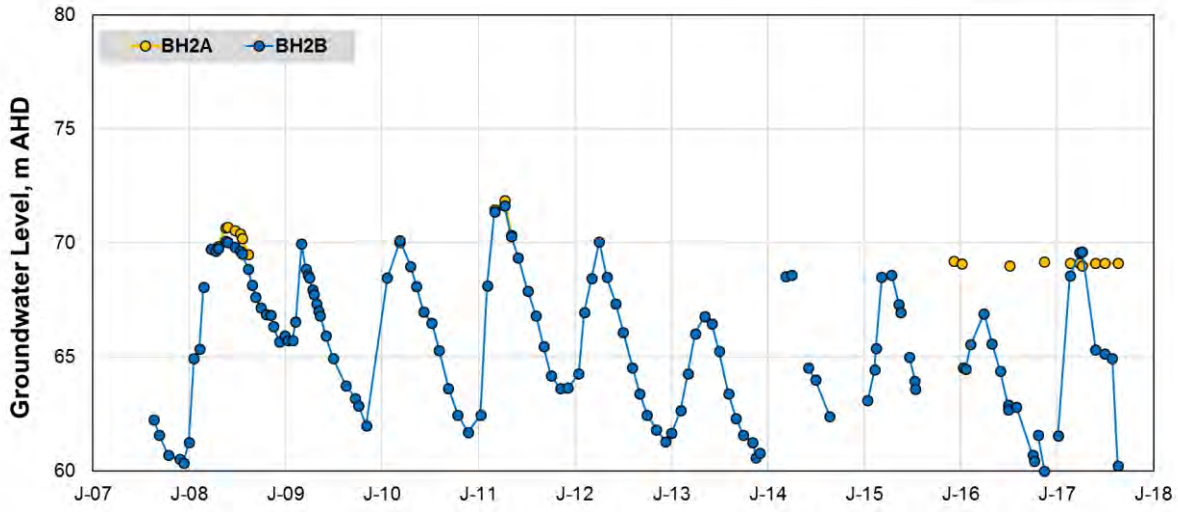


Figure 4-1. Groundwater Levels from Bores BH2A and BH2B, 2007 to 2018

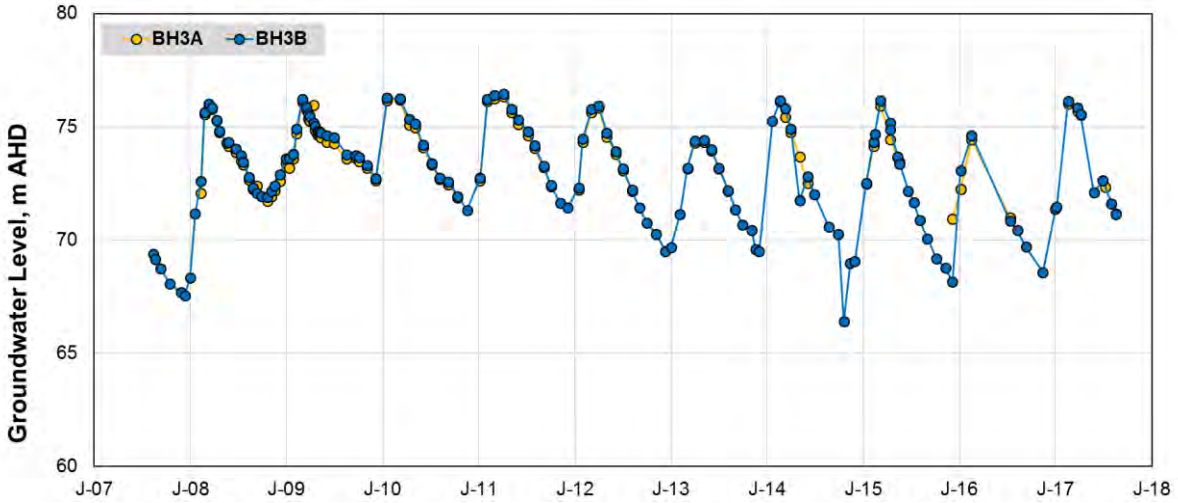


Figure 4-2. Groundwater Levels from Bores BH3A and BH3B, 2007 to 2018

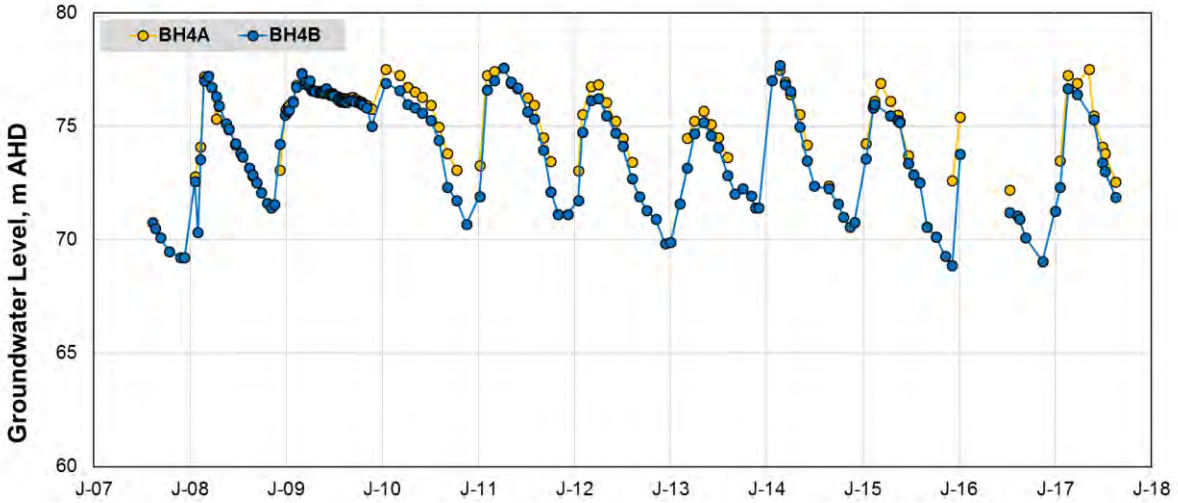


Figure 4-3. Groundwater Levels from Bores BH4A and BH4B, 2007 to 2018.

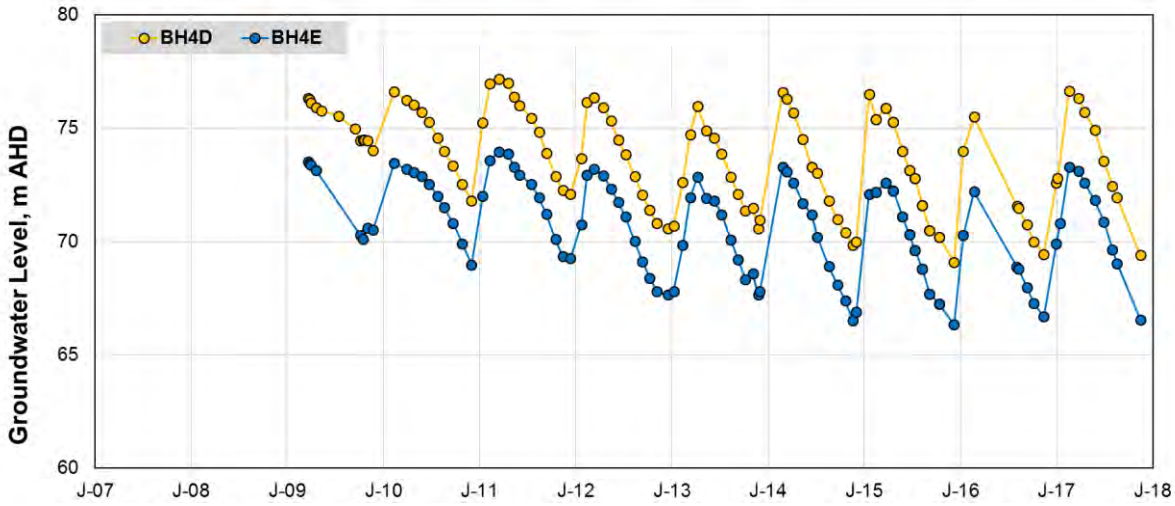


Figure 4-4. Groundwater Levels from Bores BH4D and BH4E, 2009 to 2018

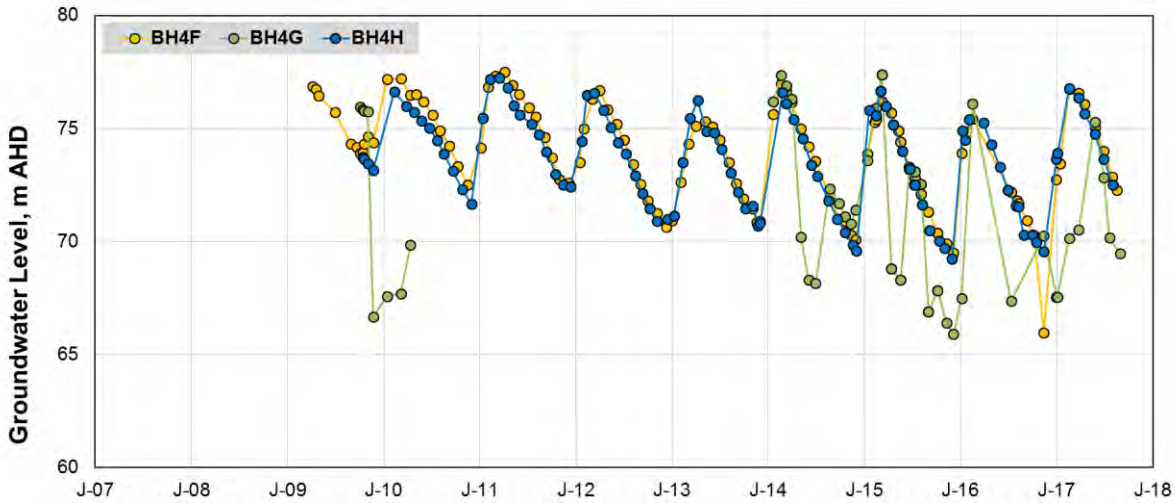


Figure 4-5. Groundwater Levels from Bores BH4F, BH4G, and BH4H, 2009 to 2018

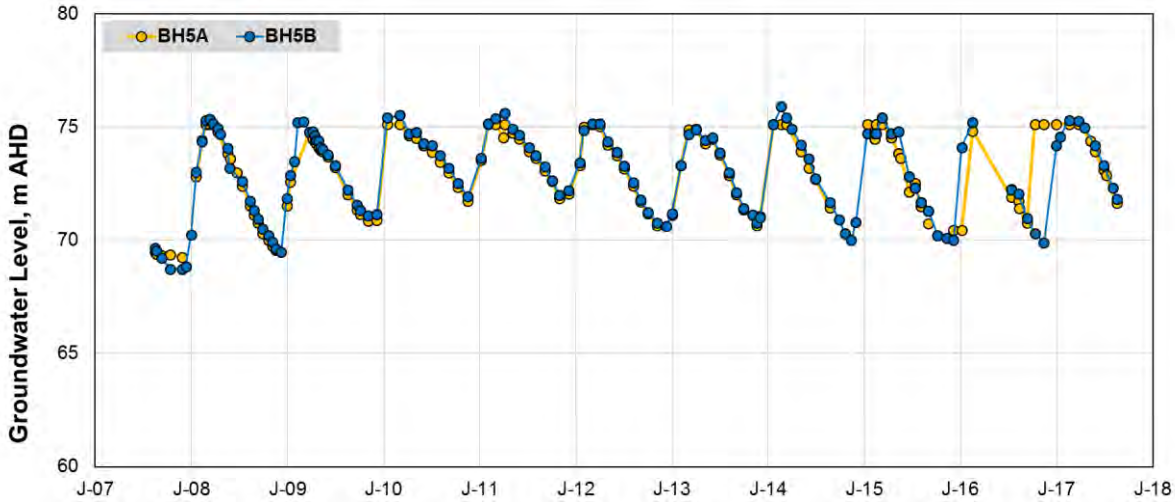


Figure 4-6. Groundwater Levels from Bores BH5A and BH5B, 2007 to 2018

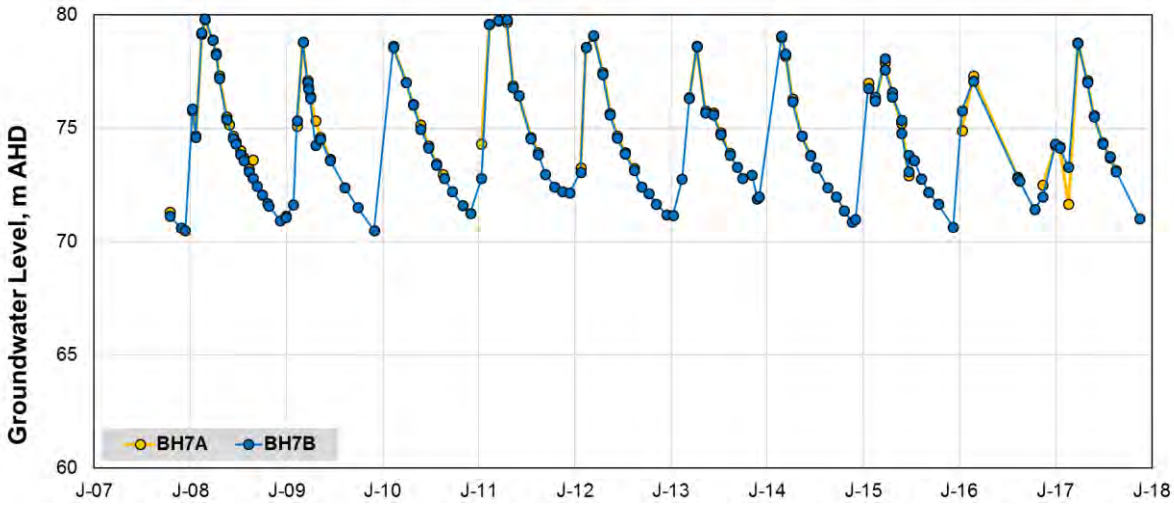


Figure 4-7. Groundwater Levels from Bores BH7A and BH7B, 2007 to 2018

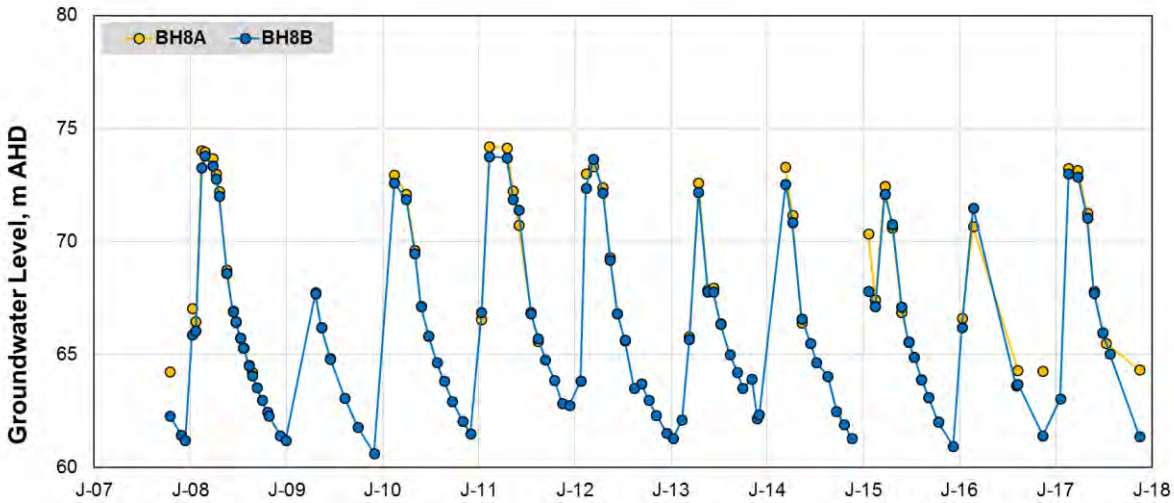


Figure 4-8. Groundwater Levels from Bores BH8A and BH8B, 2007 to 2018

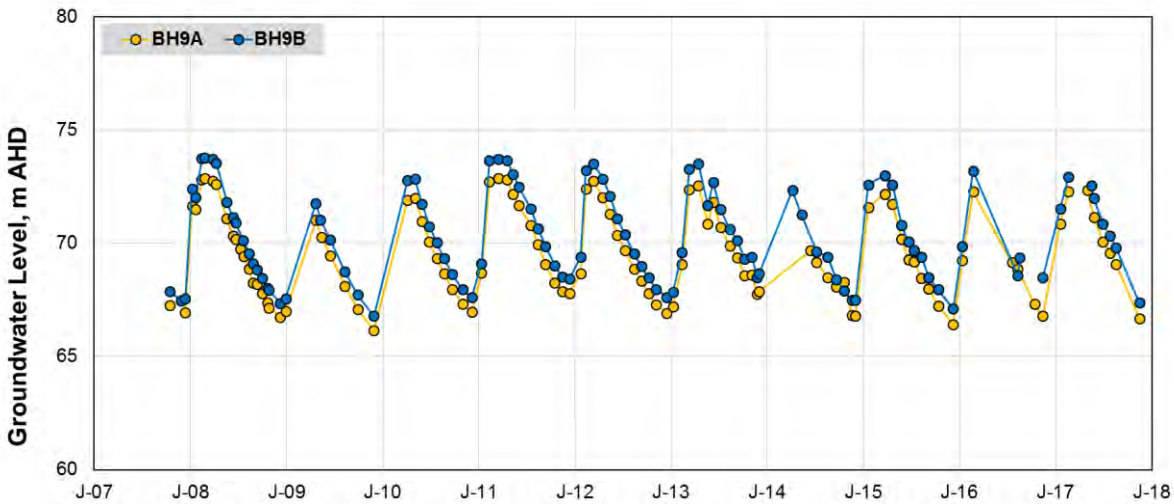


Figure 4-9. Groundwater Levels from Bores BH9A and BH9B, 2007 to 2018

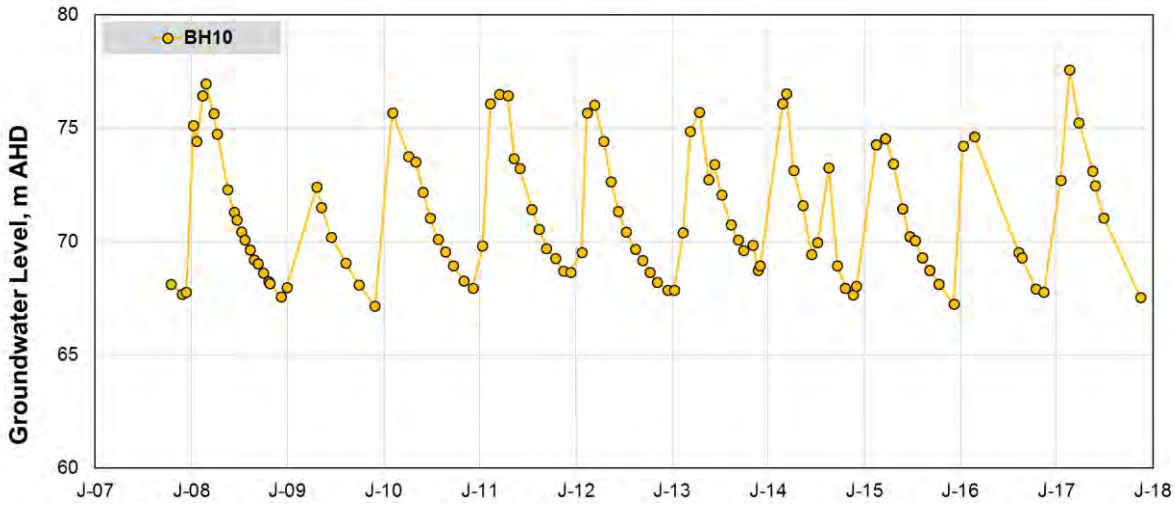


Figure 4-10. Groundwater Levels from Bore BH10, 2007 to 2018

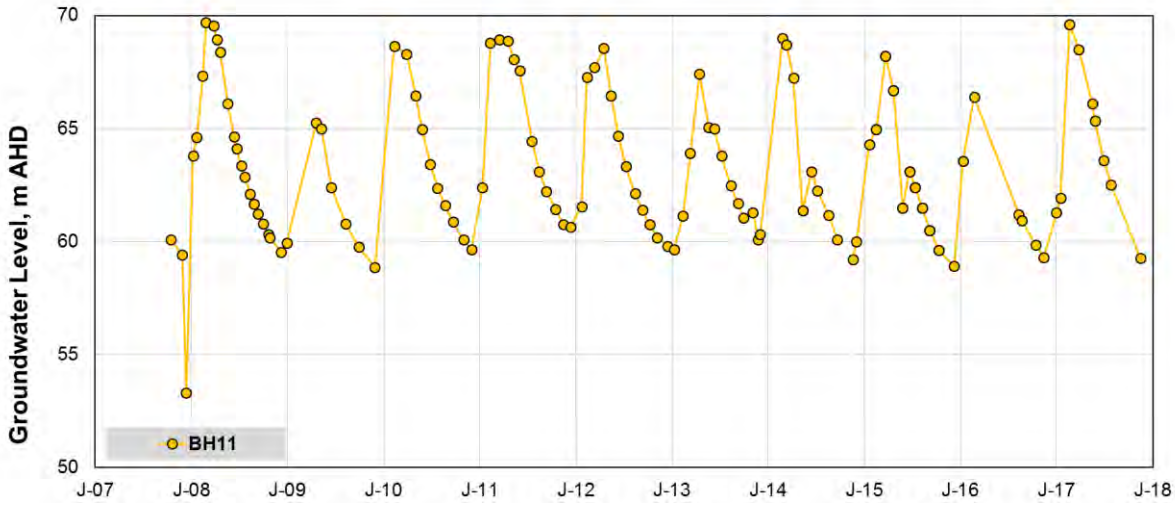


Figure 4-11. Groundwater Levels from Bore BH11, 2007 to 2018

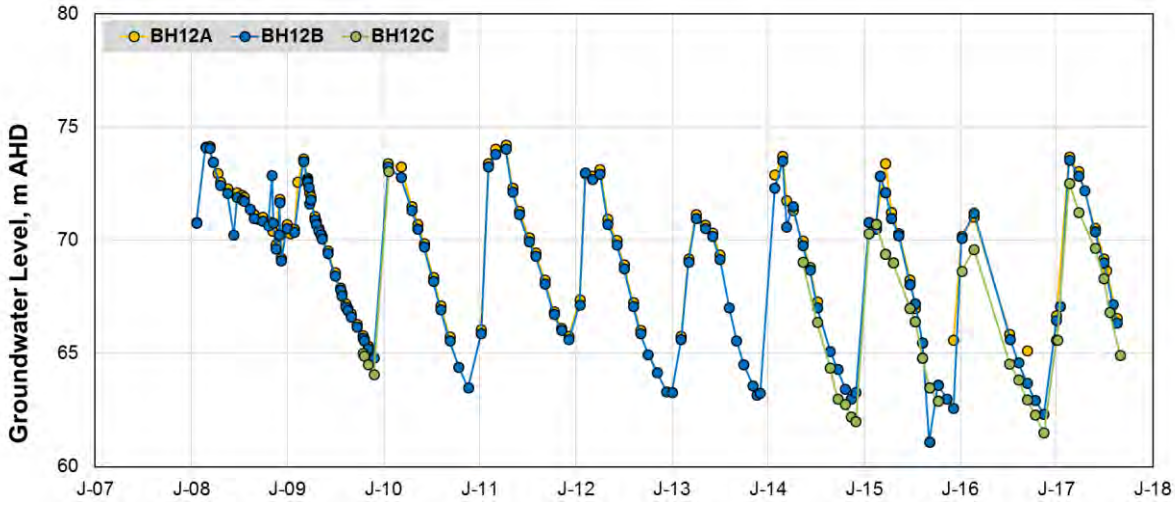


Figure 4-12. Groundwater Levels from Bores BH12A, BH12B, and BH12C, 2008 to 2018

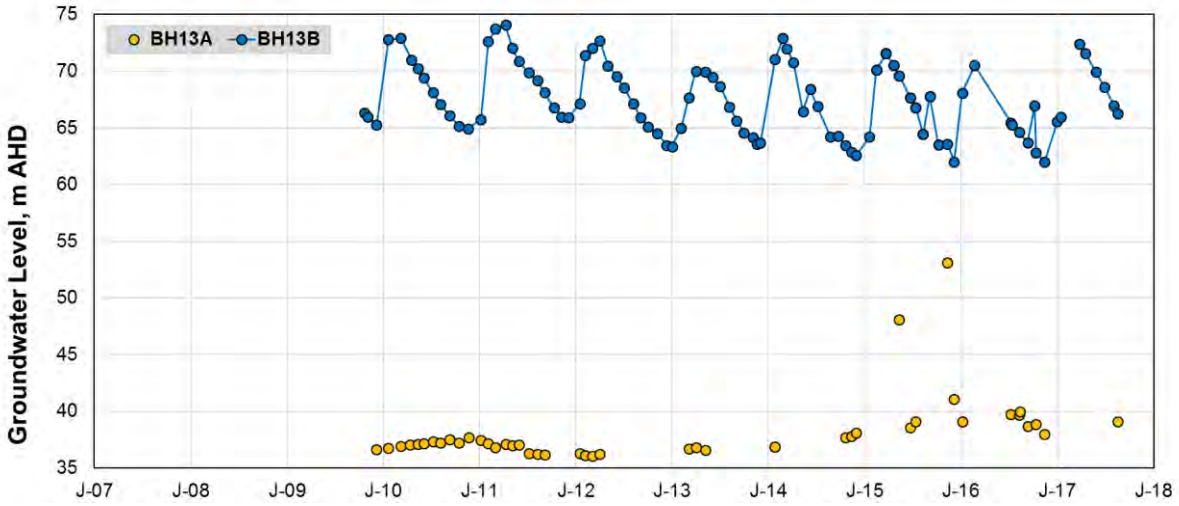


Figure 4-13. Groundwater Levels from Bores BH13A and BH13B, 2009 to 2018

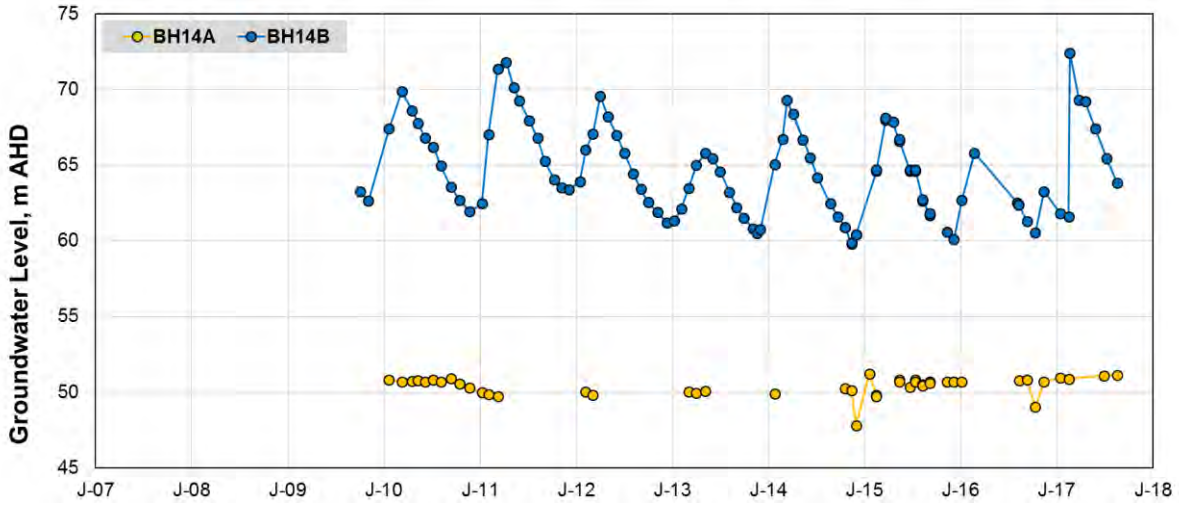


Figure 4-14. Groundwater Levels from Bores BH14A and BH14B, 2009 to 2018

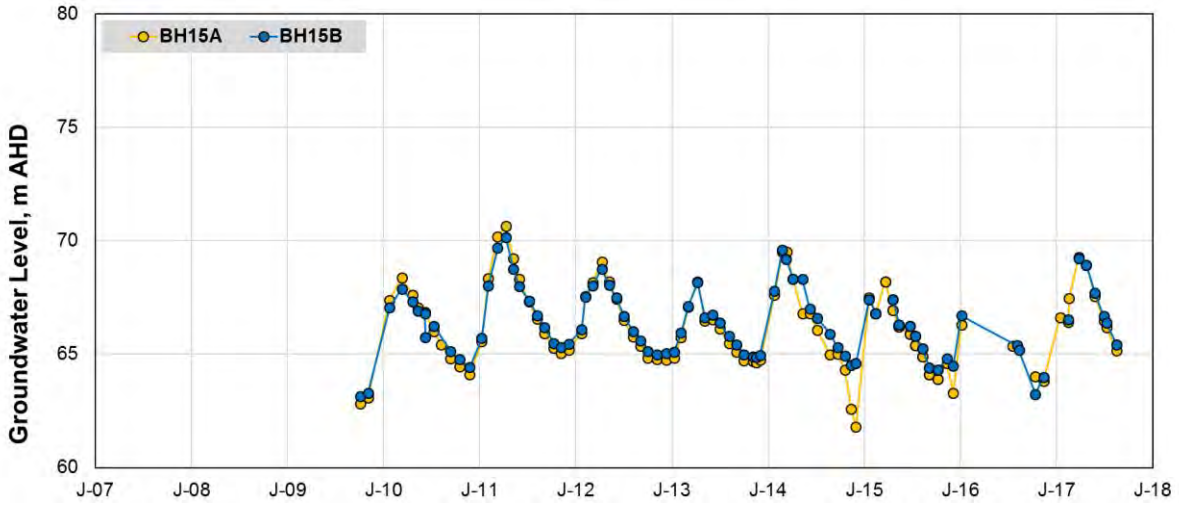


Figure 4-15. Groundwater Levels from Bores BH15A and BH15B, 2009 to 2018

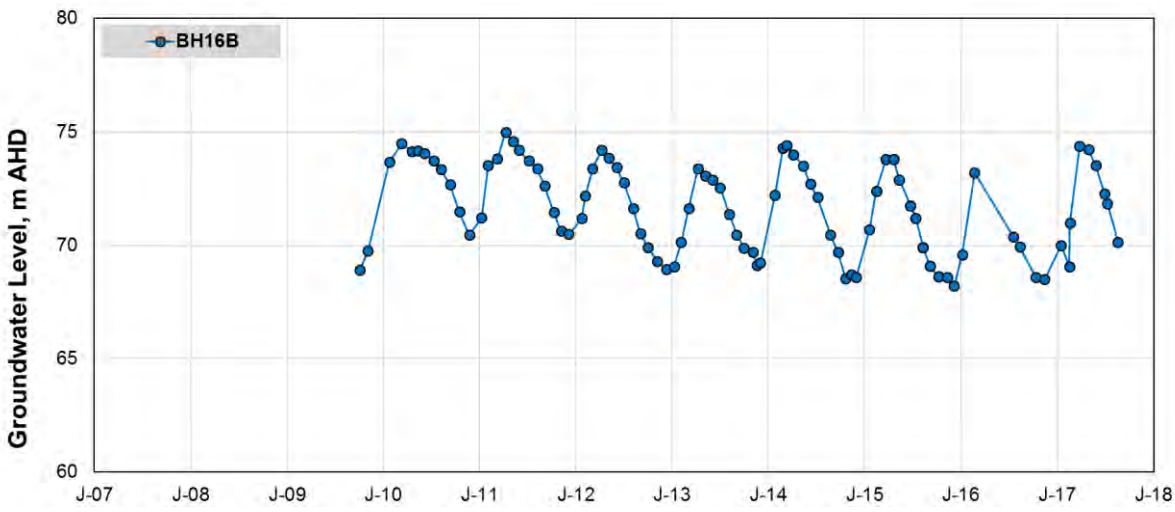


Figure 4-16. Groundwater Levels from Bore BH16B, 2009 to 2018

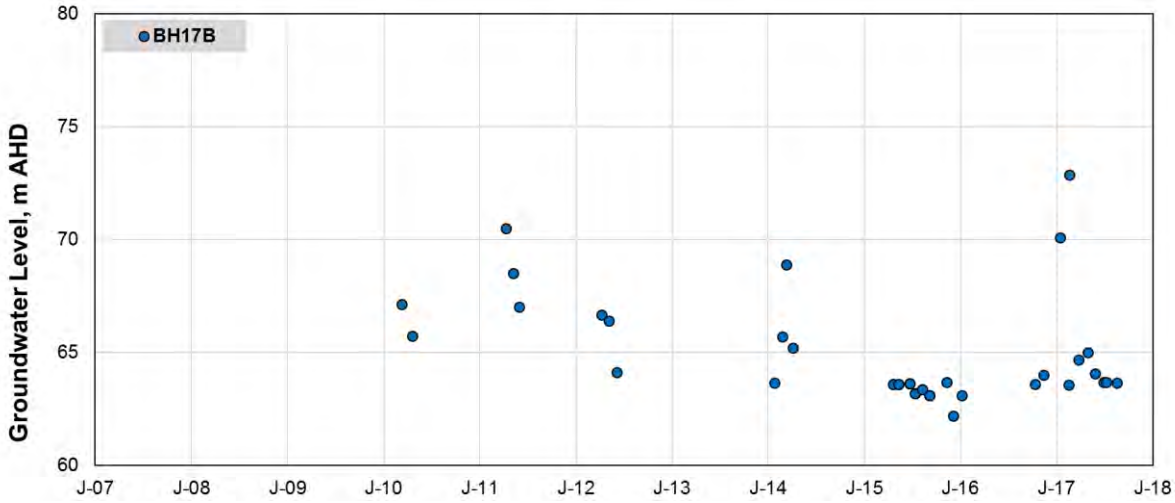


Figure 4-17. Groundwater Levels from Bore BH17B, 2009 to 2018

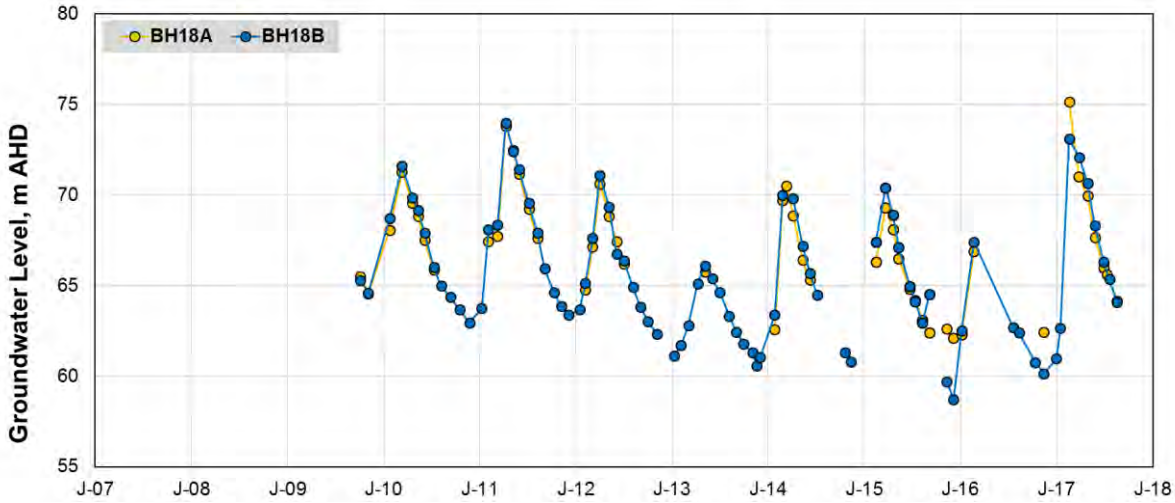


Figure 4-18. Groundwater Levels from Bores BH18A and BH17B, 2009 to 2018

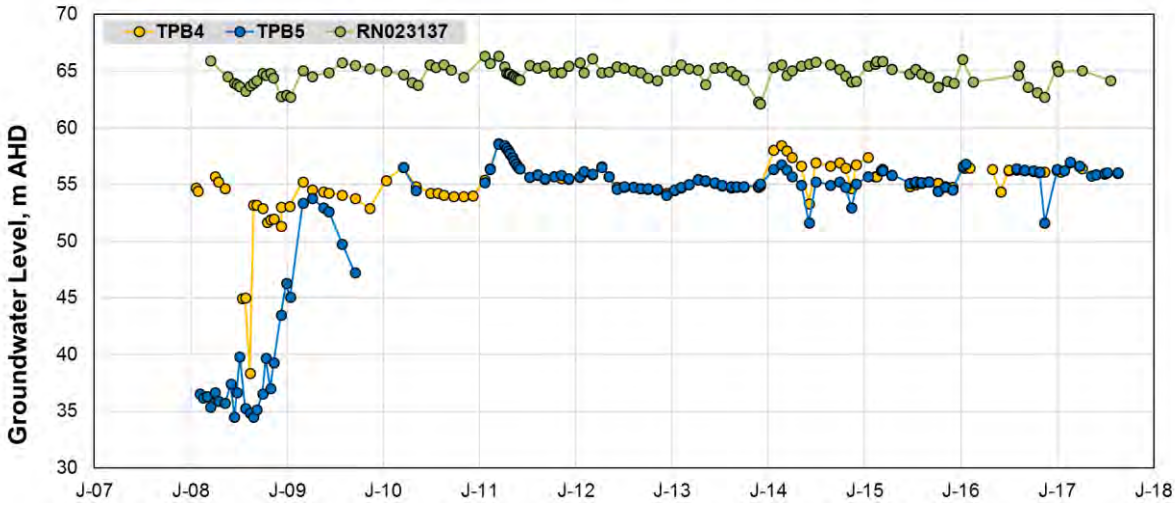


Figure 4-19. Groundwater Levels from Bores TPB4, TPB5 and RN023137, 2008 to 2018

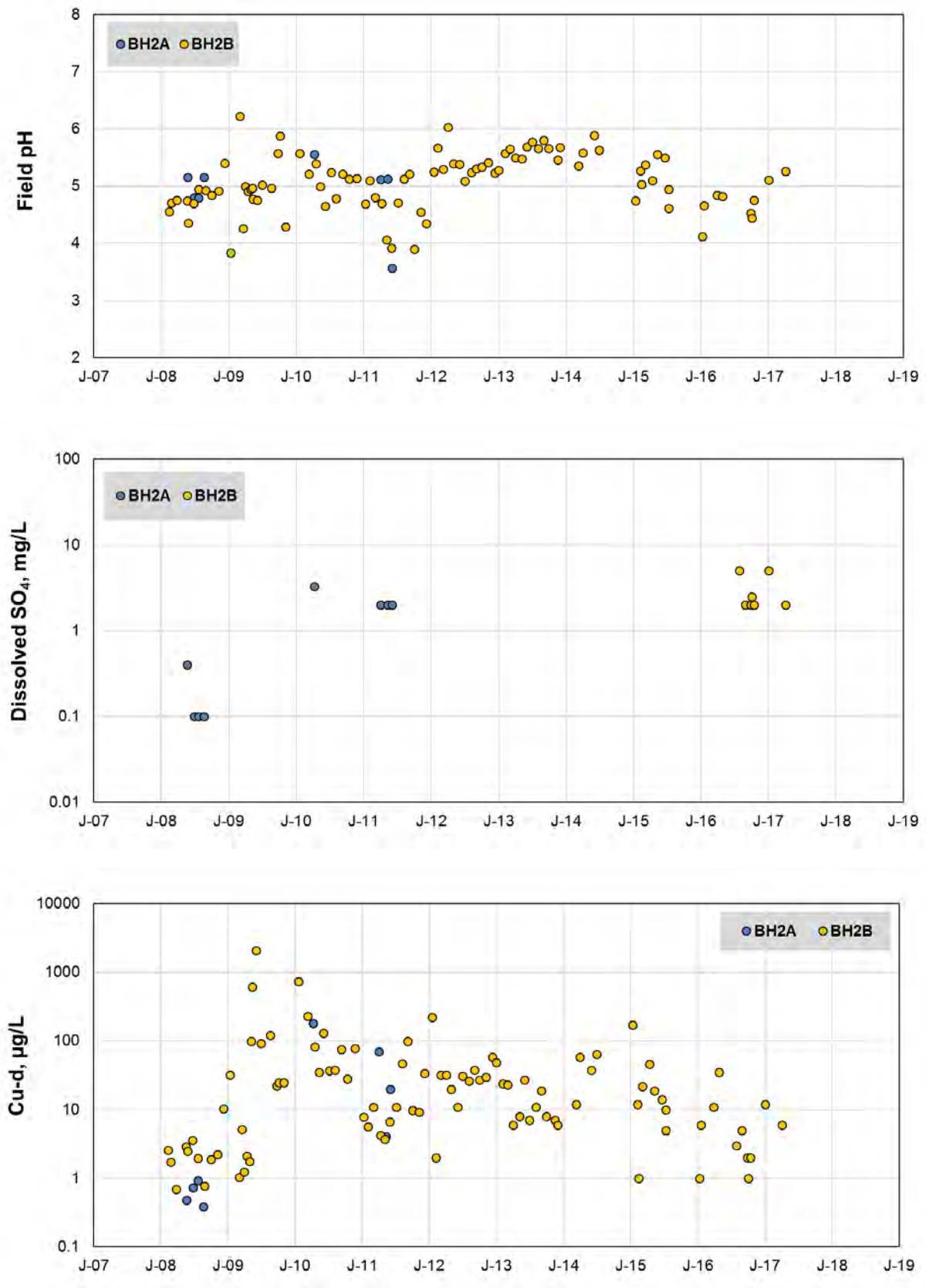


Figure 4-20. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH2A and BH2B, 2008 to 2018

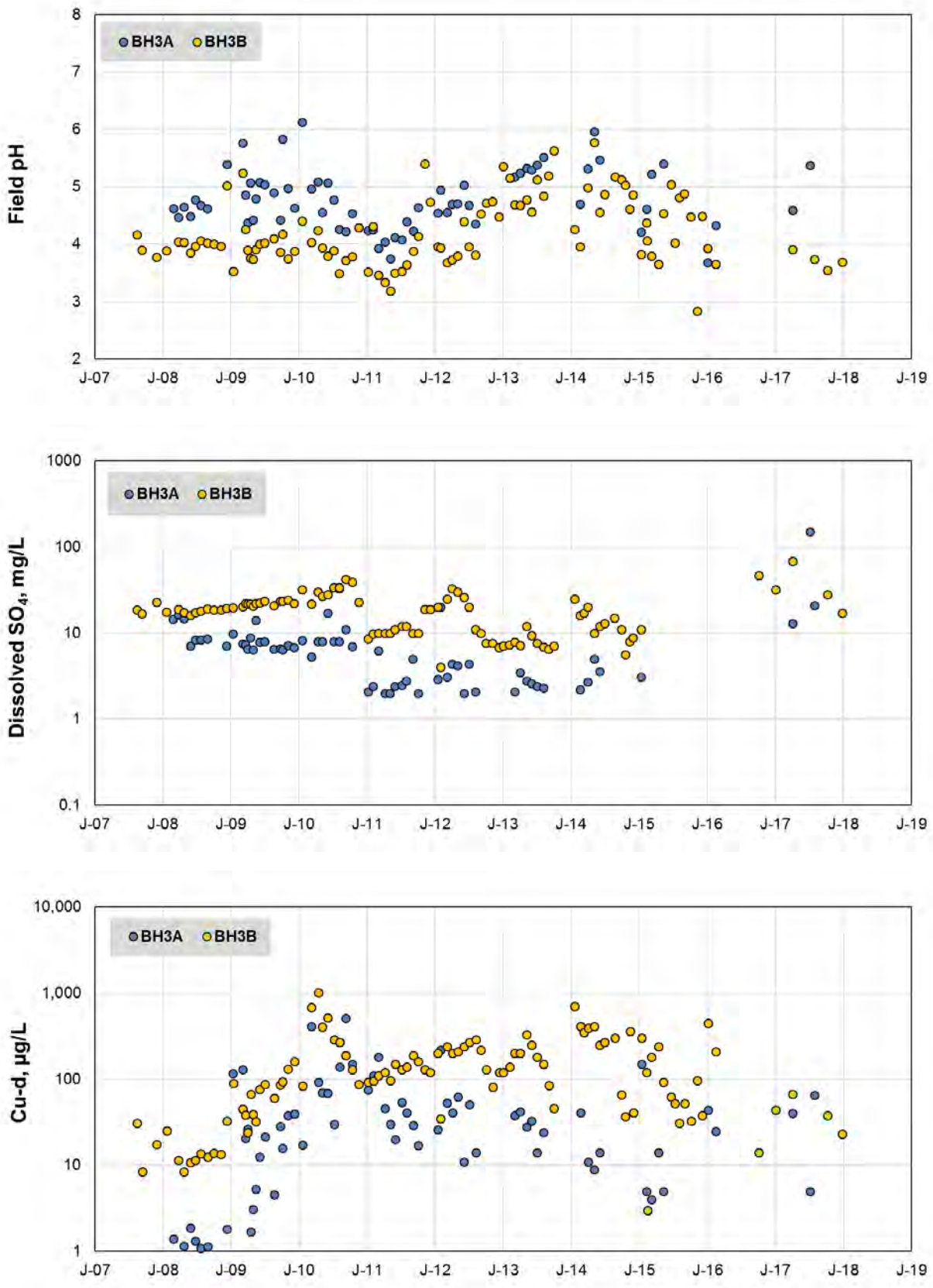


Figure 4-21. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH3A and BH3B, 2008 to 2018

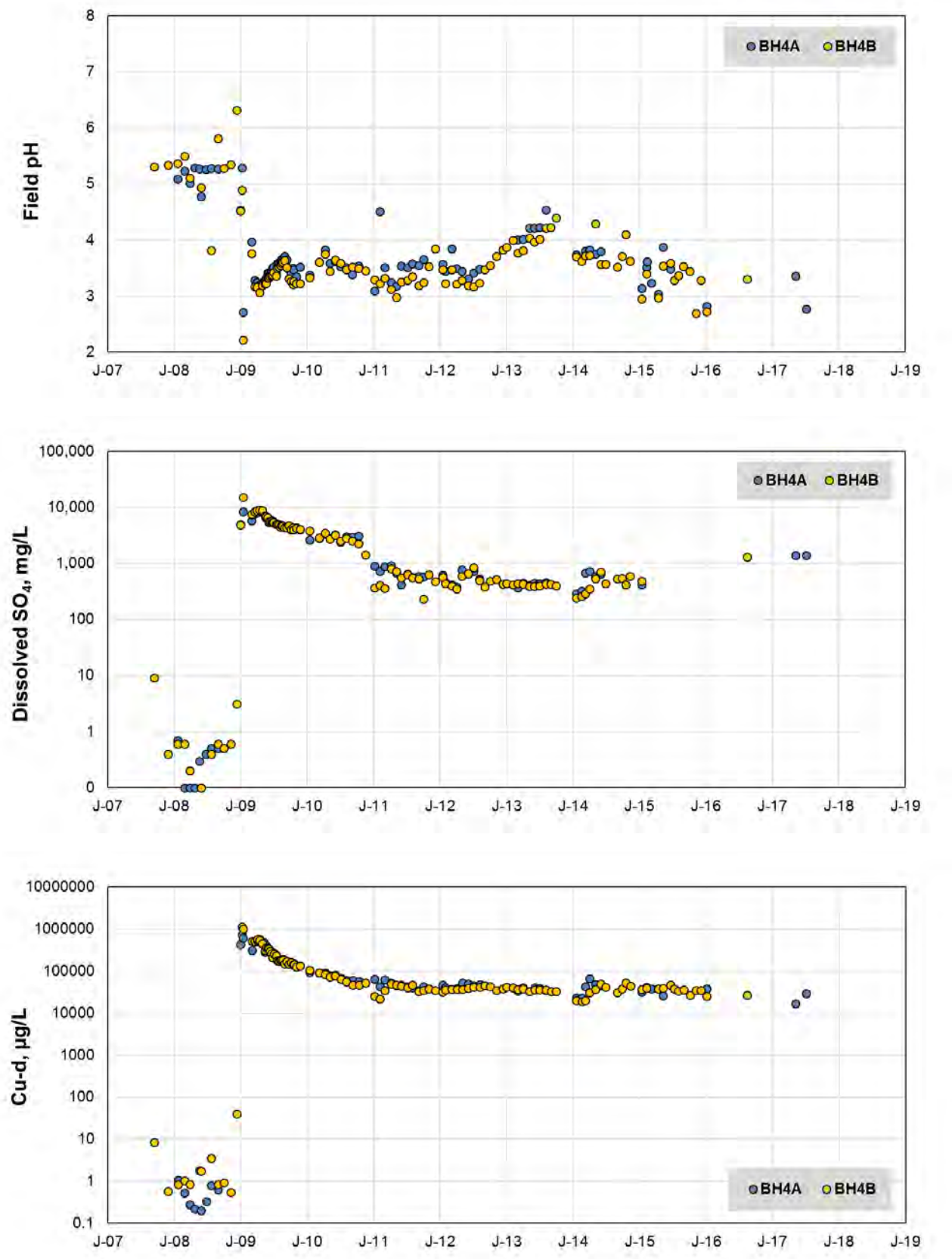


Figure 4-22. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH4A and BH4B, 2008 to 2018

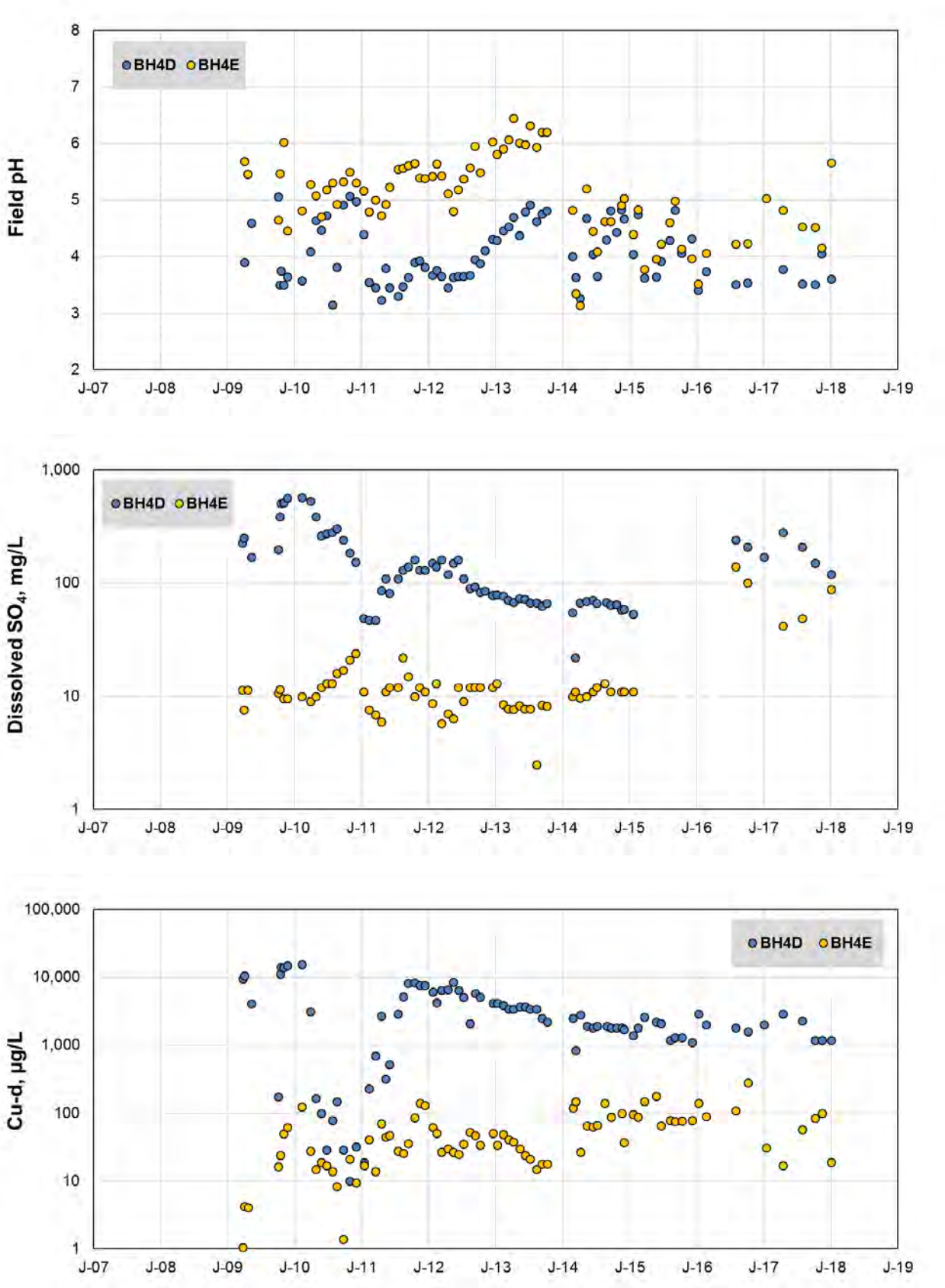


Figure 4-23. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH4D and BH4E, 2008 to 2018

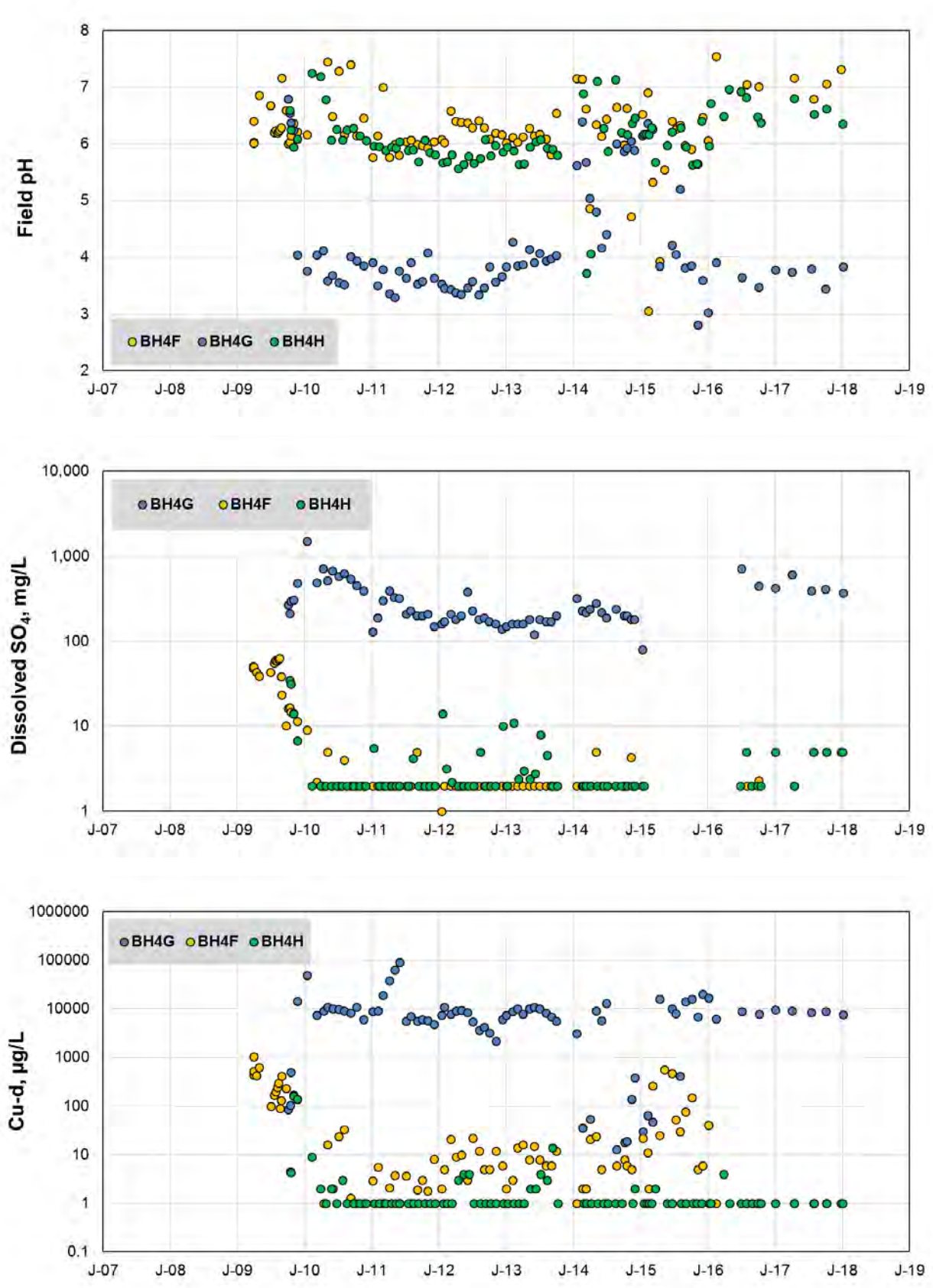


Figure 4-24. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH4F, BH4G, and BH4H, 2008 to 2018

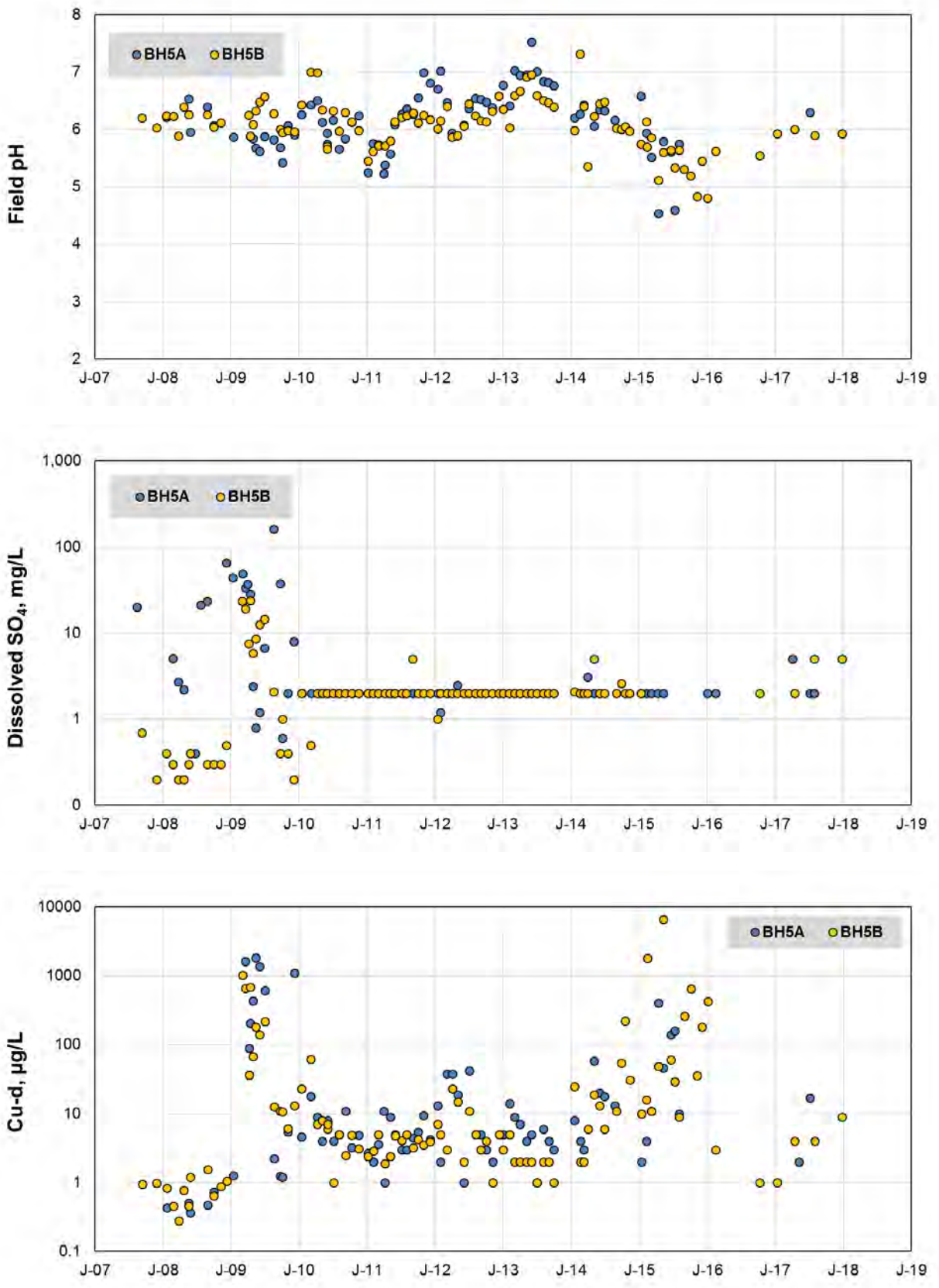


Figure 4-25. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH5A and BH5B, 2008 to 2018

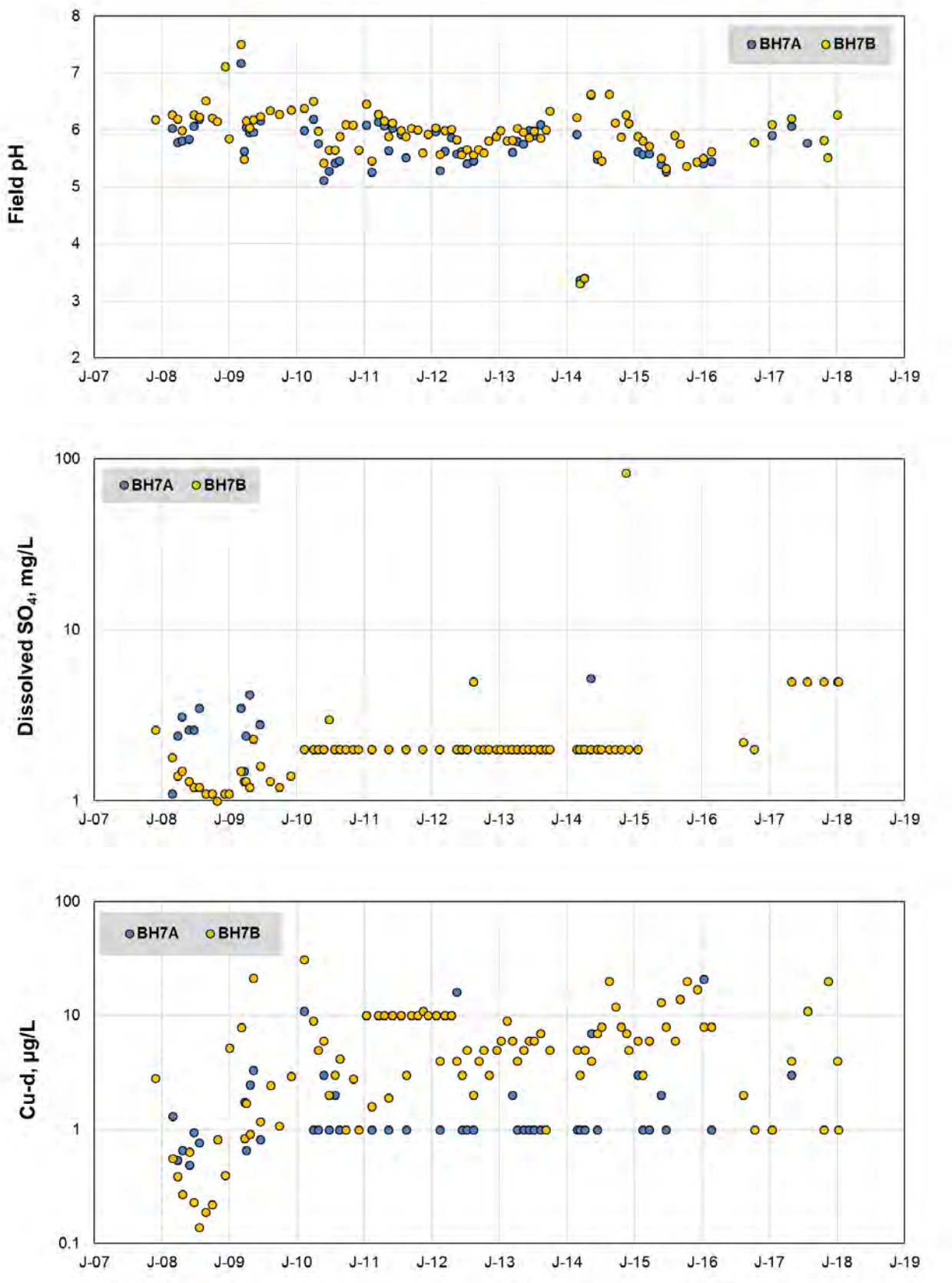


Figure 4-26. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH7A and BH7B, 2008 to 2018

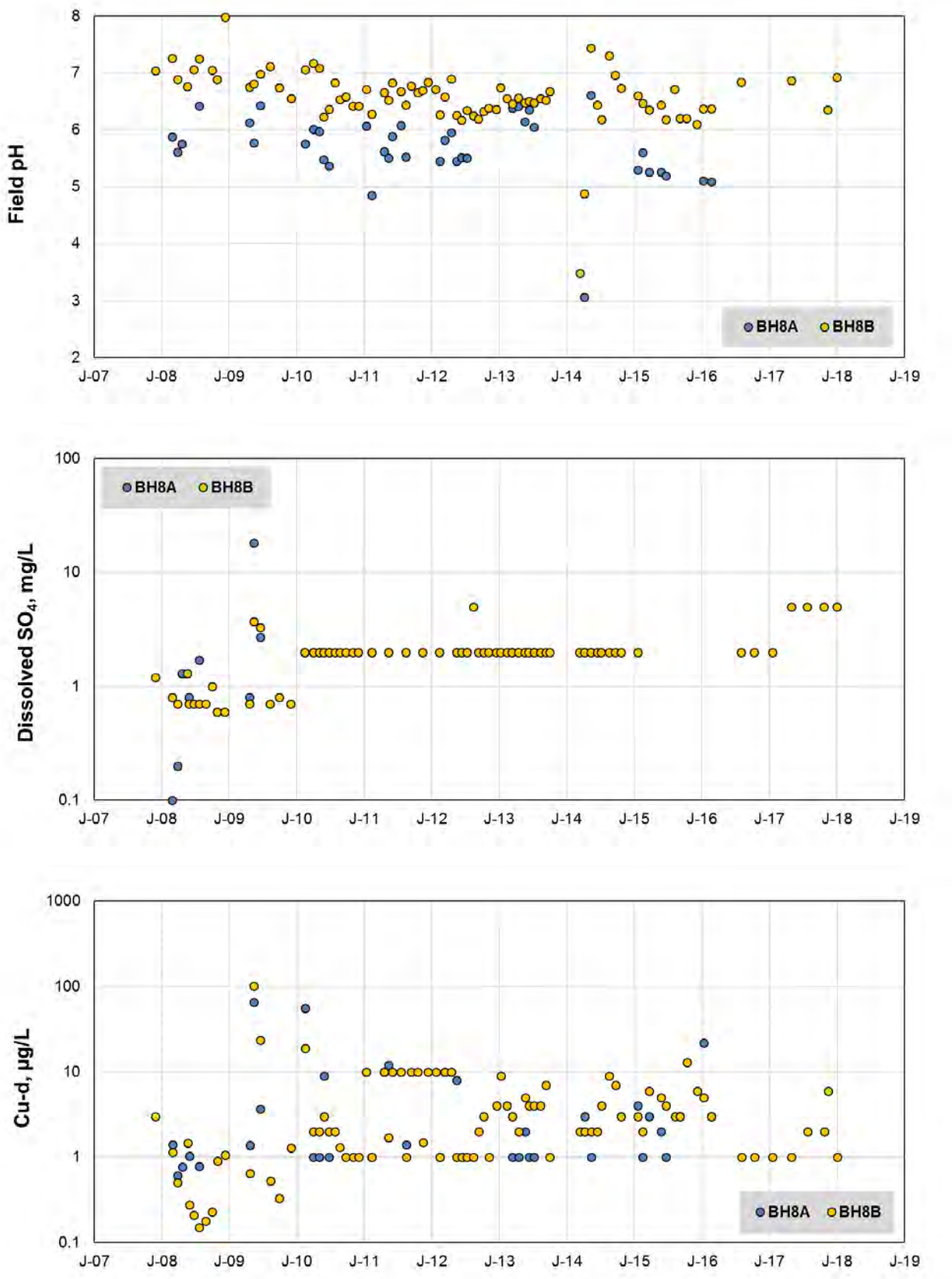


Figure 4-27. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH8A and BH8B, 2008 to 2018

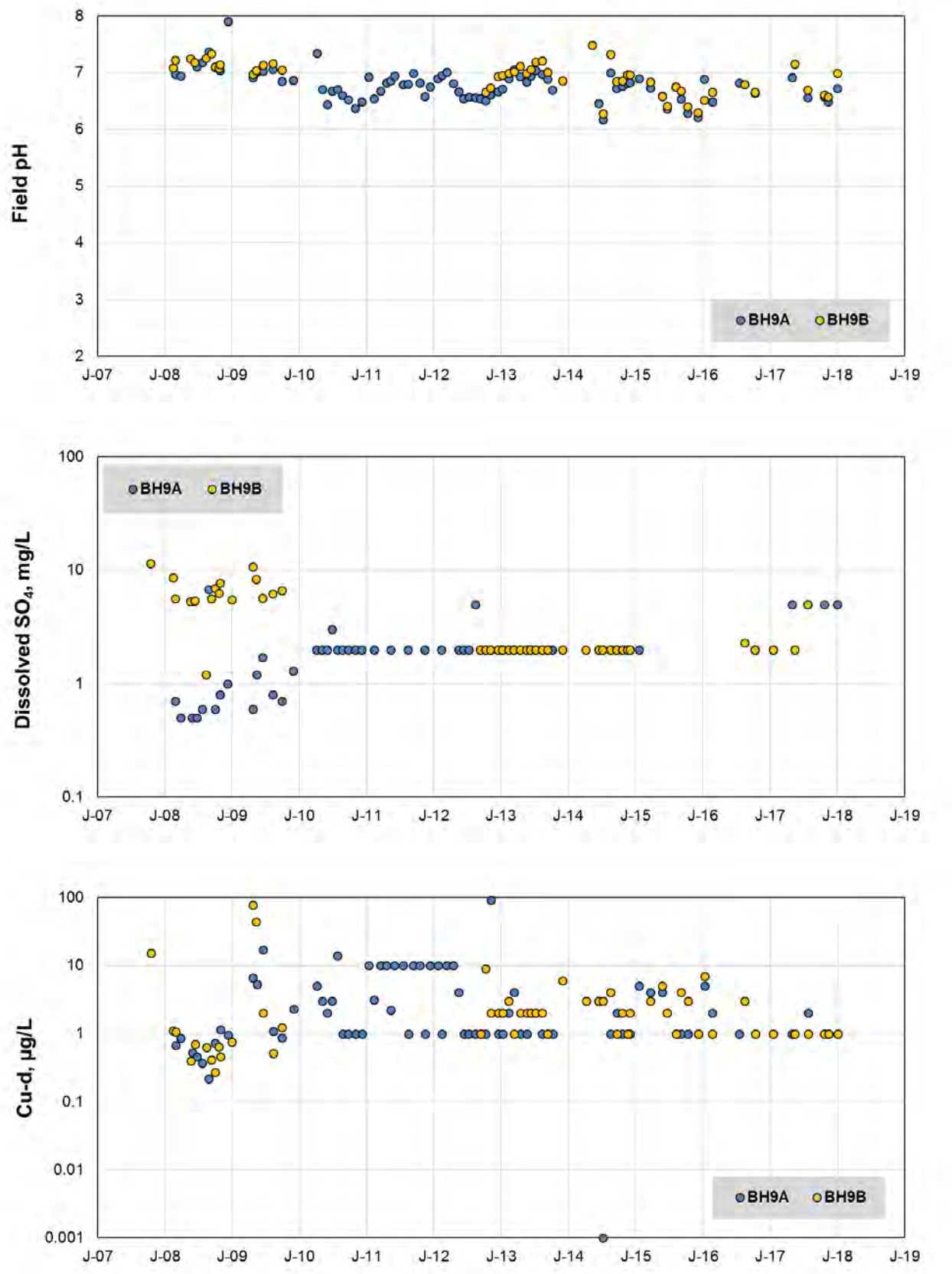


Figure 4-28. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH9A and BH9B, 2008 to 2018

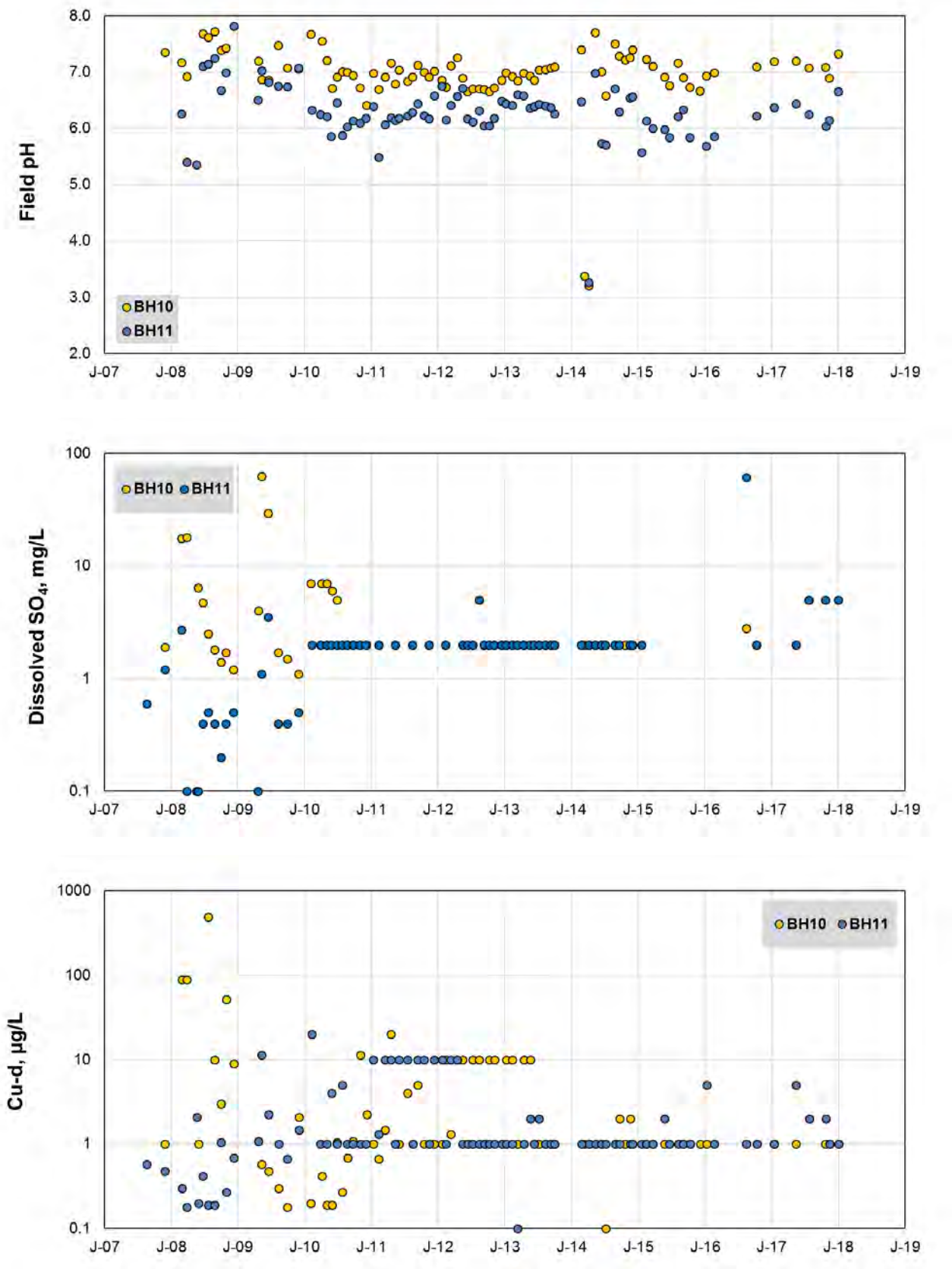


Figure 4-29. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH10 and BH11, 2008 to 2018

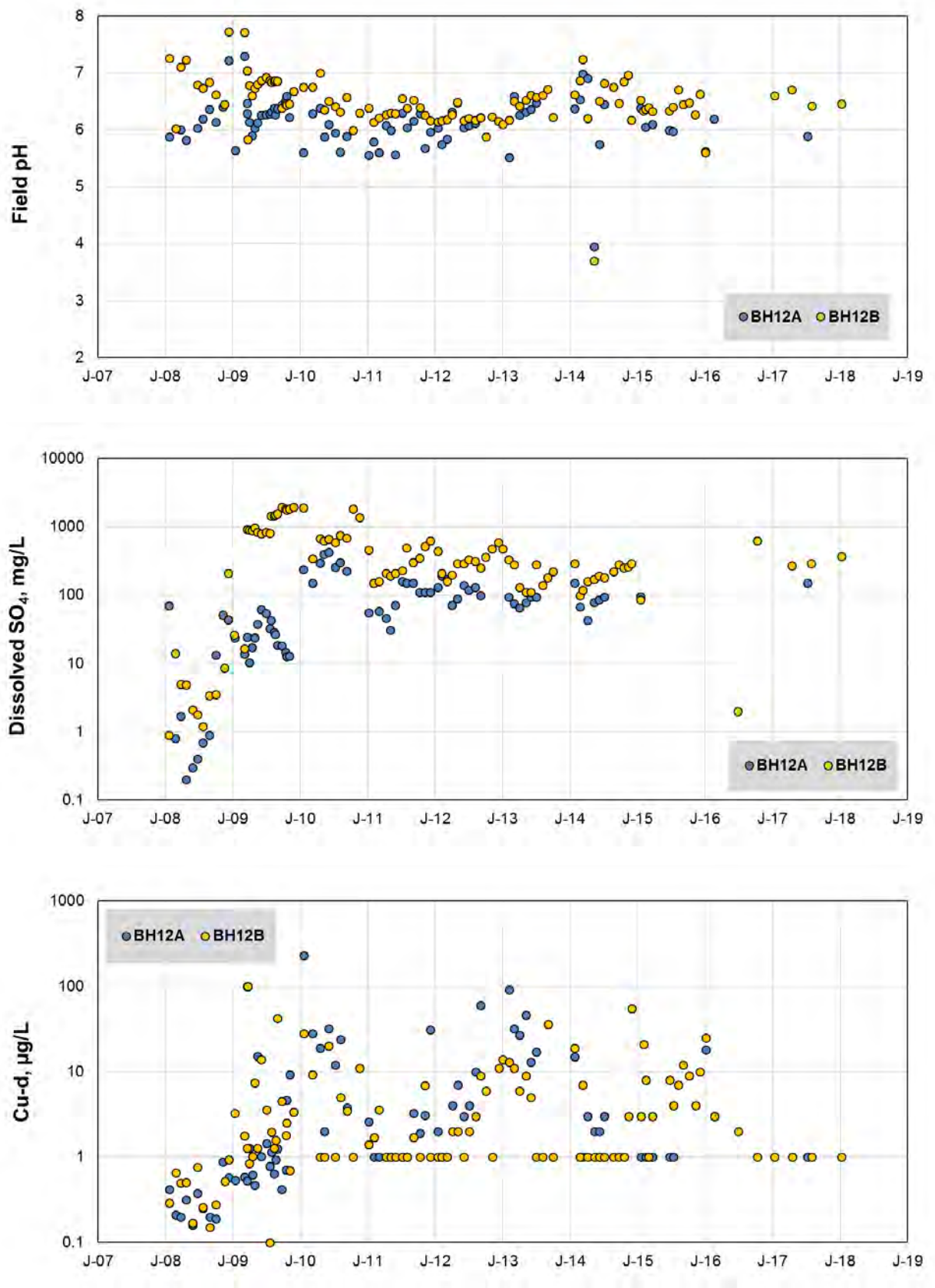


Figure 4-30. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH12A and BH12B, 2008 to 2018

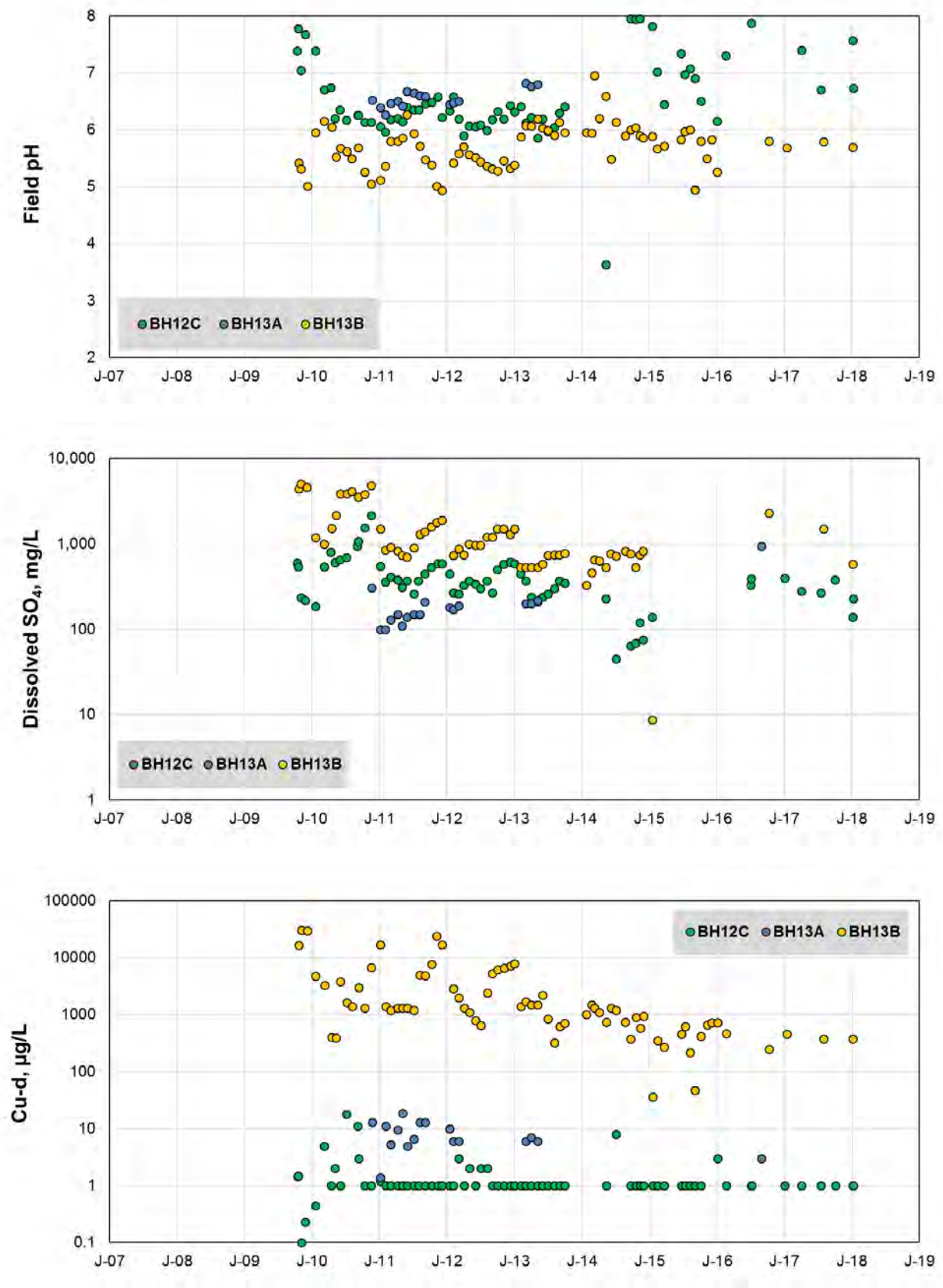


Figure 4-31. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH12C, BH13A, and BH13B, 2008 to 2018

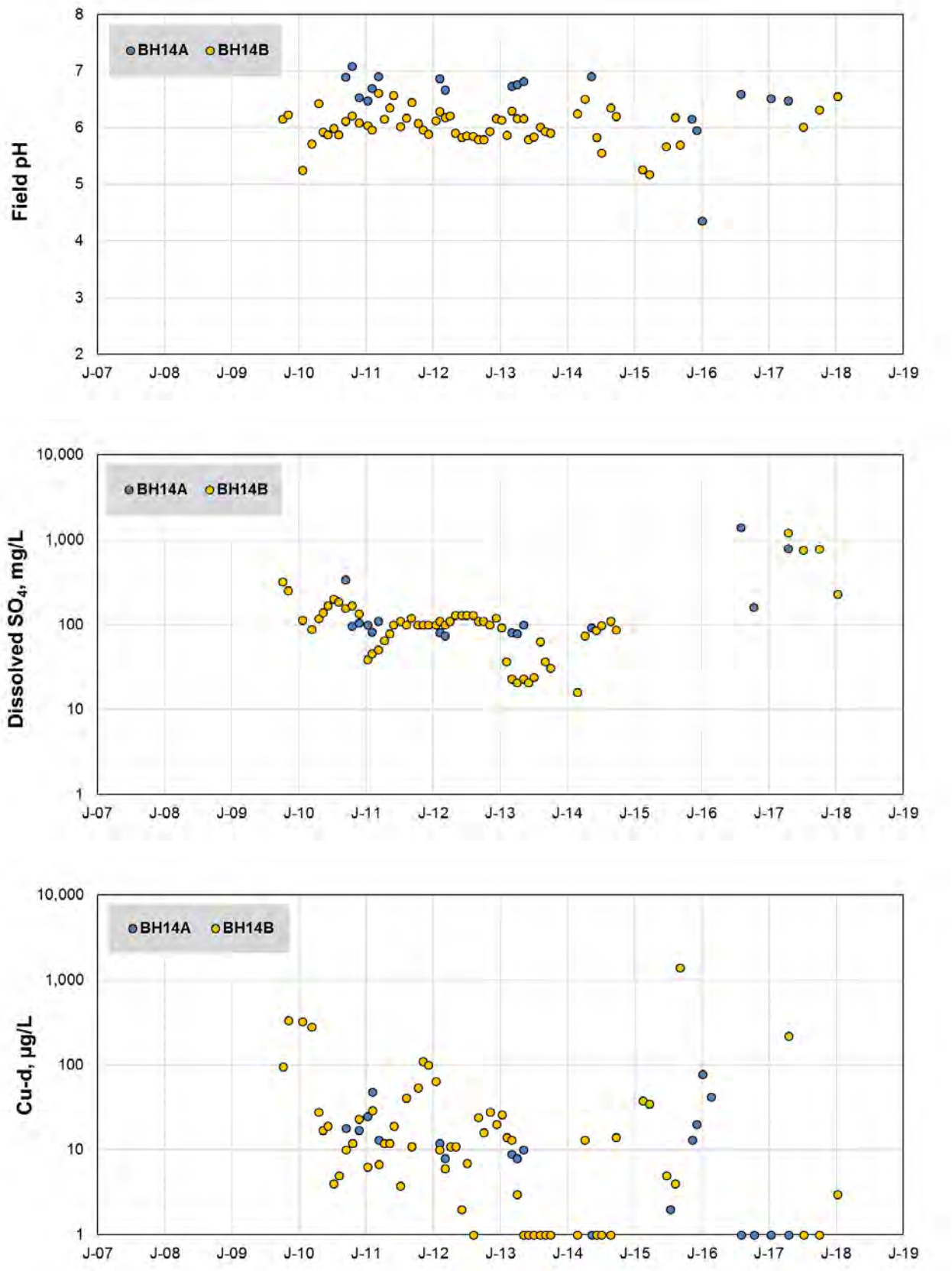


Figure 4-32. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH14A and BH14B, 2008 to 2018

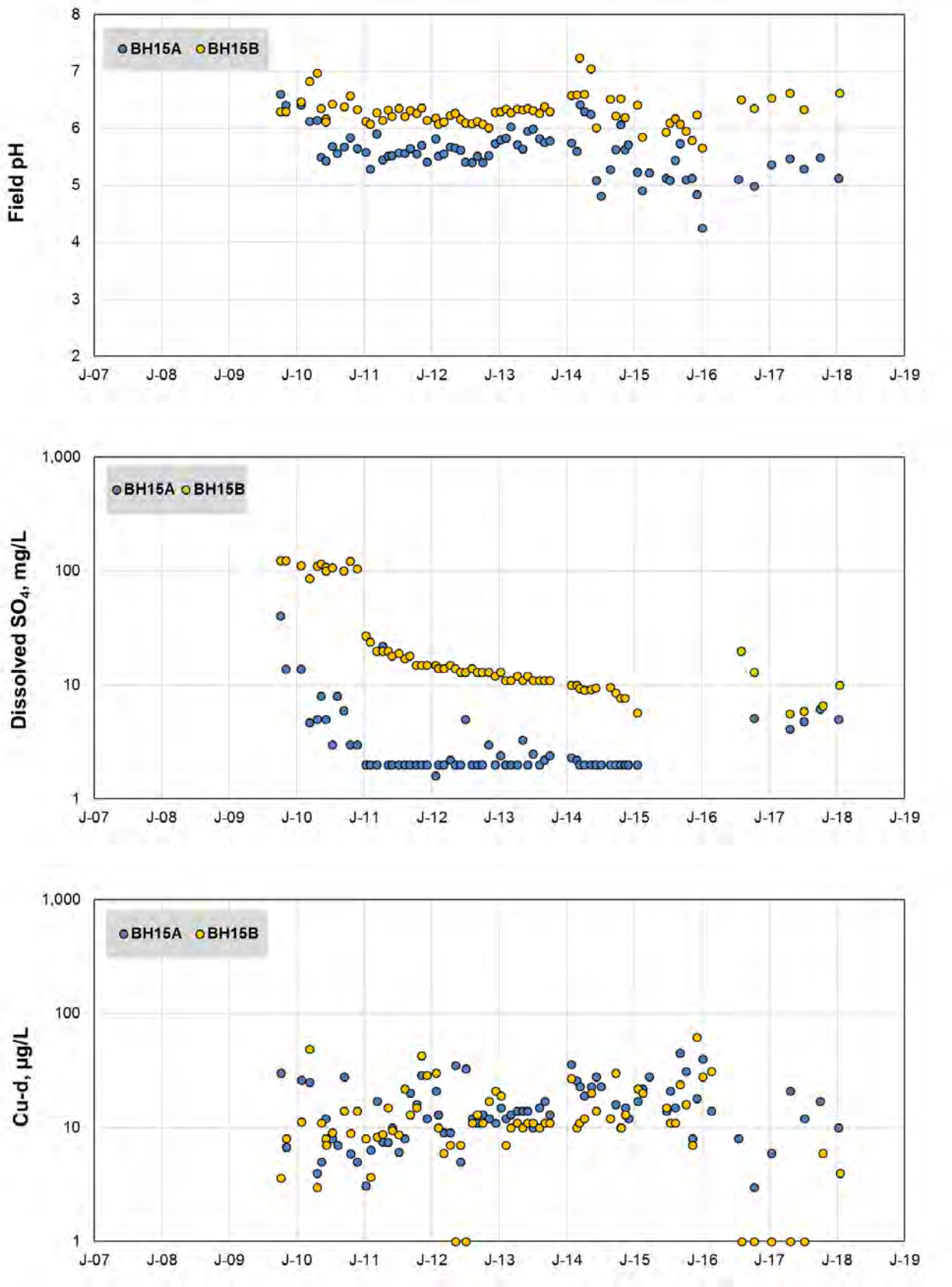


Figure 4-33. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH15A and BH15B, 2008 to 2018

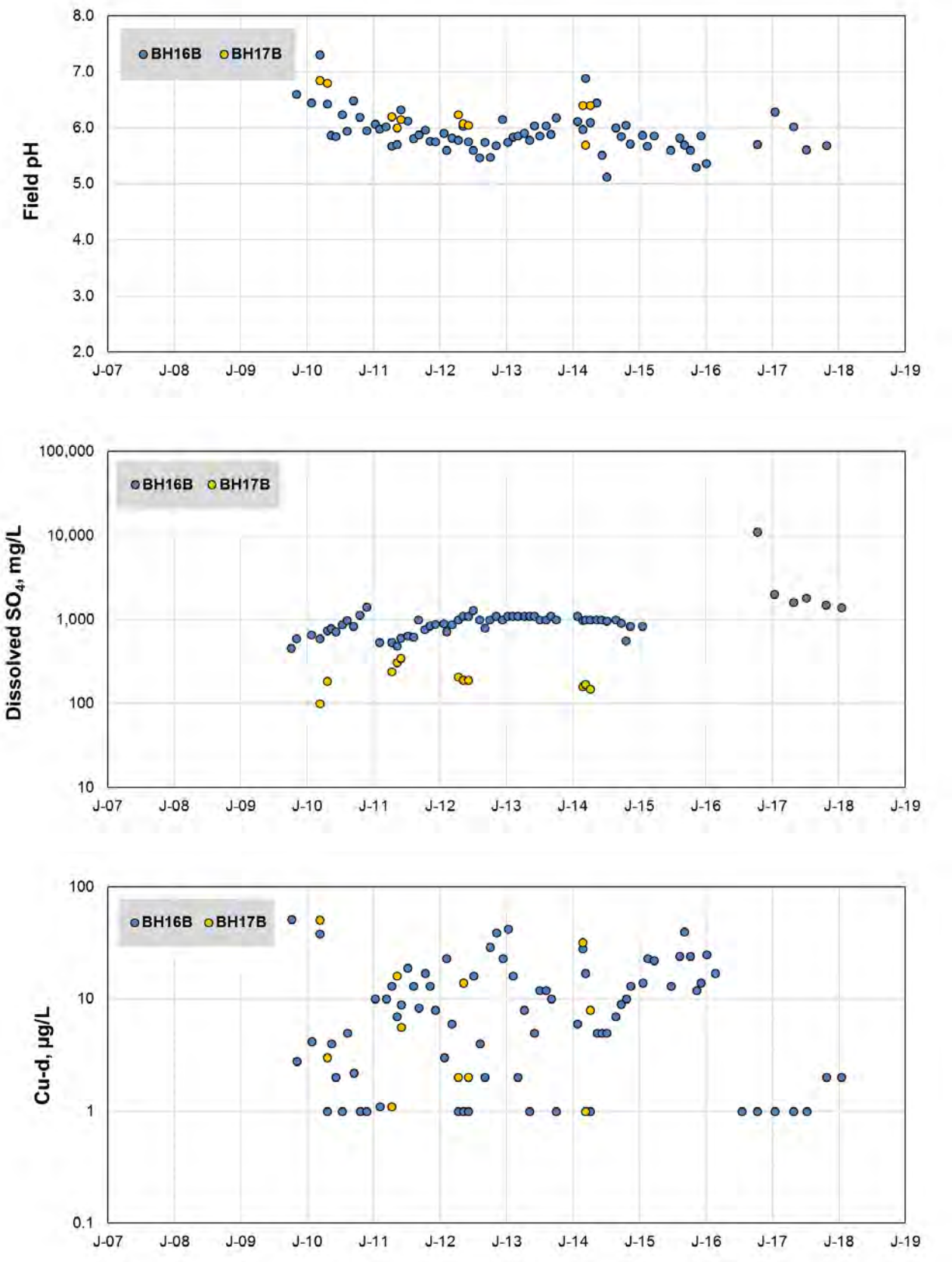


Figure 4-34. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH16B and BH17B, 2008 to 2018

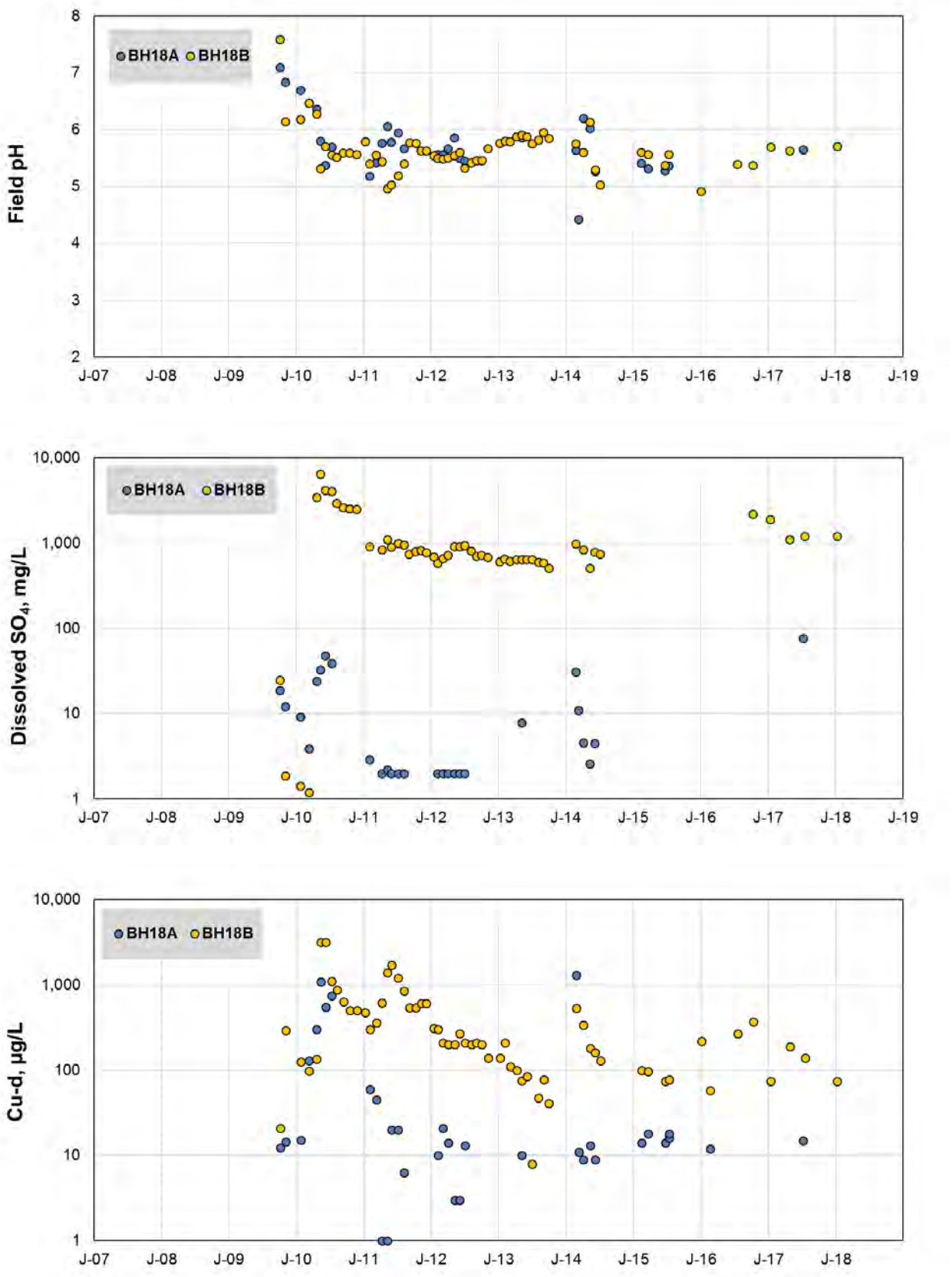


Figure 4-35. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores BH18A and BH18B, 2008 to 2018

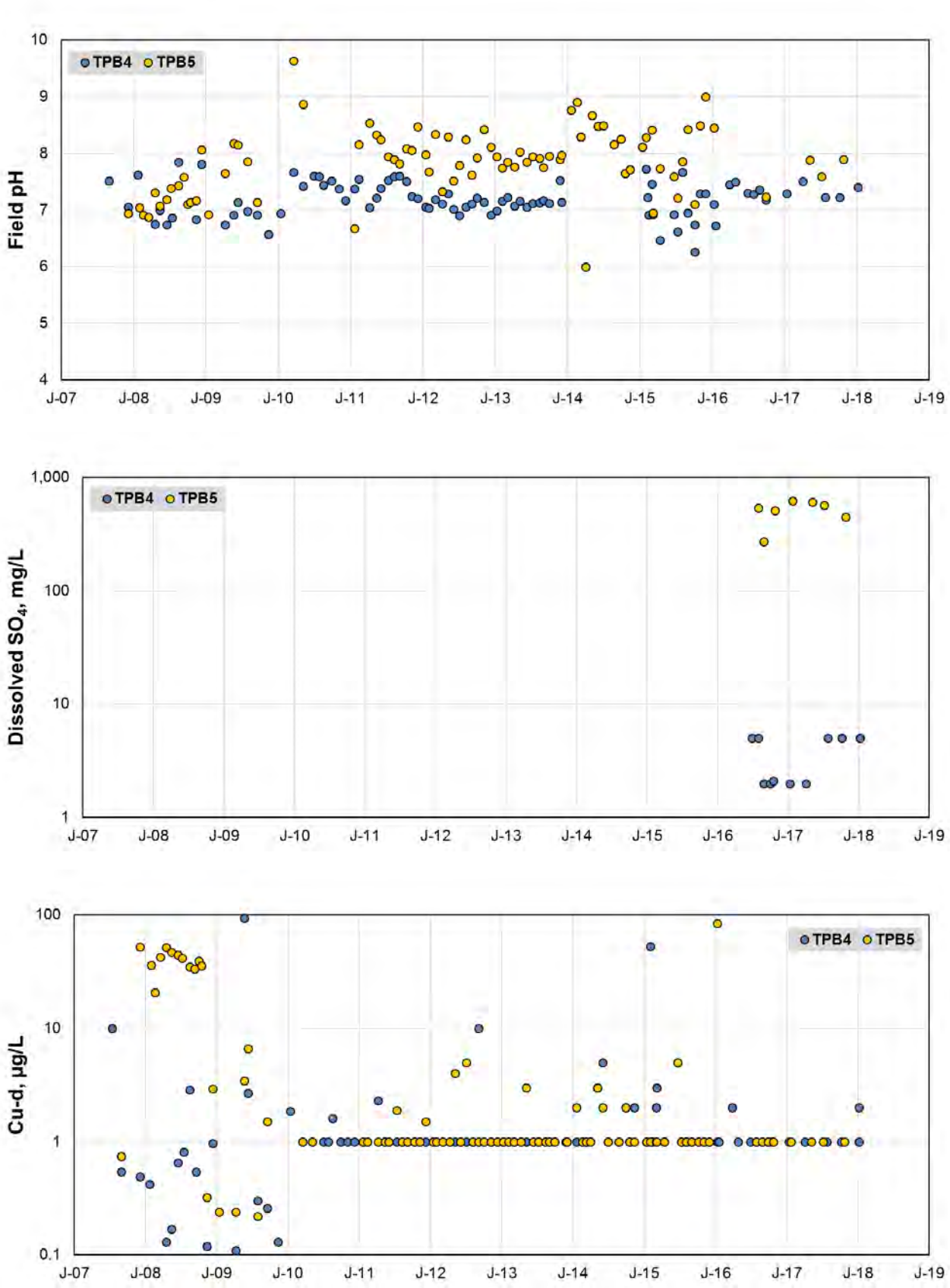


Figure 4-36. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bores TPB4 and TPB5, 2008 to 2018

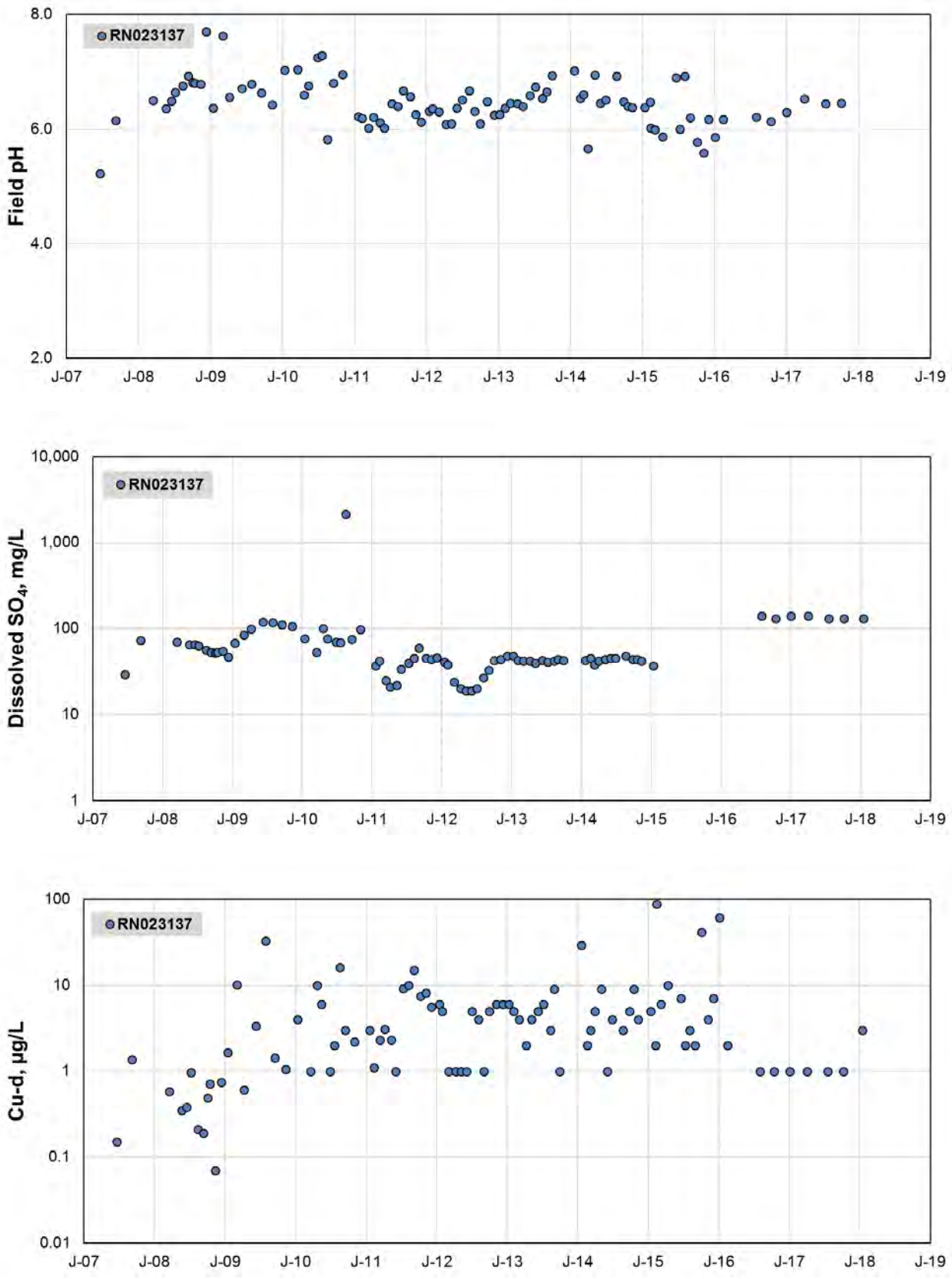


Figure 4-37. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from Bore RN023137, 2008 to 2018

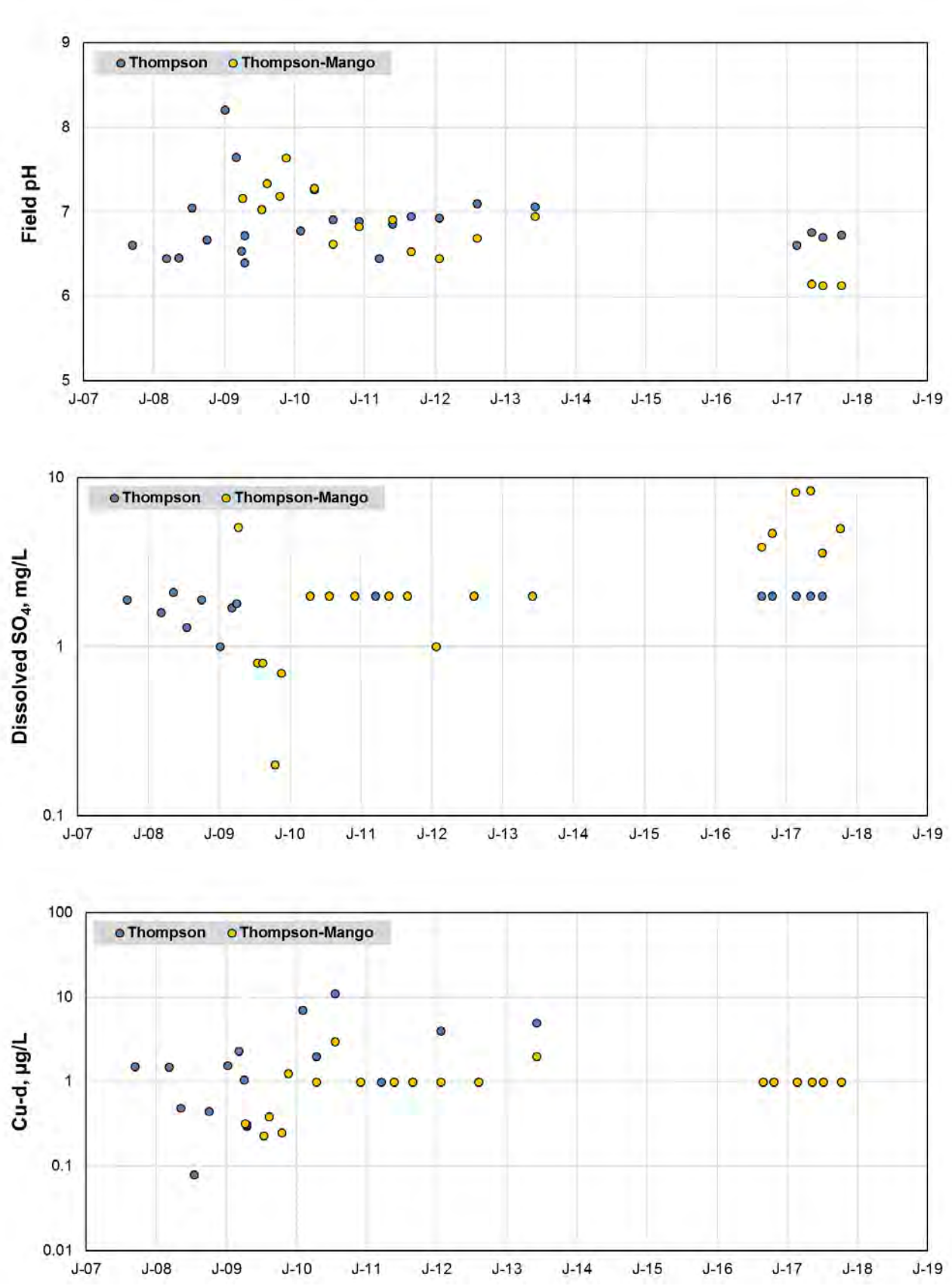


Figure 4-38. Time Trends for Field pH, SO_4, and Dissolved Cu in Groundwater from the Thompson and Thompson-Mango bores, 2008 to 2018

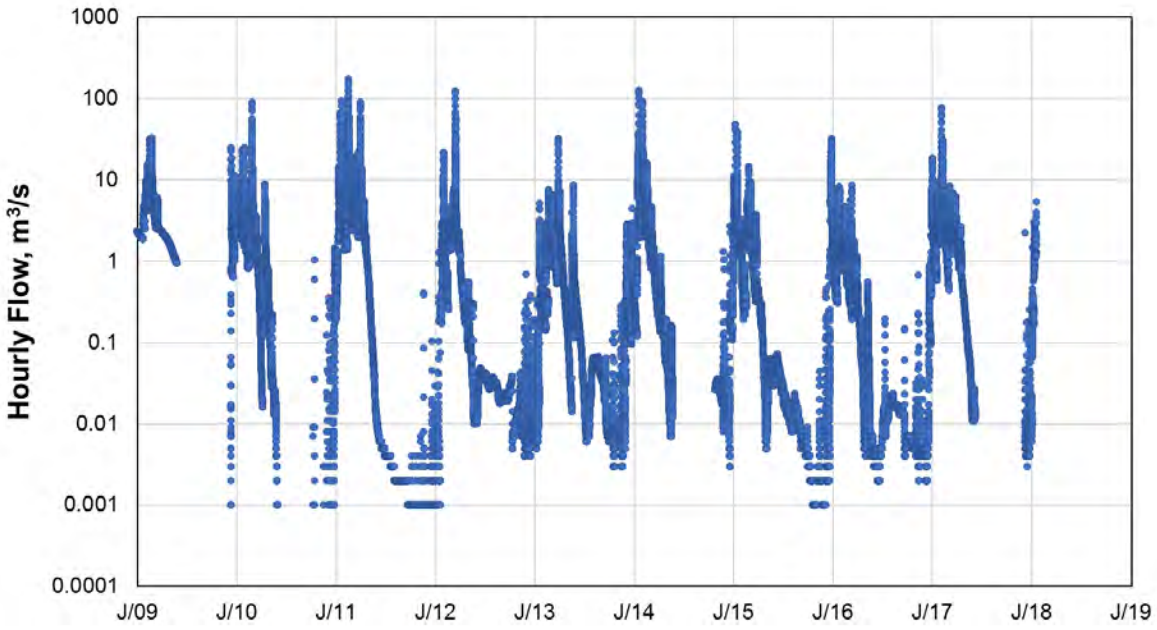


Figure 4-39. Hourly Flows at GS8150200, 2009 to 2018

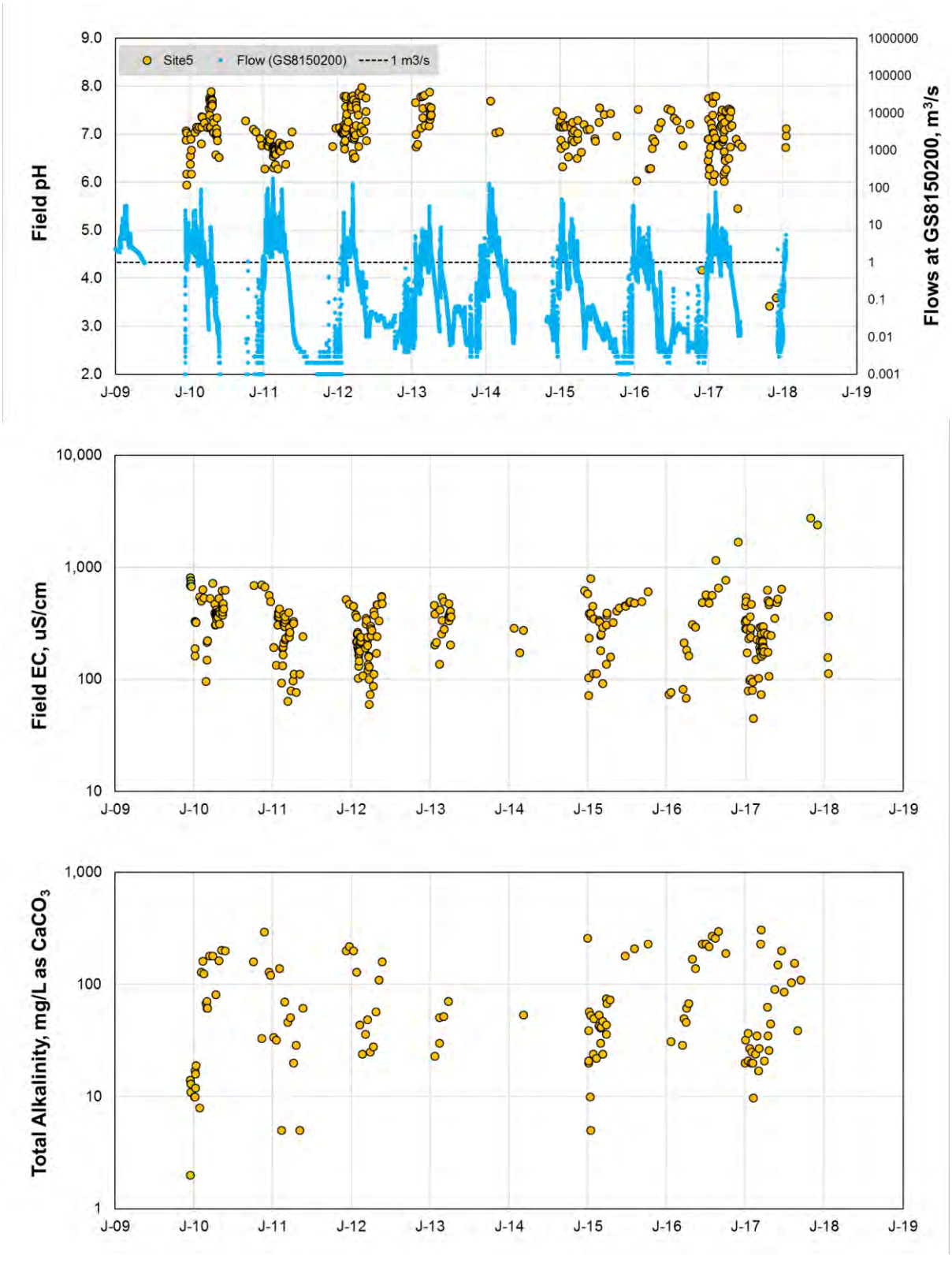


Figure 4-40. Field pH, Field EC, and Alkalinity at Site 5, 2009 to 2018

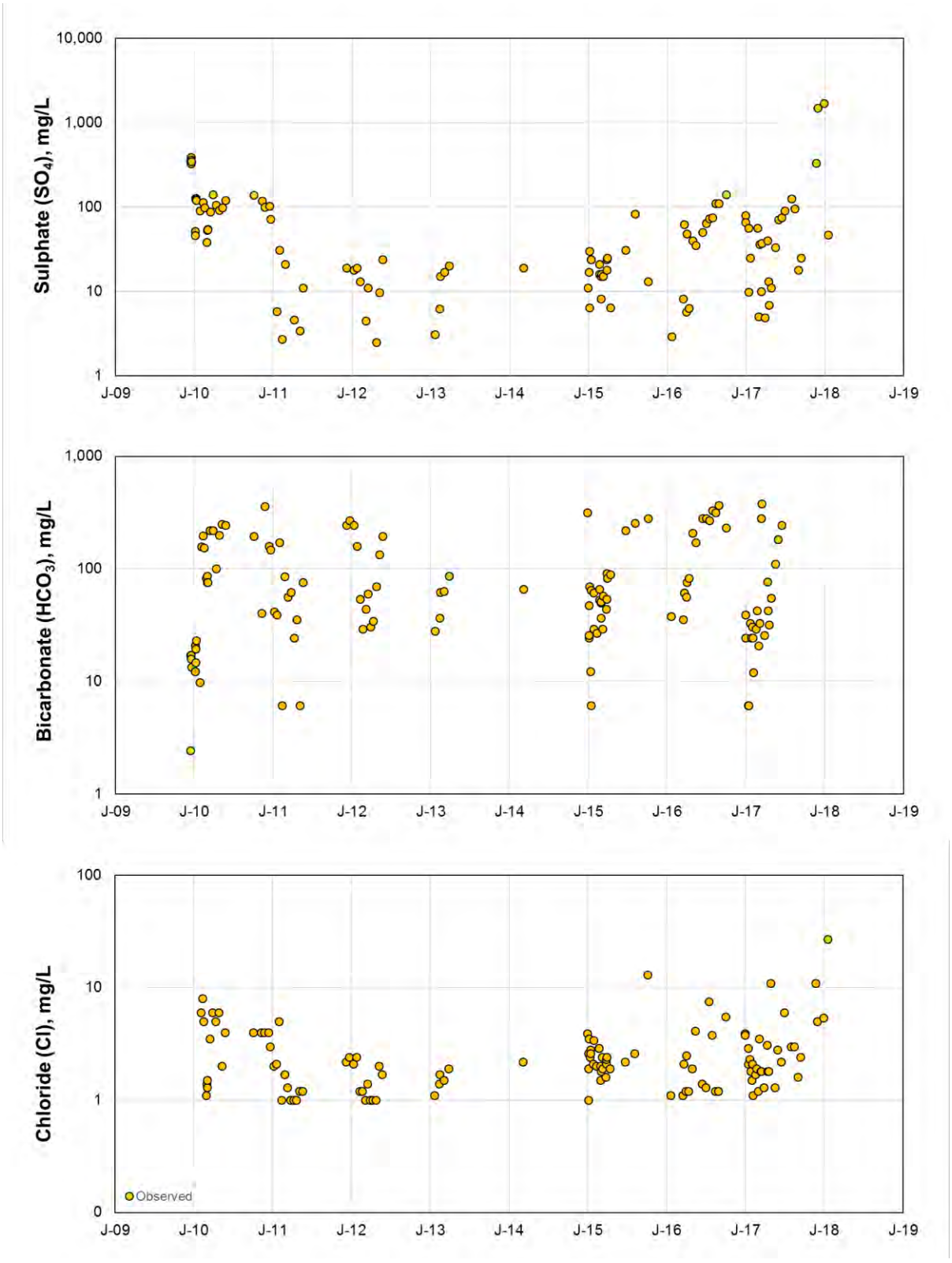


Figure 4-41. Sulphate (SO_4), Bicarbonate (HCO_3), and Chloride (Cl) Concentrations at Site 5, 2009 to 2018

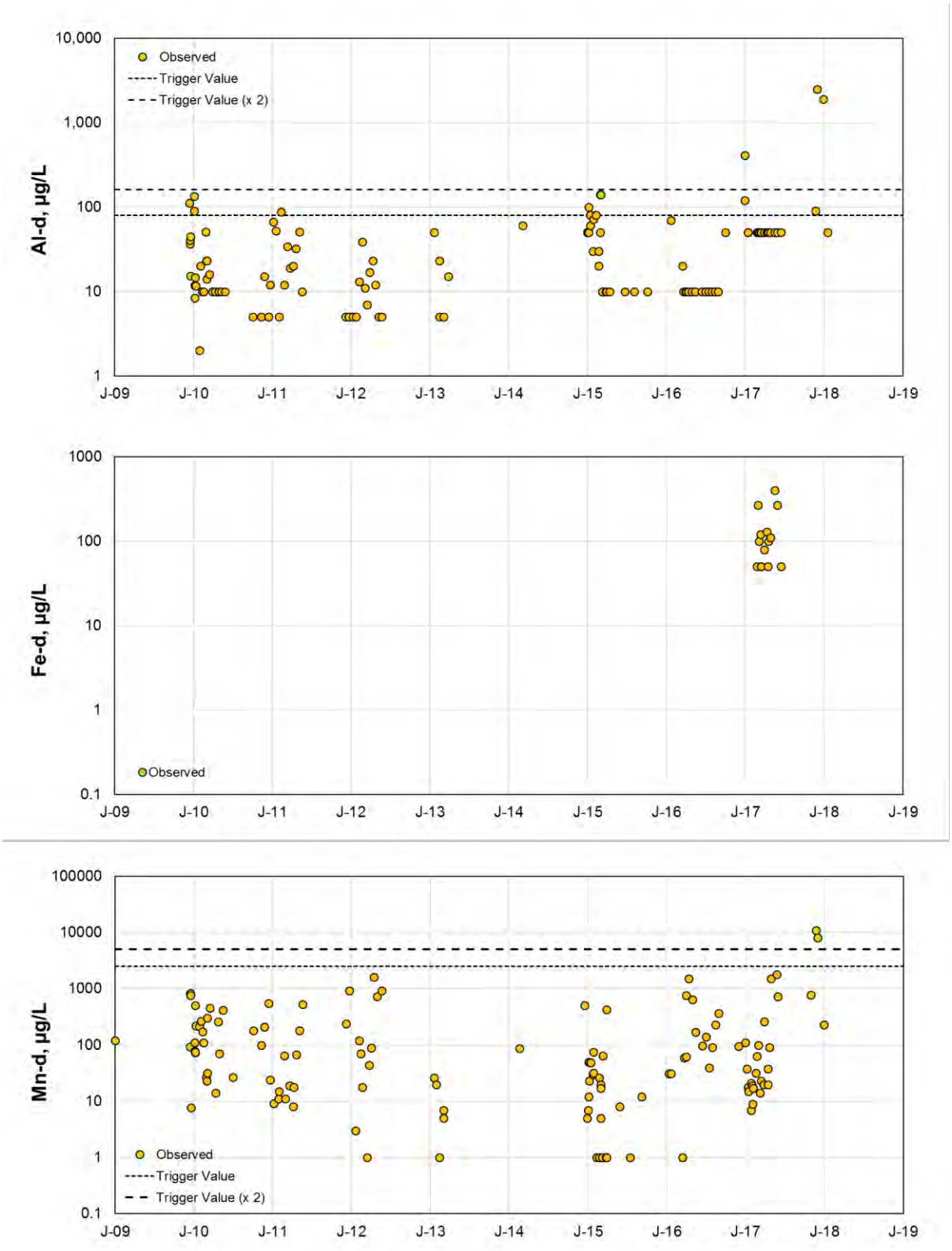


Figure 4-42. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 5, 2009 to 2018

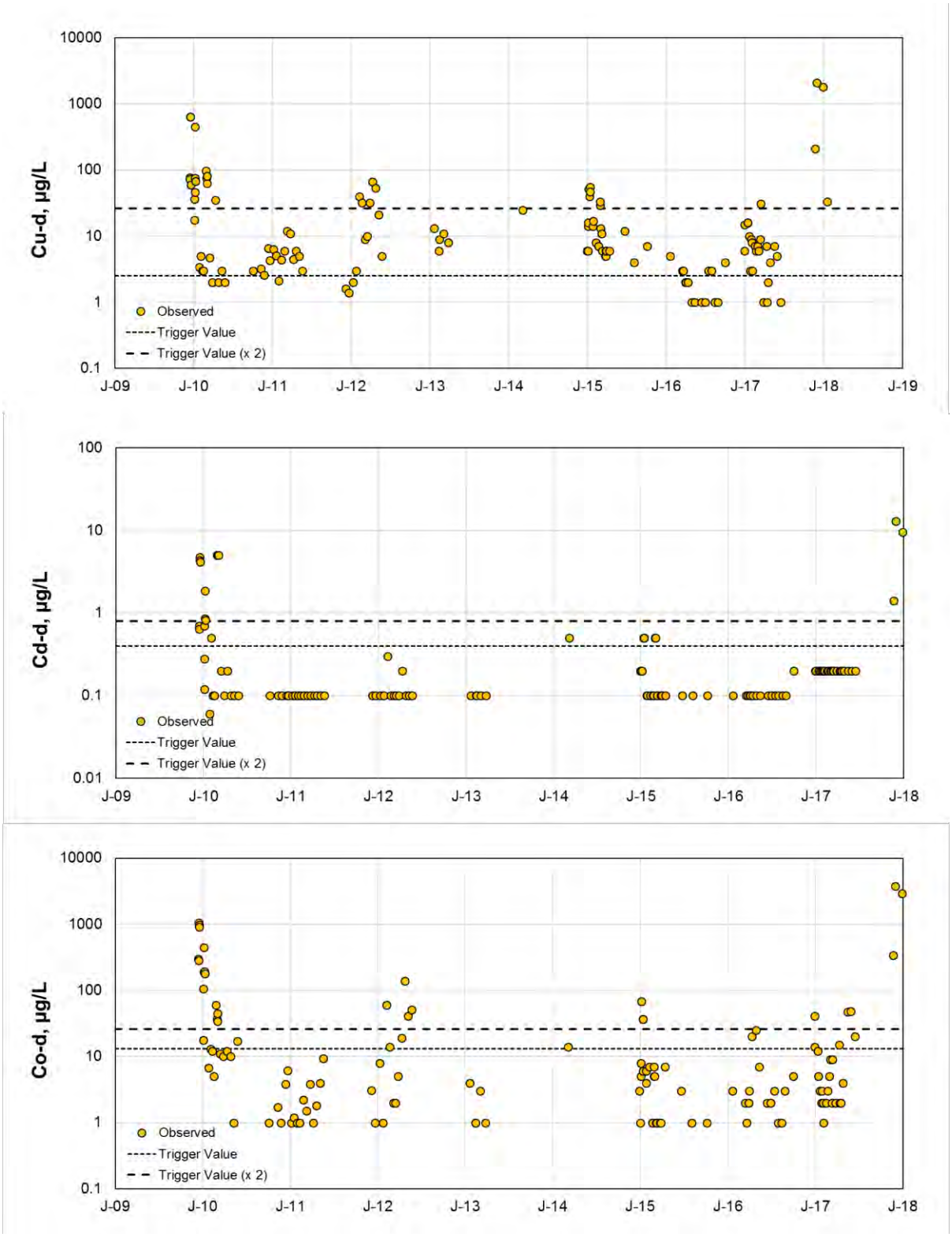


Figure 4-43. Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 5, 2009 to 2018

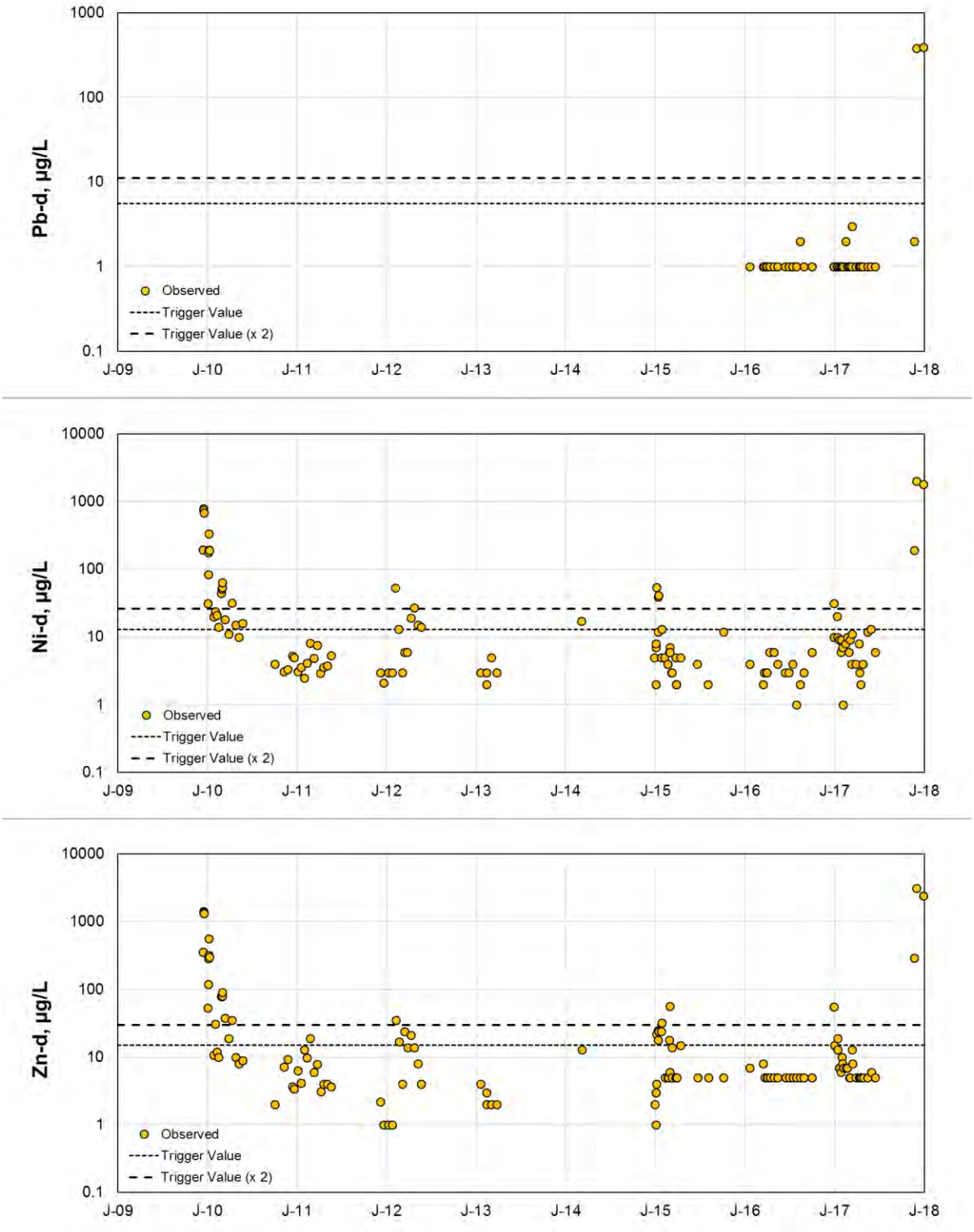
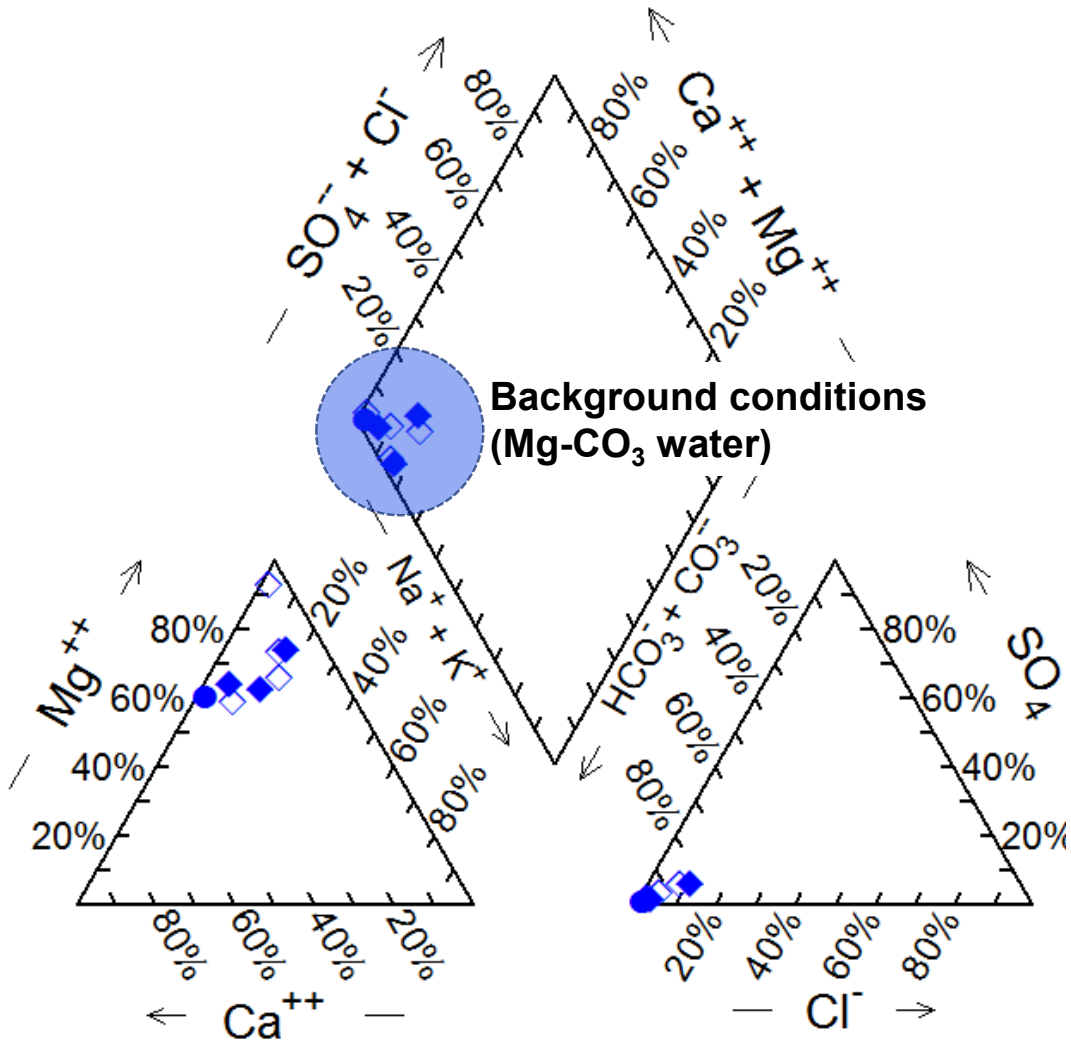
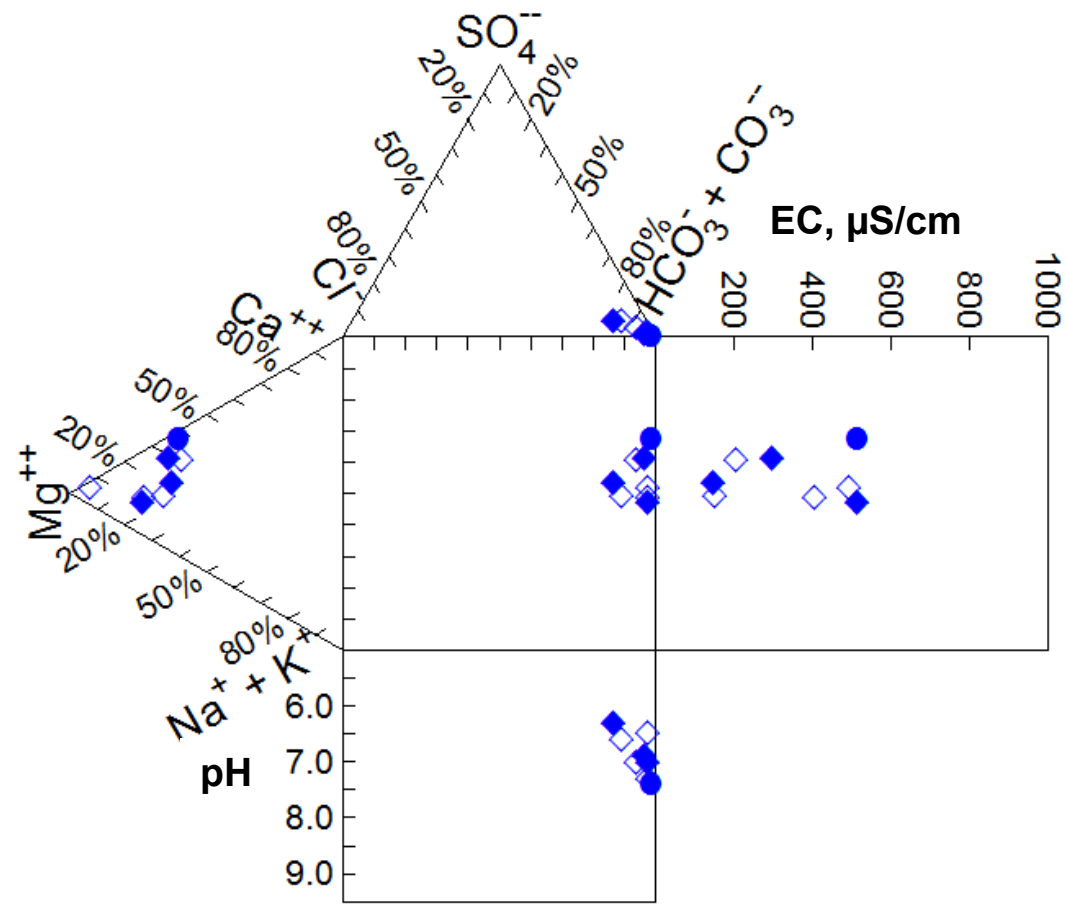


Figure 4-44. Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 5, 2009 to 2018



Monitoring Bores

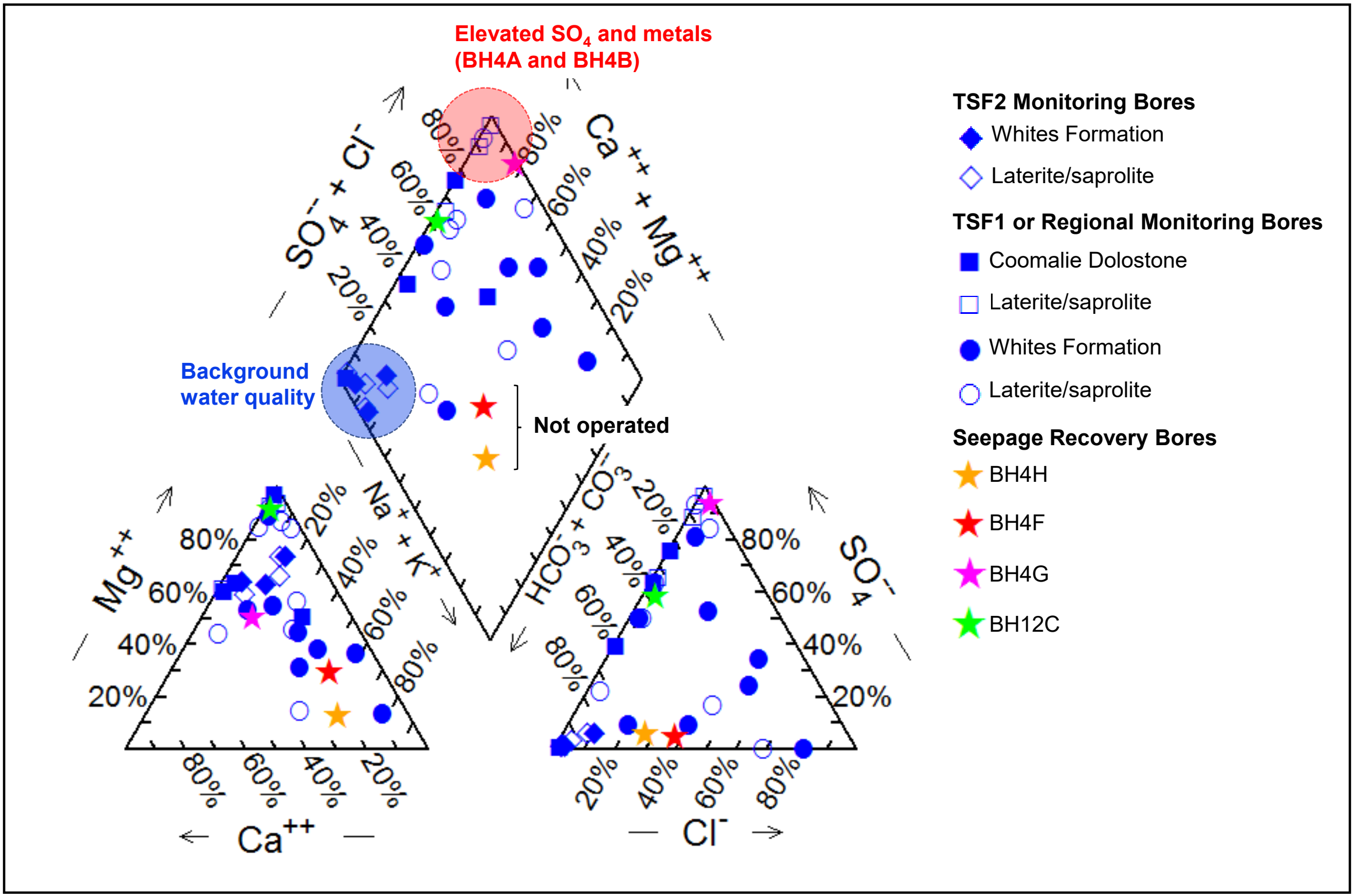
- RN022085 (Coomalie Dolostone)
- TSF2 Bores (laterite/saprolite)
- TSF2 Bores (Whites Formation)



Piper Plot and Durov Plot of the Major Ion Composition of Unimpacted Groundwater

Client: DOE RUN AUSTRALIA NL	**Figure: 5-1**
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

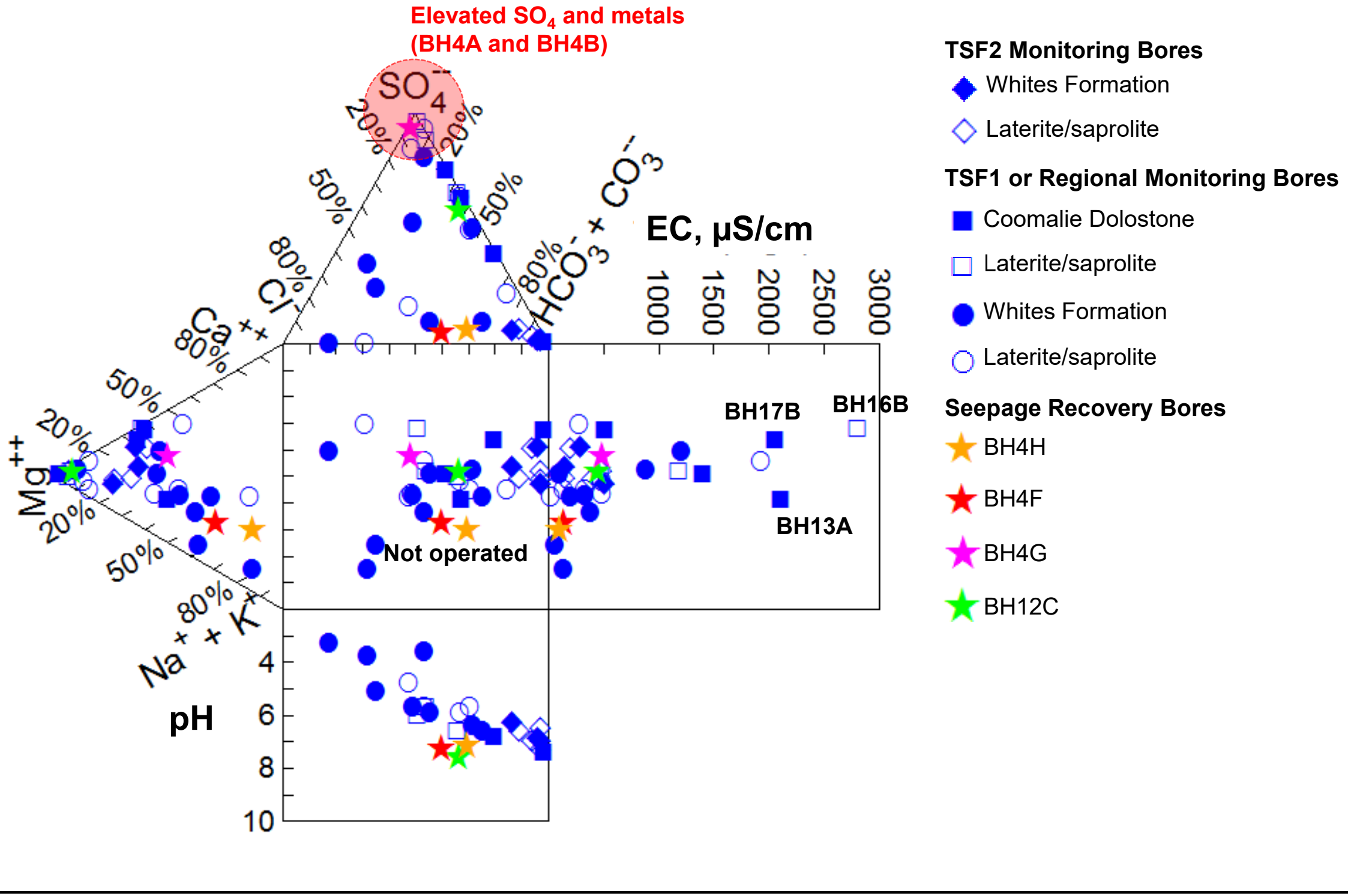
Robertson GeoConsultants Inc.



Piper Plot of the Major Ion Composition of Groundwater

Client: DOE RUN AUSTRALIA NL	**Figure: 5-2**
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

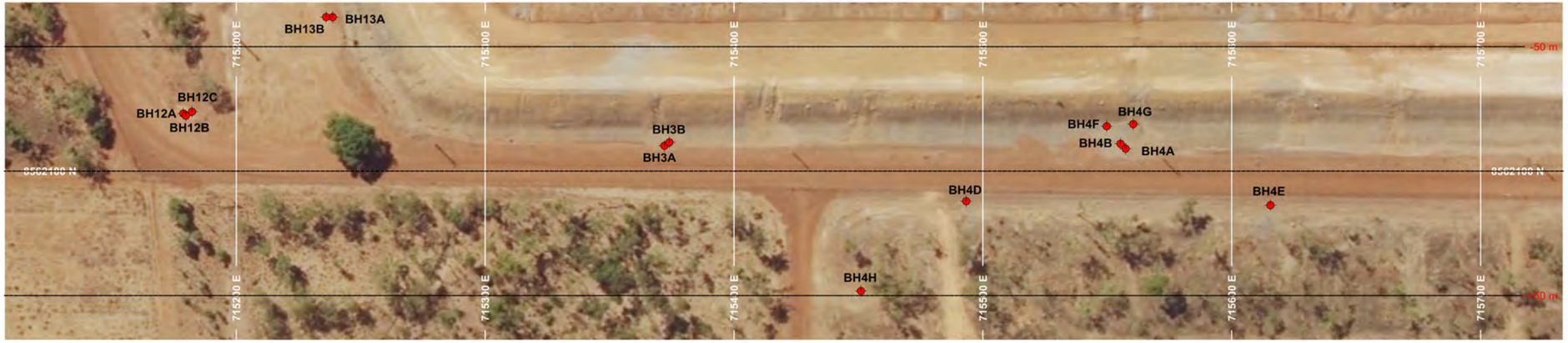
Robertson GeoConsultants Inc.

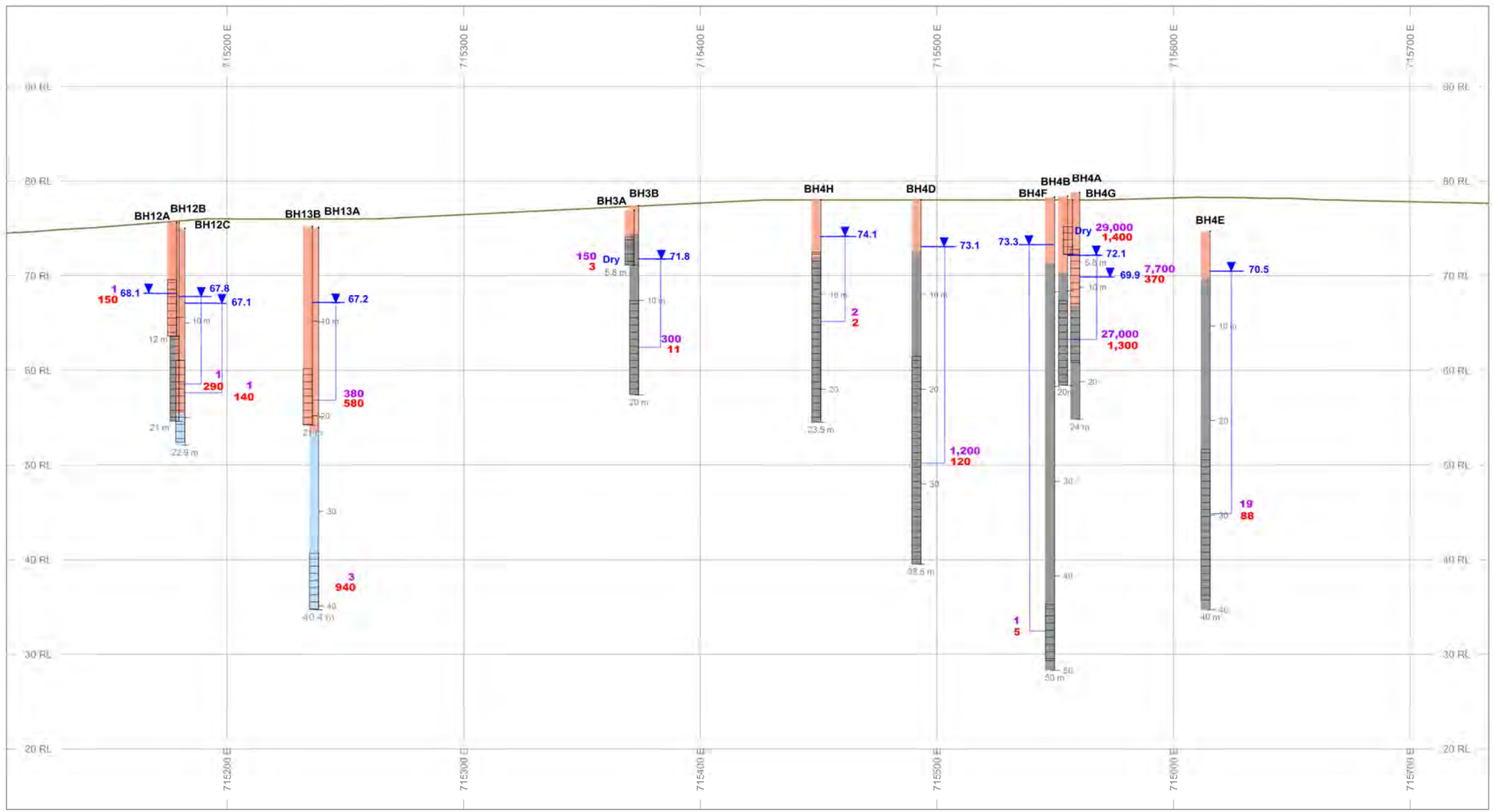


Durov Plot of the Major Ion Composition of Groundwater

Client: DOE RUN AUSTRALIA NL	Figure: 5-3
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	

Robertson GeoConsultants Inc.





HOLES PLOTTED

TOTAL 12

BH12A	BH12B	BH12C	BH3A	BH3B
BH4A	BH4B	BH4D	BH4E	BH4F
BH4G	BH4H			

Screen Intervals (m)

4 Cu (µg/L)
66 SO_4 (mg/L)

72.35 Inferred Water Table Elevation (m) November, 2017

Ground Surface On Center Line

ROCK CODES DESCRIPTION

- Laterite/Saprolite
- Whites Formation (shale)
- Coomalie Dolostone

SECTION SPECS:

REF. PT. E, N	715420 m	8562100 m
EXTENTS	626.4 m	84.96 m
SECTION TOP, BOT	98.5 m	13.53 m
TOLERANCE +/-	50 m	
VERTICAL EXAG.	4	

SCALE 1 : 2000

(m)

-10 0 10 20 30 40 50 60

GDA94 / UTM zone 52S

AZIMUTH = 90°

N W E S

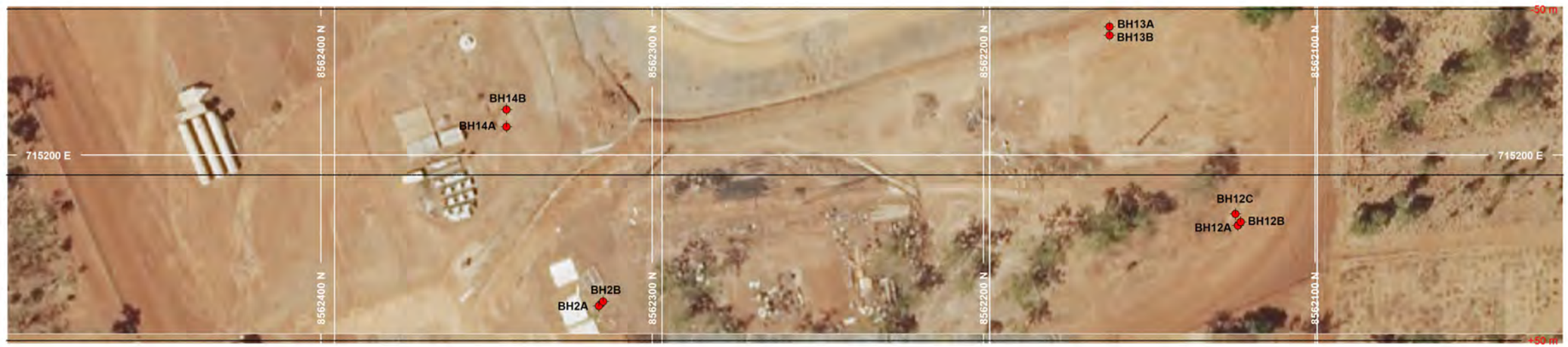
Figure: 5-4

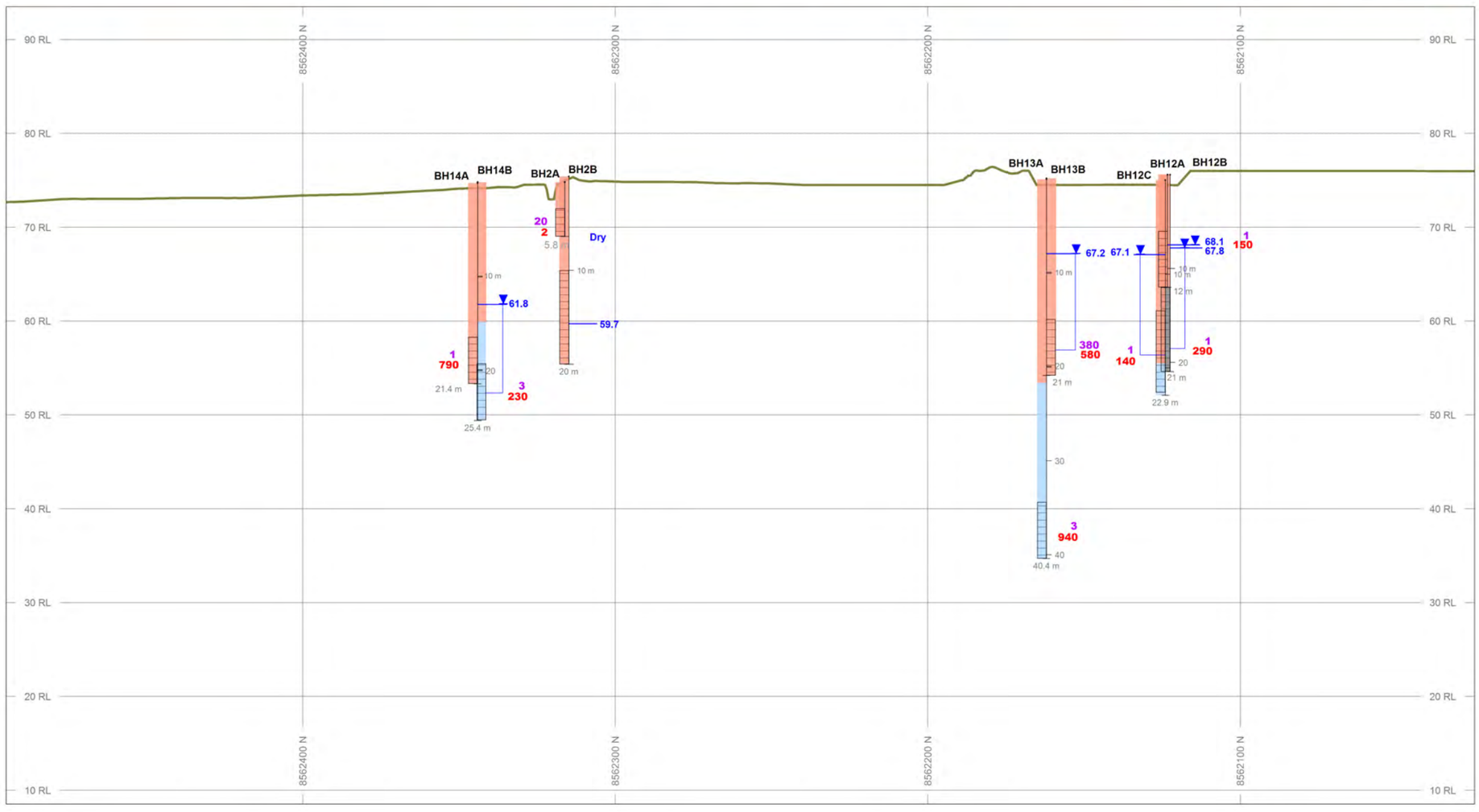
Section A-A'

Client: DOE RUN AUSTRALIA NL

Robertson GeoConsultants Inc.

Project: MMP Support	Project: 256003
Report No: 256003/1	Last Update: February, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Browns.gpf	





HOLES PLOTTED

TOTAL 9

BH12A	BH12B	BH12C	BH13A	BH13B
BH14A	BH14B	BH2A	BH2B	

Screen Intervals (m)

4 Cu (µg/L)
66 SO_4 (mg/L)

72.35 Inferred Water Table Elevation (m) November, 2017

Ground Surface On Center Line

ROCK CODES	DESCRIPTION
	Laterite/Saprolite
	Whites Formation (shale)
	Coomalie Dolostone

SECTION SPECS:

REF. PT. E, N	715194 m	8562260 m
EXTENTS	469.8 m	84.96 m
SECTION TOP, BOT	93.5 m	8.532 m
TOLERANCE +/-	50 m	
VERTICAL EXAG.	3	

SCALE 1 : 1500

(m)

-10 0 10 20 30 40 50

GDA94 / UTM zone 52S

AZIMUTH = 180°

N W E S

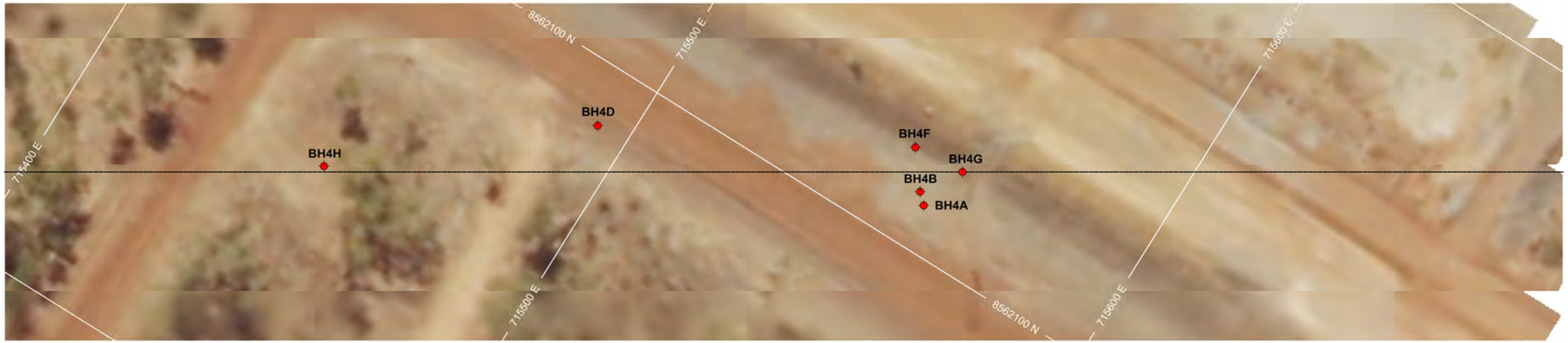
Figure: 5-5

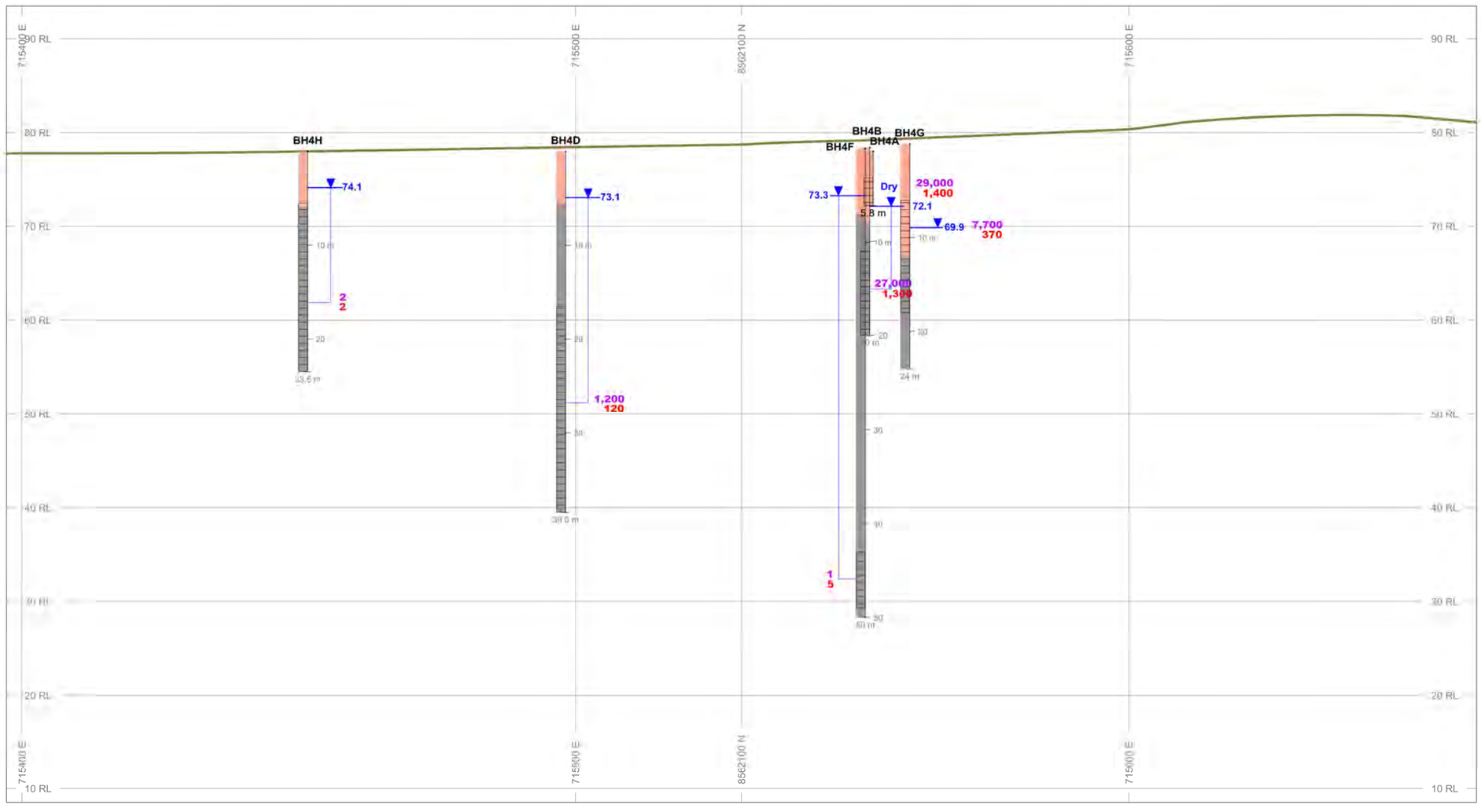
Section B-B'

Client: DOE RUN AUSTRALIA NL

Robertson GeoConsultants Inc.

Project: MMP Support	Project: 256003
Report No: 256003/1	Last Update: February, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Browns.gpf	





HOLES PLOTTED

TOTAL 6

BH4A BH4B BH4D BH4F BH4G BH4H

Screen Intervals (m)

4 Cu (µg/L)
66 SO_4 (mg/L)

72.35 Inferred Water Table Elevation (m) November, 2017

Ground Surface On Center Line

ROCK CODES DESCRIPTION

- Laterite/Saprolite
- Whites Formation (shale)
- Coomalie Dolostone

SECTION SPECS:

REF. PT. E, N	715530 m	8562100 m
EXTENTS	313.2 m	84.96 m
SECTION TOP, BOT	93.5 m	8.532 m
TOLERANCE +/-	50 m	
VERTICAL EXAG.	2	

SCALE 1 : 1000

(m)

-5 0 5 10 15 20 25 30

GDA94 / UTM zone 52S

AZIMUTH = 58°

N W E S

Figure: 5-6

Section C-C'

Client: DOE RUN AUSTRALIA NL

Robertson GeoConsultants Inc.

Project: MMP Support	Project: 256003
Report No: 256003/1	Last Update: February, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Browns.gpf	

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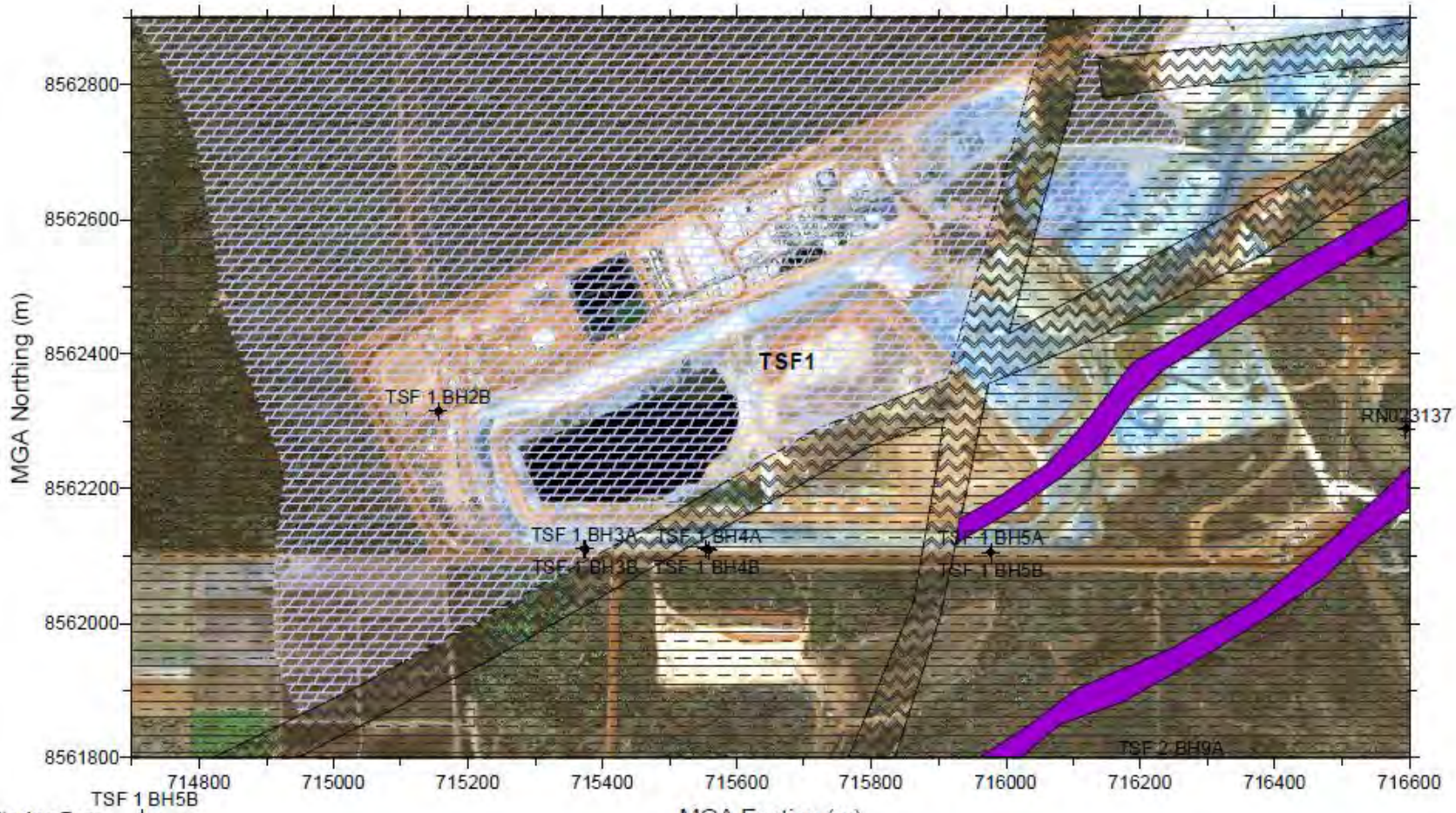


Client: COMPASS MINING PTY LIMITED (MANAGERS AND RECEIVERS APPOINTED) (ADMINISTRATORS APPOINTED)

Project: TAILINGS STORAGE FACILITY RECOMENDATIONS FOR MEDIUM AND LONG TERM SEEPAGE MITIGATION MEASURES

Title: Local Geology

URS

Drawn: CMAC | Approved: RIJV | Date: 10 Mar '09

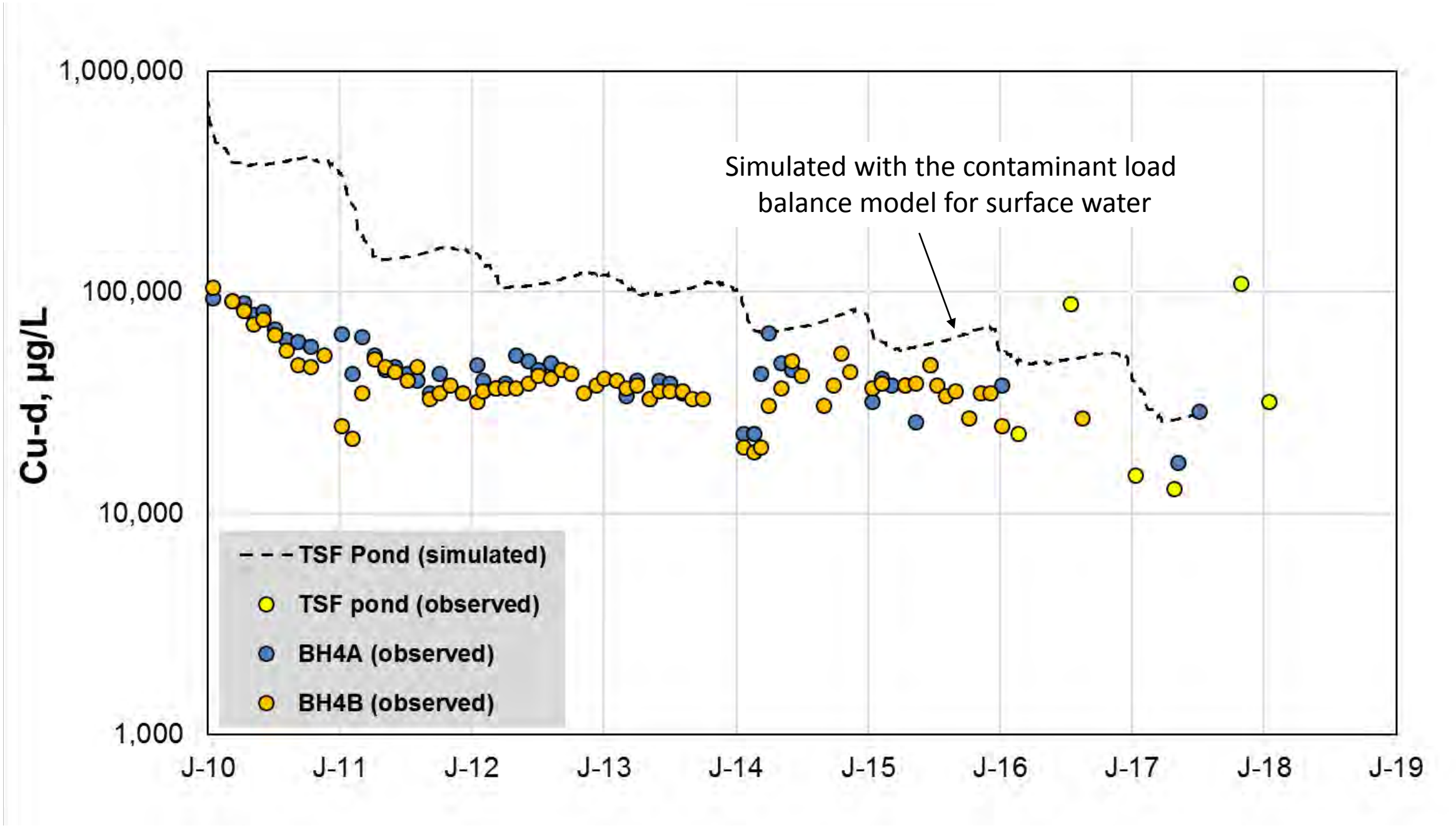
Job No: 42213883 | File No:. Figure 2.srf

Figure: 2 | Rev.A | A4

Source:

Screenshot from URS (2009) showing inferred fault locations

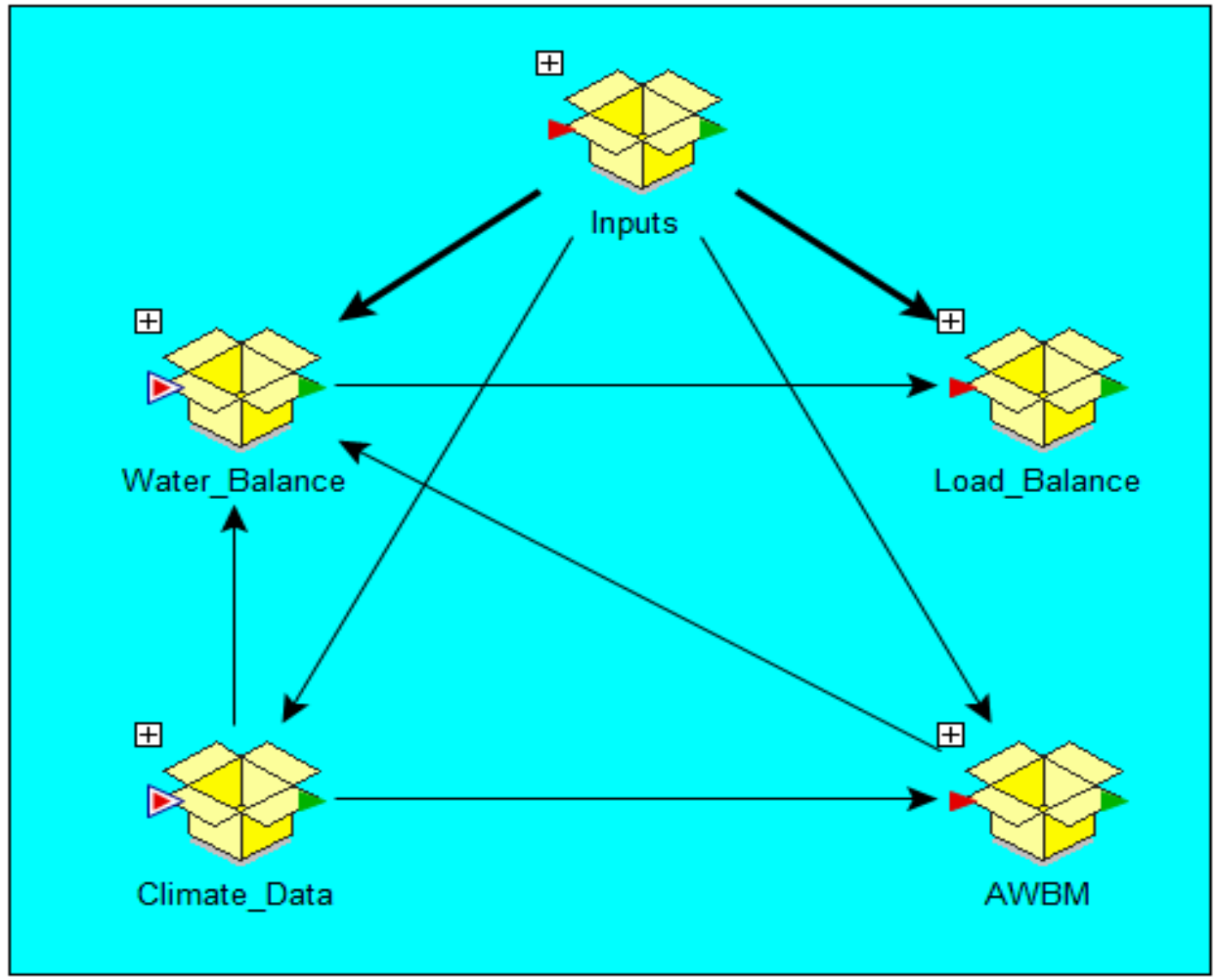
Client: DOE RUN AUSTRALIA NL	Figure: 5-7
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Feb 2018
Original File	



Simulated and Observed Cu Concentrations in TSF Pond Water and Observed Cu Concentrations for bores BH4A and BH4B

Client: DOE RUN AUSTRALIA NL	Figure: 5-8
Project: Browns MMP Support	Project No: 256003
Report No: 256003/1	Last Update: 6 Mar 2018
Original File	

Robertson GeoConsultants Inc.

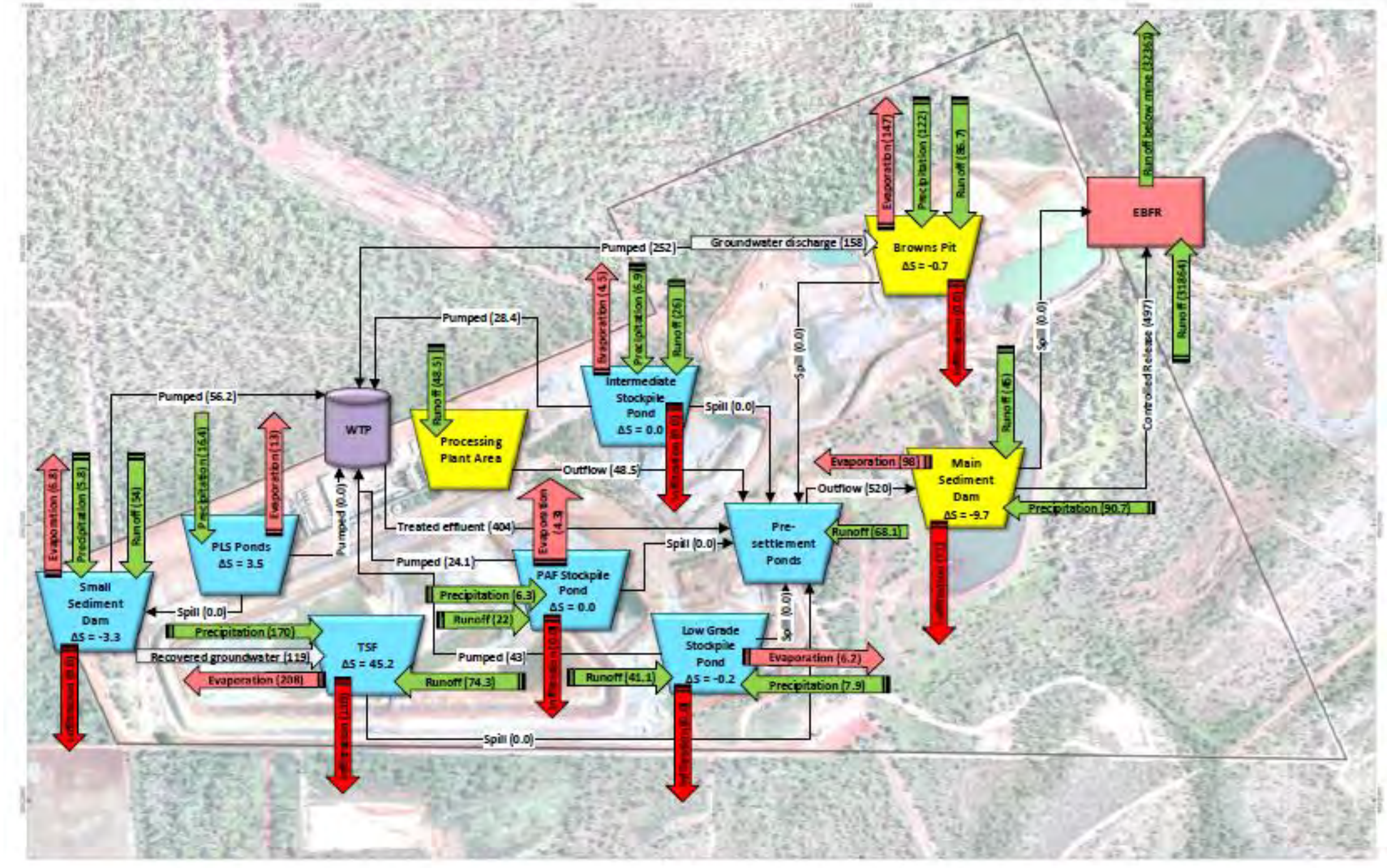


Opening Screen of 'Care and Maintenance' Water Balance and Load Balance Model

Figure: 5-9	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	

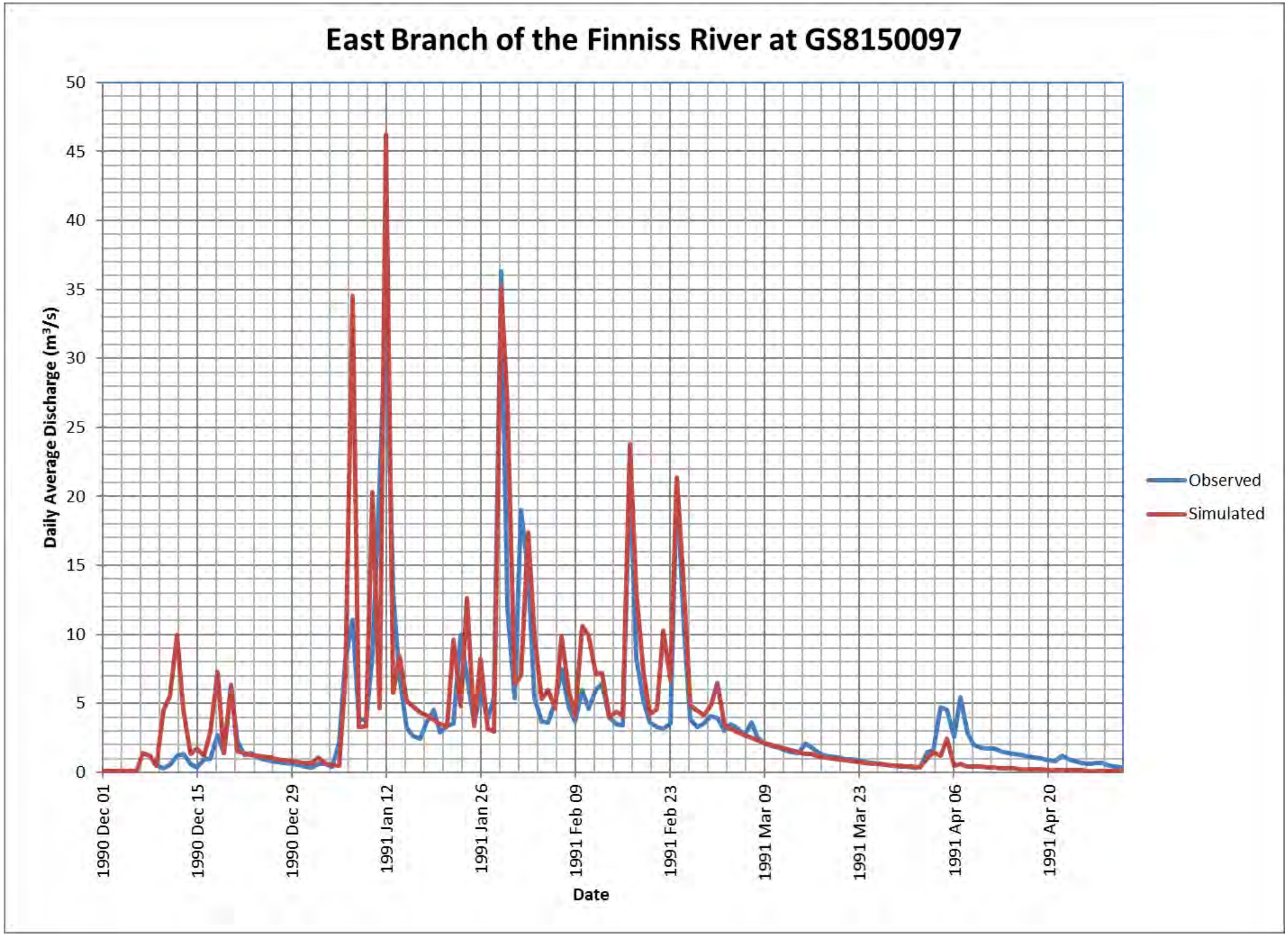
Contents of Water_Balance Container

Figure: 5-10	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	



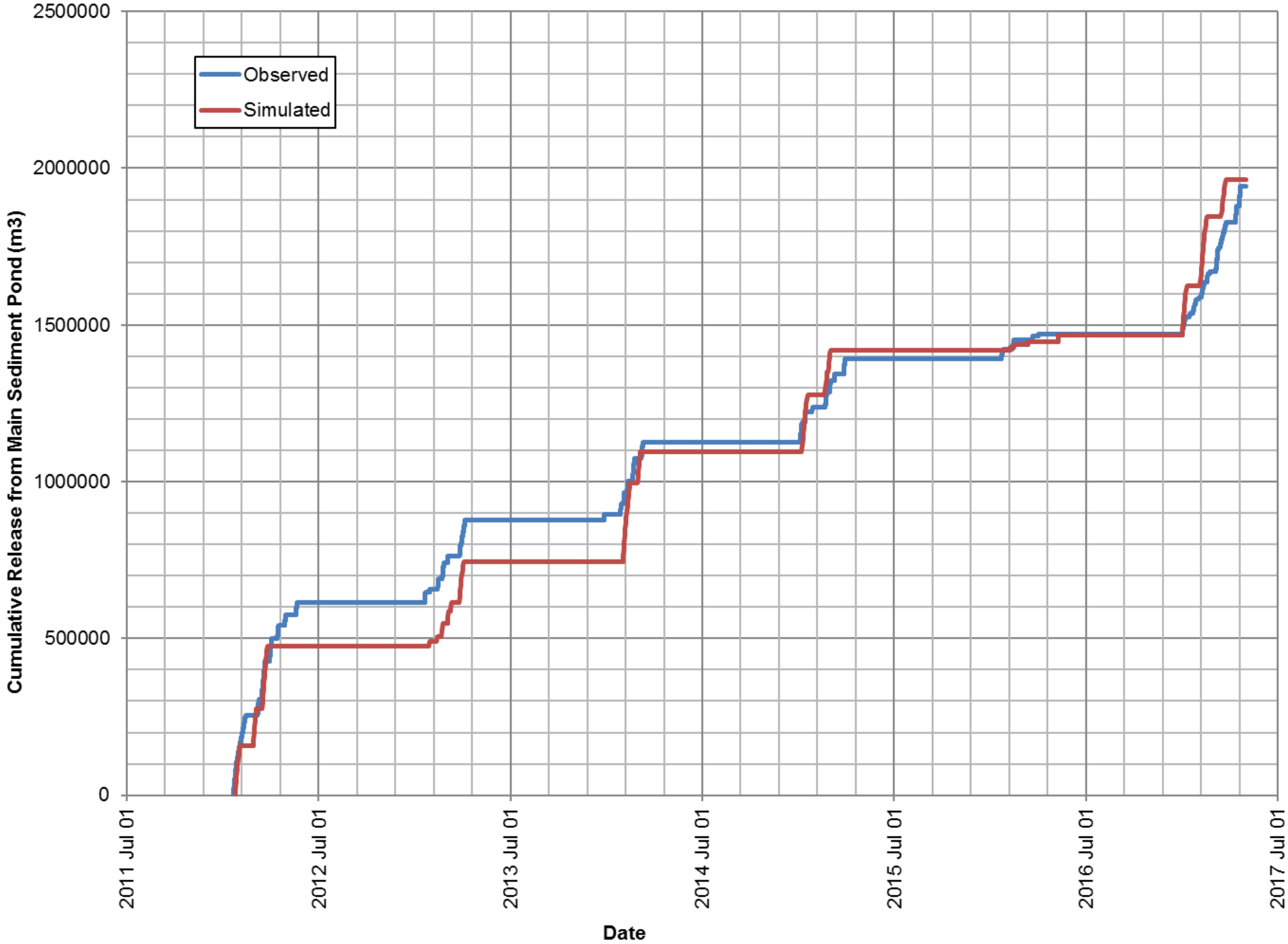
Simulated Water Balance for 2016/2017 Wet Season

Figure: 5-11	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/2	Drawn: Aida Farkish
Original File:	



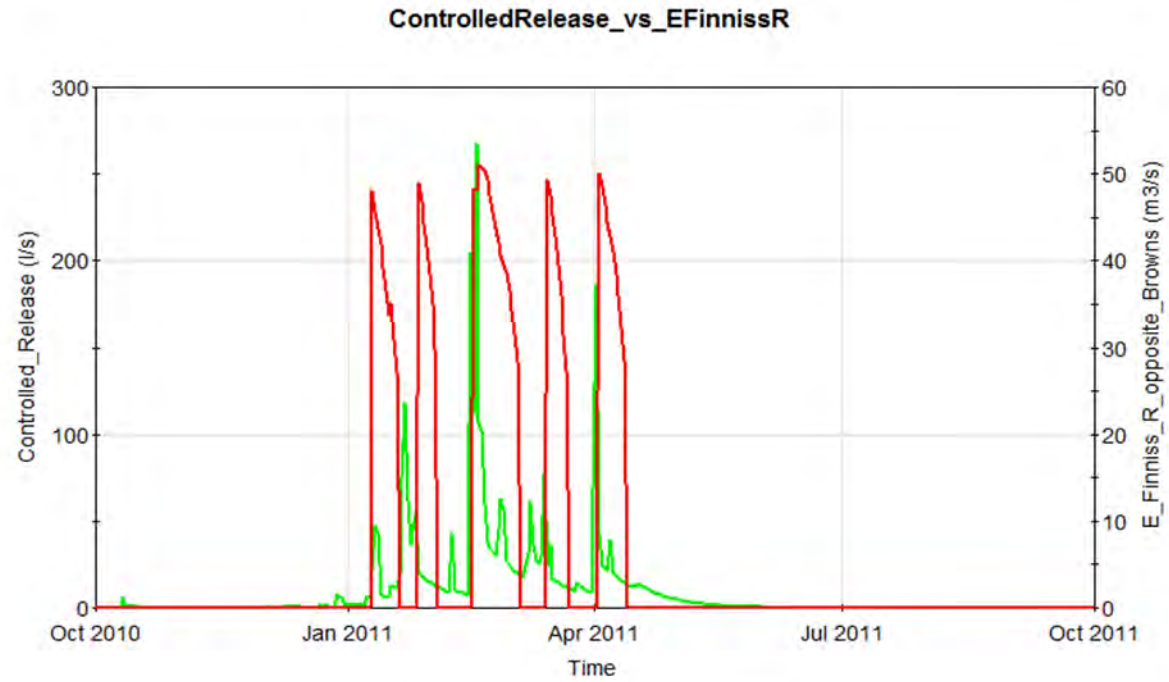
Simulated and Observed Flows in the EBFR at GS8150097, 1990/1991 Wet Season

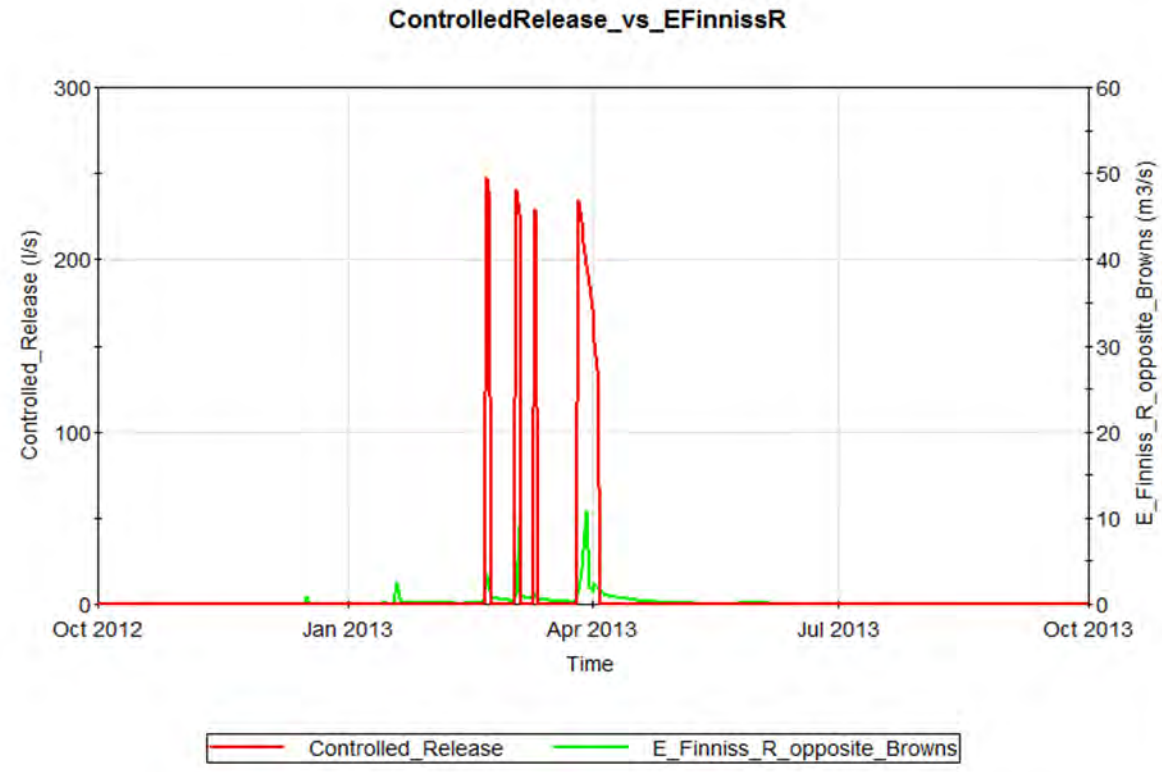
Figure: 5-12	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	



Cumulative Controlled Water Releases from the Main Sediment Dam, 2011 to 2017

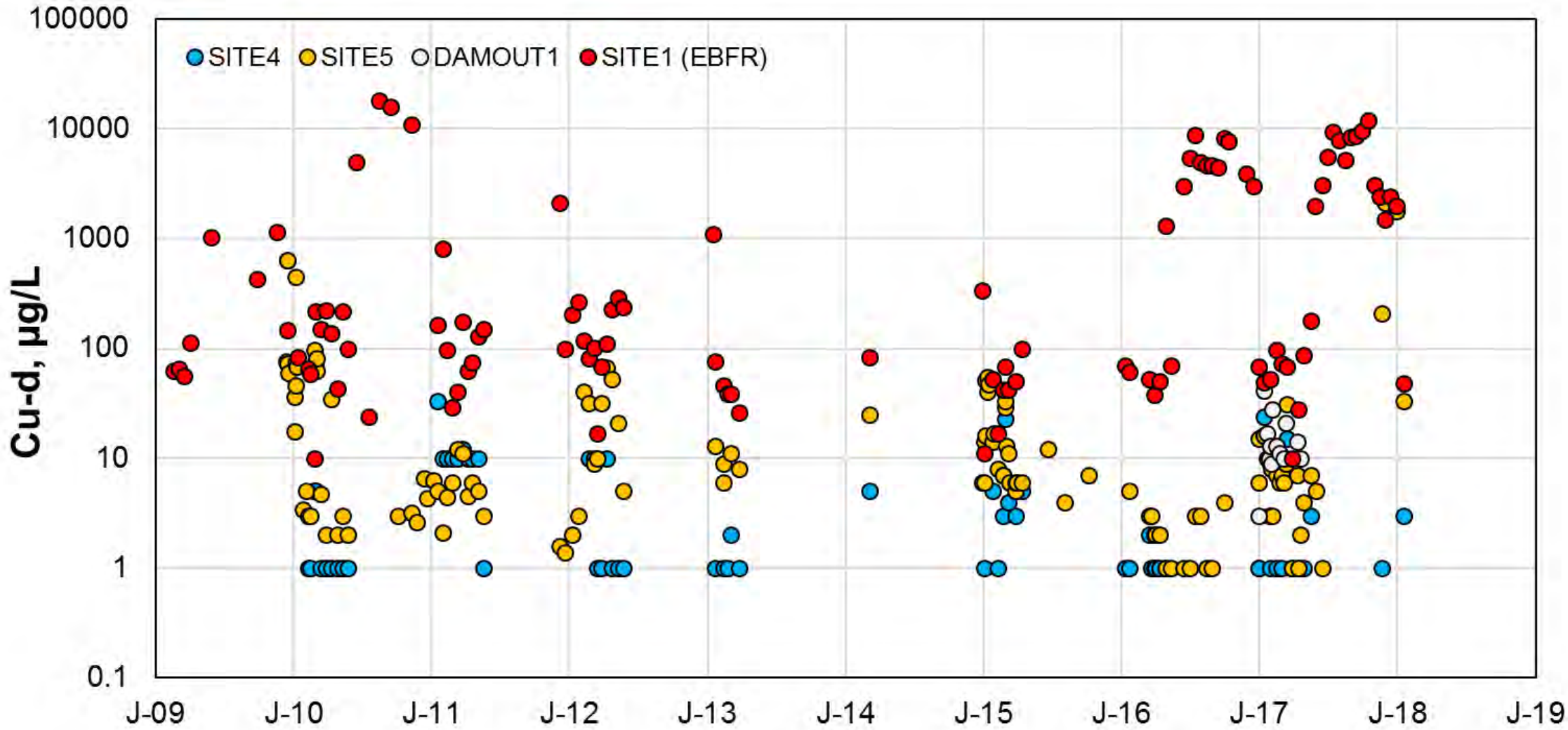
Figure: 5-13	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	





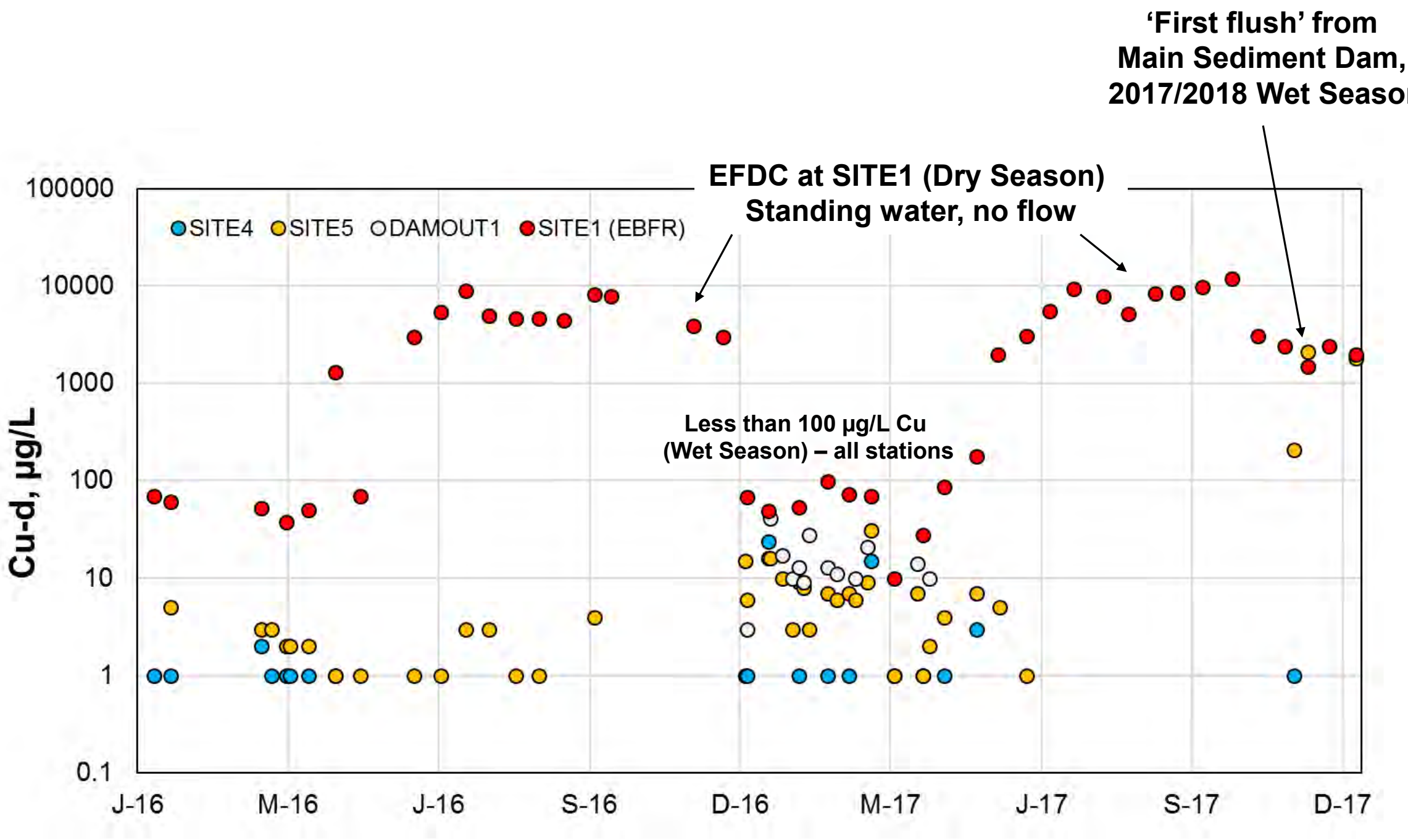
Surface release from mine vs. flow in EBFR

Figure: 5-14	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	



Dissolved Copper Concentrations in Surface Water from Selected WDL177-06 Monitoring Stations. 2009 to December 31st, 2017

Figure: 5-15	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	



Dissolved Copper Concentrations in Surface Water from Selected WDL177-06 Monitoring Stations, January 1st, 2016, to December 31st, 2017

Figure: 5-16	
Client: DOE RUN AUSTRALIA NL	Robertson GeoConsultants Inc.
Project: Browns MMP	Project No: 256003
Report No: 256003/1	Drawn: Aida Farkish
Original File:	

APPENDIX A

WASTE DISCHARGE LICENSE WDL177-06

Northern Territory Government

WASTE DISCHARGE LICENCE

(Pursuant to section 74 of the *Water Act*)

Licensee	Northern Territories Resources Pty Ltd
Licence Number:	**WDL177-06**
Registered Business Address:	6/5 Bishop Street, Woolner NT 0821
Postal Address:	PO Box 37446. Winnellie NT 0821
ACN:	124 647 829
ABN:	78 124 647 829
Premises Address:	Browns Oxide Project Old Rum Jungle Road Batchelor
Anniversary Date:	21 November
Commencement Date:	21 November 2016
Transfer Date:	5 June 2017
Expiry Date:	21 November 2018
Licensed Activity:	Discharge of waste water from Mine Lease Northern (MLN) number 142, which also receives surface water from MLN 139–147 and 150–152, into the East Finniss River

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INFORMATION ABOUT THIS LICENCE

Duration of licence

- This licence will remain in force until its expiry date, it is surrendered by the licensee, or until it is suspended or revoked by the Controller of Water Resources.
- The licensee must notify the Administering Agency within 14 days after ceasing to conduct the activity.
- The licensee may surrender the licence to the Administering Agency.

Amendment, Modification or Revocation of Licence (section 93 of the Water Act)

- As set out in section 93 of the *Water Act*, the Controller of Water Resources may, by notice:
  - amend or modify the terms and conditions of a licence;
  - revoke a licence; or
  - suspend a licence.

Public Register

- A copy of waste discharge licences and any plans for environmental management, reports, submissions or documents required as a condition of a waste discharge licence, will be placed on a register.
- A copy of the Annual Return will be placed on the register.
- The register freely available for viewing on the Northern Territory Government website.

Environmental Interests

- This section highlights the beneficial uses as declared under the *Water Act* and the sensitivity of the surrounding land use and environment associated with the location of the approved activity.
  - There are no beneficial use declarations for the East Finniss River at the time of issue of this licence.

Cultural Interests

- It is the licensee's responsibility to contact the Aboriginal Areas Protection Authority, appropriate land council or other governing body and ensure that any Authority Certificates required as a result of conducting the licenced activity are obtained and complied with.

RULES FOR INTERPRETING THE CONDITIONS OF THIS LICENCE

- Where there is a discrepancy between the conditions of this licence and any plan, standard, guideline or other document referred to in this licence, the conditions of this licence prevail to the extent of the inconsistency.
- Any reference to any standard (Australian or international) in this licence means the relevant parts of the current version of that standard.
- A reference to any guideline or code of practice (or to the relevant parts of any guideline or code of practice) in this licence means the current version of the guideline or code of practice.
- Under section 76 of the *Water Act*, any contravention of or failure to comply with this licence by the licensee may be an offence.
- In this licence, unless the contrary intention appears, words that are defined in the *Water Act* are intended to have the meaning given to them in that Act.

LICENCE CONDITIONS

GENERAL

1. The licensee must ensure the contact details recorded with the Administering Agency for this licence are correct at all times.
2. The licensee must at all times have a 24 hour emergency contact.
3. The licensee must notify the Administering Agency prior to making any operational change that will cause, or is likely to cause, an increase in the potential for environmental harm.
4. The licensee must cause clear and legible signage, in English, to be displayed in a prominent location at each public entrance to the premises that includes the following details:
    4.1. waste discharge licence number issued under the *Water Act*; and
    4.2. 24 hour emergency contact details.
5. The licensee must cause a copy of this licence to be available for inspection by any person, in hard copy form, at the premises.
6. The licensee must provide to the Administering Agency, within 10 business days of a request, a copy of any document, monitoring data or other information in relation to the activity, in the format requested by the Administering Agency.
7. All notices, reports, documents or other correspondence required to be provided as a condition of this licence, unless otherwise specified as a condition of this licence, must be provided in electronic form to the Administering Agency.
8. Within 10 business days of any amendment being made to a document listed in Table 1 the licensee must provide the amended document to the Administering Agency, along with:
    8.1. a tabulated summary of the amendment(s) with document references;
    8.2. reasons for the amendment(s); and
    8.3. an assessment of environmental risk associated with the amendment(s).

Table 1: Documents

Document title
Compass Operations Mining Management Plan (document no. COP-ENV-MMP-016)

9. The Administering Agency may require the licensee to revise or amend and resubmit any amended document. Where the Administering Agency requires a document to be resubmitted, the licensee must submit it to the Administering Agency by the date specified by the Administering Agency.
10. The licensee must, for the duration of this licence, implement, maintain and follow a Consultation and Communication Plan which includes a strategy for communicating with persons who are likely to have a real interest in, or be affected by, the activity.
11. The licensee must operate and maintain a community feedback number.
12. The licensee must display the community feedback number:
    12.1. where the licensee has a website, in a prominent location on the licensees website;
    12.2. in the Consultation and Communication Plan; and
    12.3. in other publicly available documents relating to the activity.
13. The licensee must maintain a Complaint Log for all complaints received by the licensee in relation to the activity.

14. The licensee must ensure that the Complaint Log includes, for each complaint received by the licensee, the following information:
    14.1. the person to whom the complaint was made;
    14.2. the date and time the complaint was reported;
    14.3. the date and time of the event(s) that led to the complaint;
    14.4. the contact details of the complainant if known, or where no details are provided a note to that effect;
    14.5. the nature of the complaint;
    14.6. the nature of event(s) giving rise to the complaint;
    14.7. prevailing weather conditions at the time (where relevant to the complaint);
    14.8. the action taken in relation to the complaint, including any follow-up contact with the complainant; and
    14.9. if no action was taken, why no action was taken.
15. The licensee must implement, maintain and follow an Emergency Response Plan that addresses procedures for responding to emergencies associated with the activity that may cause environmental harm.

EARLY SURRENDER OF LICENCE

16. Any reports, records or other information required or able to be provided by the licensee under this licence must be submitted to the Administering Agency prior to the licensee surrendering the licence. If the date on which a report, record or other information is required falls after the date the licensee requests to surrender this licensee, the licensee must provide the report, record or information as far as possible using data available to the licensee up to and including the date the request to surrender the licence is made.

OPERATIONAL

17. The licensee must ensure any plant and equipment used by the licensee in conducting the activity:
    17.1. is reasonably fit for the purpose and use to which it is put; and
    17.2. is maintained.

DISCHARGES

Discharges to water

18. This licence authorises discharge to water from the authorised discharge point(s) as identified in Table 2 and Appendix 1, and as otherwise allowed in accordance with the conditions of this licence.

Table 2: Authorise discharge point

Authorised discharge point	Description	Sources	Latitude	Longitude
Site 5	Boundary discharge	Uncontaminated stormwater from the mine lease Treated wastewater from the treatment plant	-12.992026	131.000723

19. The licensee must ensure that all discharge events at each authorised discharge point consist only of waste from the source(s) as specified in Table 2.
20. The licensee must ensure that all discharges only occur when:
    20.1. the East Finniss River Diversion is at a flow above 1 cumec (1000L/s) at Gauging Station GS8150200 (as at the commencement date of this Licence a flow rate above 1 cumec equates to a stream height of 1.56m (56.59 AHD) on the existing gauge board adjacent to GS8150200); and
    20.2. the pH of waste water is between 6.5-8.0 pH at Site 2 as identified in Appendix 2.
21. The licensee must, for discharges via Site 5 in Table 2, install, operate and maintain a device to measure and record, for each discharge event:
    21.1. the time the discharge commenced and the duration of the discharge;
    21.2. the discharge rate of flow; and
    21.3. the discharge volume.
22. The licensee must ensure that the discharge from all discharge events at each authorised discharge point does not:
    22.1. contain any floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter;
    22.2. cause or generate odours which would adversely affect the use of surrounding waters;
    22.3. cause algal blooms in the receiving water;
    22.4. cause visible change in the behaviour of fish or other aquatic organisms in the receiving water;
    22.5. cause mortality of fish or other aquatic organisms; or
    22.6. cause adverse impacts on plants.

MONITORING

23. The licensee must conduct surface water monitoring in accordance with Appendix 2.
24. The licensee must ensure that all samples and field environmental data are representative of the conditions at the time of sampling.
25. The licensee must ensure that all samples and field environmental data are collected in accordance with recognised Australian Standards and guidelines (such as AS/NZS 5667, ANZECC/ARMCANZ).
26. The licensee must ensure that all monitoring samples are analysed at a laboratory with current NATA accreditation or equivalent, for the parameters to be measured.
27. The licensee must implement, maintain and follow the 'Compass Resources Browns Oxide Project Water Management Plan' ("the Monitoring Plan") from the commencement date of this licence.
28. The licensee must ensure that any proposed revisions to the Monitoring Plan (other than typographical changes or revisions to formatting or referencing) are:
    28.1. reviewed by a suitably qualified professional who must produce a written report about their review;
    28.2. submitted to the Administering Agency with justification for revisions; and
    28.3. submitted to the Administering Agency, in both hard copy and electronic form (with a complete copy of the suitably qualified professional's written review), 20 business

days prior to the proposed implementation date.

29. The Administering Agency may require the licensee to revise or amend and resubmit the Monitoring Plan. Where the Administering Agency requires the Monitoring Plan to be resubmitted, the licensee must submit it to the Administering Agency by the date specified by the Administering Agency.

30. For the purposes of this condition, the word "land" does not include water [or air] on or above land.

    The licensee must for all land based monitoring points specified in Appendix 2:

    30.1. install and maintain appropriate identification signage so that they are reasonably identifiable at all times; and

    30.2. maintain safe access and egress, as is reasonably practicable.

31. The licensee must ensure any samples collected in accordance with Appendix 2, the Monitoring Plan or in connection with the activity or this licence, are obtained by, or under the supervision of a qualified sampler.

32. The licensee must ensure that, for each sample collected in accordance with Appendix 2, the Monitoring Plan or the activity, the following information must be recorded and retained:

    32.1. the date on which the sample was collected;

    32.2. the time at which the sample was collected;

    32.3. the location at which the sample was collected;

    32.4. the name of the person who collected the sample;

    32.5. the chain of custody forms relating to the sample;

    32.6. the field measurements (if any) and analytical results (if any) relating to the sample; and

    32.7. laboratory quality assurance and quality control documentation.

RECORDING AND REPORTING

33. The licensee must keep records of all non-compliances with this licence. These records must be adequate to enable the licensee to comply with the non-compliance notification conditions of this licence.

34. The licensee must notify the Administering Agency of any non-compliance with this licence as soon as practicable after (and in any case within 24 hours after) first becoming aware of the non-compliance.

35. The licensee must include in the notification of non-compliance the following information:

    35.1. when the non-compliance was detected and by whom;

    35.2. the date and time of the non-compliance;

    35.3. the actual and potential causes and contributing factors to the non-compliance;

    35.4. the risk of environmental harm arising from the non-compliance;

    35.5. the action(s) that have or will be undertaken to mitigate any environmental harm arising from the non-compliance;

    35.6. corrective actions that have or will be undertaken to ensure the non-compliance does not reoccur.

36. The licensee must as soon as practicable and in any case within 24 hours notify the Administering Agency when commencing discharge from the Main Sediment Dam on the premises.

37. The licensee must keep records of all exceedances of trigger values specified in the Table 3. These records must be adequate to enable the licensee to comply with the exceedance notification conditions of this licence.

Table 3: Discharge trigger values

			Site Code	Site 5
			Latitude	-12.992026
			Longitude	131.000723
Parameter	**Abbr.**	**Units**	**Analysis**	**Trigger values**
Metals and Metalloids				
Aluminium	Al	µg/l	Filtered (0.45 µm)	80[a]
Cadmium	Cd			0.4[a]
Cobalt	Co			13
Copper	Cu			2.5[b]
Iron	Fe			-
Lead	Pb			5.6[a]
Manganese	Mn			2500[a]
Nickel	Ni			13[a]
Uranium	U			NA
Zinc	Zn			15[a]

[a] 90% species protection trigger levels, ANZECC/ARMCANZ 2000

[b] 80% species protection trigger levels, ANZECC/ARMCANZ 2000

Note: trigger values are not to be modified to account for hardness

38. The licensee must as soon as practicable (and in any case within 24 hours) after becoming aware, notify the Administering Agency:
    - 38.1. when a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions;
    - 38.2. when a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.
39. The licensee must ensure that the notification of the trigger value exceedance includes the following information:
    - 39.1. when the exceedance was detected and by whom;
    - 39.2. the date and time of the exceedance;
    - 39.3. the actual and potential causes and contributing factors to the exceedance;
    - 39.4. the risk of environmental harm arising from the exceedance;
    - 39.5. the action(s) that have or will be undertaken to address the exceedance and/or environmental harm.
40. The licensee must submit a completed Annual Return to the Administering Agency within 10 business days after each anniversary date of this licence which report relates to the preceding

12 month period.

41. The licensee must complete and provide to the Administering Agency a Monitoring Report, as prescribed by this licence, within 10 business days after each anniversary date of this licence, or an alternative date agreed to by the Administering Agency.
42. The licensee must ensure that each Monitoring Report:
    - 42.1. is prepared in accordance with the requirements of the NT EPA 'Guideline for Reporting on Environmental Monitoring';
    - 42.2. includes a tabulation of all monitoring data required as a condition of this licence;
    - 42.3. includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available);
    - 42.4. includes an estimate of the volume of contaminated groundwater leaving the mine lease (including estimates of individual contaminant volumes e.g. metal and metalloids);
    - 42.5. includes spatial images of contaminated groundwater generated by activities on the mine lease at differing depths/aquifer; and
    - 42.6. includes an assessment of environmental impact from the activity.
43. The Administering Agency may require the licensee to revise or amend and resubmit any Monitoring Report. Where the Administering Agency requires the Monitoring Report to be resubmitted, the licensee must submit it to the Administering Agency by the date specified by the Administering Agency.

Performance Improvement

44. The Licensee must provide a Radionuclide Monitoring Plan to the Administering Agency by 1 March 2017.
45. The Radionuclide Monitoring Plan required under condition 44 must:
    - 45.1. include summary and interpretation of all the radionuclide (i.e. radium 226, polonium 210, lead 210) water quality data collected as part of mining operations or in association with the activity;
    - 45.2. identify the risk to the environment or human health from radionuclide discharged or emitted from the premises, including radium 226, polonium 210, lead 210, uranium isotope 238 and gross alpha emissions;
    - 45.3. identify a radionuclide monitoring program for surface water which includes:
        - monitoring locations;
        - monitoring parameters; and
        - a monitoring schedule.
46. The Administering Agency may require the licensee to revise or amend and resubmit any Radionuclide Monitoring Plan. Where the Administering Agency requires the Radionuclide Monitoring Plan to be resubmitted, the licensee must submit it to the Administering Agency by the date specified by the Administering Agency.
47. The licensee must monitor in accordance with the radionuclide monitoring program identified in condition 45.3.

END OF LICENCE CONDITIONS

This licence is not valid unless signed below:

Joanne Townsend

Controller of Water Resources

Dated the 5 / 6 / 2017

END NOTES

WDL177 was issued to HNC (Australia) Resources Pty Ltd on 18 February 2010.

WDL177-01 was issued to HNC (Australia) Resources Pty Ltd on 11 February 2011 as an amendment to WDL177.

WDL177-02 was issued to HNC (Australia) Resources Pty Ltd on 17 December 2012 upon the expiry of WDL177-01.

WDL177-03 was issued to HNC (Australia) Exploration and Mining Pty Ltd on 6 March 2013 as an amendment to WDL177-02.

WDL177-04 was issued to HNC (Australia) Exploration and Mining Pty Ltd on 19 December 2014 upon the expiry of WDL177-03.

WDL177-05 was issued to Compass Operations Pty Ltd on 21 November 2016 upon the expiry of WDL177-04.

WDL177-06 (this licence) is issued to Northern Territories Resources Pty Ltd following application for transfer received from Compass Operations Pty Ltd on 13 December 2016.

DEFINITIONS

In this licence, unless a contrary intention appears:

Term	Definition
24 hour emergency contact	the phone number of a person who can be contacted at any time and be capable of responding to and providing information about any incident associated with the activity.
Administering Agency	means the Department of Environment and Natural Resources, or if dissolved, another Government Department with the responsibility of administering the Act.
Activity	the Licenced activity as described on the covering page of this licence.
Annual Return	an Administering Agency prescribed format for demonstrating and reporting compliance with the conditions of this licence.
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000: National Water Quality Management Strategy: *Australian Guidelines for Water Quality Monitoring and Reporting.*
Business days	a day not Saturday, Sunday or a public holiday, in the Northern Territory.
Community feedback number	a telephone number enabling members of the public to contact, at any time, a person or voice mail system that can accept, on behalf of the licensee, enquiries or complaints about the activity, and to which the licensee must respond.
Complaint Log	a register of complaints to be maintained by the Licensee that records the details of each complaint received in relation to the activity.
Consultation and Communication Plan	a written plan documenting proposed consultation and communications for the activity before, during and after the activity which includes a strategy for communicating with members of the public who are likely to have a real interest in, or be affected by, the activity.
Contact details	includes the 24 hour emergency contact, and name, position title and phone number of a representative of the licensee who can be contacted about the licence and activity.
Contaminant	a solid, liquid or gas or any combination of such substances and includes: (a) noise, odour, heat and electromagnetic radiation; (b) a prescribed substance or prescribed class of substances; and (c) a substance having a prescribed property or prescribed class of properties.
Discharges	allow a liquid, gas or other substance to flow out from where it has been confined.
Emergency Response Plan	a written plan documenting the licensee's procedures for responding to emergencies caused by, resulting from or associated with the activity and that may cause environmental harm.
Environmental audit	has the meaning given in section 47 of the WMPC Act.
Environmental harm	any harm to or adverse effect on, or potential harm to or potential adverse effect on, the environment
Environmental nuisance	means:(a) an adverse effect on the amenity of an area that: (i) is caused by noise, smoke, dust, fumes or odour; and (ii) unreasonably interferes with or is likely to unreasonably interfere with the enjoyment of the area by persons who occupy a place within the area or are otherwise lawfully in the area; or (b) an unsightly or offensive condition caused by contaminants or waste.

Term	Definition
incident	includes: (a) an accident, emergency or malfunction; and (b) a deliberate action, whether or not that action was taken by the person conducting the activity in the course of which the incident occurred.
Land	includes water and air on, above or under land.
Litter	litter, garbage, rubbish, refuse or waste matter, and includes the body of a dead animal.
Maintain	kept in a manner that it does not present or cause a risk of environmental harm or a hazard to persons or property or, for the purposes of documents including plans, a process of reviewing and amending documentation to ensure it is relevant.
Material environmental harm	environmental harm that: (a) is not trivial or negligible in nature; (b) results or is likely to result in not more than $50,000 being spent in taking appropriate action to prevent or minimise the harm or rehabilitate the environment; or (c) results in actual or potential loss or damage to the value of not more than $50,000.
NATA	National Association of Testing Authorities, Australia.
Non-compliance	failure or refusal to comply, whether by act or omission, with obligations or requirements and includes any exceedance of a licence limit.
Non-compliance notification	an Administering Agency prescribed format for notifying the Administering Agency of a non-compliance.
NT EPA	means the Northern Territory Environment Protection Authority
Plant and equipment	all material items used in association with the activity, including (but not limited to) storage vessels and containers, pipe work and hosing, vehicles (including vessels), tools, and measuring equipment.
Point source discharge	means any discernible, confined or discrete conveyance from which contaminants or waste are or may be discharged.
Pollute	in relation to water, means directly or indirectly to alter the physical, thermal, chemical, biological or radioactive properties of the water so as to render it less fit for a prescribed beneficial use for which it is or may reasonably be used, or to cause a condition which is hazardous or potentially hazardous to: (a) public health, safety or welfare; (b) animals, birds, fish or aquatic life or other organisms; or (c) plants.
Pollution	(a) a contaminant or waste that is emitted, discharged, deposited or disturbed or that escapes; or (b) a contaminant or waste, effect or phenomenon, that is present in the environment as a consequence of an emission, discharge, deposition, escape or disturbance or a contaminant or waste.
Premises	the premises identified in this licence which includes equipment, plant and structures, whether stationary or portable, and the land on which premises are situated.
Public entrance	access to the premises that is utilised by the public.
Qualified person	a person registered under Section 68 of the WMPC Act.
Qualified sampler	a person who has training and experience in obtaining samples from the relevant environmental medium.
Serious environmental	environmental harm that is more serious than material environmental harm

Term	Definition
harm	and includes environmental harm that: (a) results or is likely to result in more than $50,000 being spent in taking appropriate action to prevent or minimise the harm or rehabilitate the environment; (b) results in actual or potential loss or damage to the value of more than $50,000; (c) damages an aspect of the environment that is of a high conservation value or of special significance; and (d) is irreversible or otherwise of a high impact or on a wide scale.
Solid inert waste	solid waste that has no active chemical or biological properties. These wastes do not undergo environmentally significant physical, chemical or biological transformation.
Stormwater	water flowing over ground surfaces, in natural streams and drains as a direct result of rainfall over a catchment and consists primarily of rainfall runoff.
Trigger values	assigned value for each indicator used to assess the risk to an environmental value, a value that initiates some type of pre-defined management action.
Waste	Includes matter or a thing, whether wholly or partly in a solid, liquid or gaseous state, which, if added to water, may pollute the water.
Wastewater	water that contains a contaminant or waste.
Water	means water, whether or not it contains impurities.
WMPC Act	the Northern Territory *Waste Management and Pollution Control Act*.

APPENDIX 1: Surface water discharge and monitoring locations

NORTHERN TERRITORY GOVERNMENT

NR MAPS

WDL177-05 Water Monitoring Locations

Legend

Monitoring Locations

Metres 200 400

www.lrm.nt.gov.au/nrmapsnt

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The Northern Territory of Australia does not warrant that the product or any part of it is correct or complete and will not be liable for any loss damage or injury suffered by any person as a result of its inaccuracy or incompleteness.

APPENDIX 2: Surface water monitoring programme

	Site Code			SITE 1	SITE 2	DAMOUT01	SITE 4	SITE 5	TREAT01
	Site Description			East Finniss River Upstream	Main Sediment Dam	Main Sediment Dam Pipe Outlet	Middlebrook Creek Upstream	Boundary	Water treatment outflow[a]
			Latitude	-12.99167	-12.993444	-12.993478	-12.999194	-12.992026	-12.995369
			Longitude	131.00299	130.998944	130.999281	131.001785	131.000723	130.989172
Parameter	**Abbr.**	**Units**	**Analysis**	**Monitoring Frequency**					
Field Measurements									
Water Level		m	In situ	F*	F & U	U	F*	D	F
pH	pH	pH							
Electrical Conductivity	EC	µS/cm							
Dissolved Oxygen	DO	% sat.							
Turbidity	NTU	NTU							
Temperature	T	°C							
Metals and Metalloids									
Aluminium	Al	µg/L	Total and Filtered (0.45µm)	F*	F & U	U	F*	F* & U	F
Cadmium	Cd								
Cobalt	Co								
Copper	Cu								
Iron	Fe								
Lead	Pb								
Manganese	Mn								
Nickel	Ni								
Uranium	U								
Zinc	Zn								

	Site Code			SITE 1	SITE 2	DAMOUT01	SITE 4	SITE 5	TREAT01
	Site Description			East Finniss River Upstream	Main Sediment Dam	Main Sediment Dam Pipe Outlet	Middlebrook Creek Upstream	Boundary	Water treatment outflow[a]
			Latitude	-12.99167	-12.993444	-12.993478	-12.999194	-12.992026	-12.995369
			Longitude	131.00299	130.998944	130.999281	131.001785	131.000723	130.989172
Parameter	**Abbr.**	**Units**	**Analysis**	**Monitoring Frequency**					
Major Chemistry									
Total Suspended Solids	TSS	mg/L		F*	F & U	U	F*	F* & U	F
Hardness	$CaCO_3$								
Carbonate	CO_3								
Bicarbonate	HCO_3								
Calcium	Ca								
Magnesium	Mg								
Potassium	K								
Sodium	Na								
Chloride	Cl								
Sulfate	SO_4								

Key D = daily (when discharging); F = fortnightly; F* = fortnightly when flowing; M = monthly; NA = not applicable; U = upon discharge

[a] Samples to be collected from one of the flowing outflow pipes for CCD1 or CCD2

APPENDIX B

RECENT UPGRADES TO WATER TREATMENT PROCESS

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-027
27th April 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

Browns Water Treatment Description 2017

In response to your email on the 2nd May 2017 please find below a detailed description of our improvement plans for the water treatment process for 2017.

Northern Territories Resources Pty Ltd (NTR) strives for continual improvement and as such there have been changes made throughout the season to improve the performance of the treatment process. These are listed below.

1. Water quality monitoring of the treatment water has been ongoing all season. This is the first year that comprehensive analysis of the treated water has been undertaken.
2. Process changes have been implemented in response to the water quality data to improve metal recovery. These changes have included;

    i. Increased reagent addition,
    ii. Modification to the reagent delivery system,
    iii. Modification to the flocculent delivery system,
    iv. Increased residence time of treated water in the tanks,
    v. Turning off the rakes in the CCD's to improve the settling of the metal precipitates,
    vi. Improved blending of the water types (ie low pH water blended with better quality water) prior to treatment.

Water treatment operations ceased at site on 5 May 2017 for the season.

As mentioned in past correspondence, NTR has been working on a project to transition from sodium carbonate to slaked lime as the reagent used in the water treatment process. Due to plant/equipment modifications required for the new process, it was not practical to do this during the wet season due to the disruptions this would have caused to our site stormwater management.

The water treatment process will be altered during the 2017 dry season in preparation for the 2017/18 wet season commencing around October 2017. These changes have been approved by

the Department of Primary Industry and Resources (DPIR) in the Care and Maintenance Mining Management Plan (MMP). Intended process changes include:

- Switch from using soda ash (sodium bicarbonate) as the precipitant to using slaked lime (calcium hydroxide),
- Employ mechanical agitation in two treatment tanks to more effectively mix the precipitation reagent into the feed water enhancing both reaction rate and precipitation efficiency,
- Employ gentle mechanical agitation in a flocculent treatment tank to promote precipitate flocculation to enhance final water clarity,
- Utilise the thickeners solely as clarifying units to promote complete settling and clarification of the treated water,
- Utilise a final thickener tank to readjust water pH as appropriate prior to discharge of treated water to the sedimentation pond.

Each of these measures is designed to reduce the metals loading in the treated water to be released from the site. The design of the modified water treatment circuit has taken into account the following:

- The dissolved metals in the water to be treated all have a minimum solubility in the pH range of 9 to 11. An optimum treatment target range is pH 9.5 to 10.
- Soda ash, due to its bicarbonate/carbonate buffering effect, limits the maximum treatment pH to approximately 9.4.
- The water treatment pH can be effectively controlled to any pH in the target range using slaked lime.
- Several metals and in particular, copper, are more soluble in a carbonate media than in a hydroxide alone; i.e., a lower residual copper concentration can be achieved using lime as a precipitant rather than soda ash.
- The sulphate content of the water to be treated will be precipitated by lime as gypsum. Whereas, following soda ash treatment, sulphate remains in solution as sodium sulphate.
- The co-precipitation of gypsum along with the metal hydroxides will enhance precipitate growth and the susceptibility of the particulates to flocculation with polymer flocculants in the subsequent unit operation step. Thus, ultimately enhancing the final clarity of the treated water.

These outlined changes to the Brown's water treatment process will be effected by bringing into service some currently idled equipment and completing some alterations to the piping and pumping systems. It is anticipated the changes will be completed well in advance of the next wet season.

Should you have any further questions please contact Natasha Rodwell on 0421 541 299.

We would like to also take this opportunity to extend the invitation to visit site where we can run you through our water management activities and demonstrate the new treatment process.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

APPENDIX C

STATISTICAL SUMMARY OF GROUNDWATER QUALITY

Appendix Table C1. Groundwater Quality Results for Bore BH2B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH2B	1/11/2016	4.1	32					6	31											20	0.1	1	1		55	1	1	0.3	5	-
BH2B	1/20/2016	4.7	19					5	25											20	0.1	1	6		15	65	1	0.1	36	-
BH2B	3/30/2016	4.8	31	31		6											1			20	0.1	2	11		230	2	1	0.1	58	-
BH2B	4/29/2016	4.8	5	26													1			120	0.1	2	35		15	32	8	0.1	170	-
BH2B	7/31/2016										29	8	10	5	3	1	1	3	1	20	0.1	1	3		16	20	1	0.1	42	52%
BH2B	8/30/2016										80	8	9	2	3	1	1	3	1	10	0.1	1	5		21	37	1	0.1	28	31%
BH2B	9/30/2016	4.5	26	32			283		21		92	6	7	2	3	1	1	3	1	50	0.2	1	2		15	27	1	5	19	15%
BH2B	10/6/2016	4.4	28	34		2	313		24		75	6	7	3	3	1	1	3	1	50	0.2	1	1		13	8	1	5	6	29%
BH2B	10/17/2016	4.8	19	33			207		16		81	5	6	2	4	2	1	3	1	50	0.2	1	2		16	6	1	5	17	2%
BH2B	1/4/2017	5.1	21	30		3	310				15	20	24	5	3		1	2		50	0.2	2	12	50	15	6	1	5	17	
BH2B	4/5/2017	5.3	42	34		3	221		37		2,000	11	13	2	4	1	2	11	1	5000	0.2	1	6		51	4	3	5	17	109%
No. of sampling campaigns		11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	-
No. of measurements		9	9	7	0	4	5	2	6	0	7	7	7	7	7	6	9	7	6	11	11	11	11	1	11	11	11	11	11	-
% of samples analyzed		82%	82%	64%	0%	36%	45%	18%	55%	0%	64%	64%	64%	64%	64%	55%	82%	64%	55%	100%	100%	100%	100%	9%	100%	100%	100%	100%	100%	-
Minimum		4.1	5	26	-	2	207	5	16	-	15	5	6	2	3	1	1	2	1	10	0.1	1	1	-	13	1	1	0.1	5	2%
Maximum		5.3	42	34	-	6	313	6	37	-	2,000	20	24	5	4	2	2	11	1	5,000	0.2	2	35	-	230	65	8	5	170	109%
Mean		4.7	25	31	-	4	267	5	26	-	339	9	11	3	3	1	1	4	1	492	0.1	1	8	-	42	19	2	2	38	40%
Median		4.8	26	32	-	3	283	5	25	-	80	8	9	2	3	1	1	3	1	50	0.1	1	5	-	16	8	1	0.3	19	30%
Standard Deviation		0.3	10	3	-	2	50	0	7	-	733	5	6	1	0	0.4	0.4	3	-	1,496	0.1	0.5	10	-	64	20	2	3	47	35%
80th Percentile		4.9	31	33	-	4	310	5	31	-	90	10	13	5	4	1	1	3	1	50	0.2	2	11	-	51	32	1	5	42	52%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C2. Groundwater Quality Results for Bore BH3A and BH3B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH3A	1/6/2016	3.7	66	30	73	5		5	77											40	0.2	25	44		65	16	1	0.1	61	
BH3A	2/17/2016	4.3	91	31	91	7		5	86											860	0.1	4	25		12	4	1	0.1	33	
BH3A	4/6/2017	4.6	79	41		3	247		78		510	5	6	13	10	1	2	9	1	190	0.2	11	40		29	10	4	5	28	2%
BH3A	7/8/2017	5.4	355	34		4	184				6,100	12	15	150	12	12	27	25	2	70	0.200	4	5	50	86	15	1	5	35	7%
BH3A	8/1/2017										47	20	24	21	27	1	1	14	3	50	0.2	55	65	50	160	60	1	5	230	60%
No. of sampling campaigns		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
No. of measurements		4	4	4	2	4	2	2	3	0	3	3	3	3	3	3	3	3	3	5	5	5	5	2	5	5	5	5	5	3
% of samples analyzed		80%	80%	80%	40%	80%	40%	40%	60%	0%	1	1	1	1	1	1	1	1	1	1	100%	1	1	0	1	1	1	100%	1	60%
Minimum		3.7	66	30	73	3	184	5	77	-	47	5	6	13	10	1	1	9	1	40	0.1	4	5	50	12	4	1	0.1	28	2%
Maximum		5.4	355	41	91	7	247	5	86	-	6,100	20	24	150	27	12	27	25	3	860	0.2	55	65	50	160	60	4	5.0	230	60%
Mean		4.5	148	34	82	5	216	5	80	-	2,219	12	15	61	16	5	10	16	2	242	0.2	20	36	50	70	21	2	3.0	77	23%
Median		4.5	85	32	82	5	216	5	78	-	510	12	15	21	12	1	2	14	2	70	0.2	11	40	50	65	15	1	5.0	35	7%
Standard Deviation		0.7	139	5	13	2	45	0	5	-	3,369	8	9	77	9	6	15	8	1	351	0.0	21	22	0	58	22	1	2.7	86	32%
80th Percentile		4.9	197	37	87	6	235	5	83	-	3,864	17	20	98	21	8	17	21	3	324	0.2	31	48	50	101	25	2	5.0	95	39%
BH3B	1/6/2016	3.9	106	30	27	2		4	128											270	0.5	56	450		120	40	6	1.0	130	
BH3B	2/17/2016	3.7	146	30	25	2		4	150											390	0.2	23	210		66	15	8	1.2	59	
BH3B	10/6/2016								210		18	5	0	47	18	1	1	13	3	730	0.2	100	14		270	54	1	5	39	52%
BH3B	1/4/2017										5	20	24	32	16	1	1	12		1000	0.2	120	44	50	350	72	10	5	44	62%
BH3B	4/6/2017	3.9	241	24		0	267		240		17	5	0	68	20	1	2	15	3	1700	0.2	250	67		710	130	14	5	77	50%
BH3B	8/1/2017	3.7	174	29	1	383																								
BH3B	10/9/2017	3.6	167	36		1	331				70	20	0	28	33	1	2	16	4	1,200	0.2	170	38	60	460	150	15	5	76	26%
BH3B	12/28/2017	3.7	143	33		0	393				41	20	0	17	42	1	1	9	2	340	0.2	26	23	60	79	88	9	5	87	90%
No. of sampling campaigns		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of measurements		6	6	6	3	6	3	2	4	0	5	5	5	5	5	5	5	5	4	7	7	7	7	3	7	7	7	7	7	5
% of samples analyzed		75%	75%	75%	38%	75%	38%	25%	50%	0%	63%	63%	63%	63%	63%	63%	63%	63%	50%	88%	88%	88%	88%	38%	88%	88%	88%	88%	88%	63%
Minimum		3.6	106	24	1	0	267	4	128	-	5	5	0	17	16	1	1	9	2	270	0.2	23	14	50	66	15	1	1	39	26%
Maximum		3.9	241	36	27	383	393	4	240	-	70	20	24	68	42	1	2	16	4	1,700	0.5	250	450	60	710	150	15	5	130	90%
Mean		3.7	163	30	17	65	331	4	182	-	30	14	5	38	26	1	1	13	3	804	0.2	106	121	57	294	78	9	4	73	56%
Median		3.7	157	30	25	2	331	4	180	-	18	20	0	32	20	1	1	13	3	730	0.2	100	44	60	270	72	9	5	76	52%
Standard Deviation		0.1	45	4	15	156	63	0	52	-	26	8	11	20	11	0	1	3	1	528	0.1	83	160	6	236	48	5	2	31	23%
80th Percentile		3.9	174	33	26	2	368	4	222	-	47	20	5	51	35	1	2	15	4	1,160	0.2	160	181	60	438	122	13	5	85	67%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C3. Groundwater Quality Results for Bore BH4A and BH4B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH4A	1/6/2016	2.8	111	31	68	5		4	1,697											18,000	7.5	12,000	38,000		26,000	5,300	77	240	2,600	
BH4A	5/9/2017	3.4	1,871	31		0	113				5			1,400	5	180	72	12		12,000	4.8	5,900	17,000	160	11,000	2,800	50	190	1,600	47%
BH4A	7/8/2017	2.8	1,527	33		2	314				290			1,400	8	150	84	28	7	22,000	8.9	10,000	29,000	780	24,000	4,900	48	200	2,700	35%
No. of sampling campaigns		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
No. of measurements		3	3	3	1	3	2	1	1	0	2	0	0	2	2	2	2	2	1	3	3	3	3	2	3	3	3	3	3	2
% of samples analyzed		100%	100%	100%	33%	100%	67%	33%	33%	0%	1	0%	0%	67%	67%	67%	67%	67%	33%	100%	100%	100%	100%	67%	100%	100%	100%	100%	100%	67%
Minimum		2.8	111	31	68	0	113	4	1,697	0	5	0	0.0	1,400	5	150	72	12	7	12,000	5	5,900	17,000	160	11,000	2,800	48	190	1,600	35%
Maximum		3.4	1,871	33	68	5	314	4	1,697	0	290	0	0.0	1,400	8	180	84	28	7	22,000	9	12,000	38,000	780	26,000	5,300	77	240	2,700	47%
Mean		3.0	1,170	32	68	2	214	4	1,697	-	148	-	-	1,400	7	165	78	20	7	17,333	7	9,300	28,000	470	20,333	4,333	58	210	2,300	41%
Median		2.8	1,527	31	68	2	214	4	1,697	-	148	-	-	1,400	7	165	78	20	7	18,000	8	10,000	29,000	470	24,000	4,900	50	200	2,600	41%
Standard Deviation		0.3	933	1	-	2	142	-	-	-	202	-	-	0	2	21	8	11	-	5,033	2	3,110	10,536	438	8,145	1,343	16	26	608	9%
80th Percentile		3.1	1,733	32	68	4	274	4	1,697	-	233	-	-	1,400	8	174	82	25	7	20,400	8	11,200	34,400	656	25,200	5,140	66	224	2,660	45%
BH4B	1/6/2016	2.7	960	31	73	5		4	1,405											12,000	5	9,700	25,000		20,000	4,200	60	170	2,000	
BH4B	8/17/2016	3.3	1,201	31		2			1,500		2,300	5	6	1,300	17	70	69	33	3	19,000	7	13,000	27,000		36,000	6,000	11	140	2,900	55%
No. of sampling campaigns		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
No. of measurements		2	2	2	1	2	0	1	2	0	1	1	1	1	1	1	1	1	1	2	2	2	2	0	2	2	2	2	2	1
% of samples analyzed		100%	100%	100%	50%	100%	0%	50%	100%	0%	1	50%	50%	50%	50%	50%	50%	50%	50%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%	50%
Minimum		2.7	960	31	-	2	-	4	1,405	-	2,300	5	6	1,300	17	70	69	33	3	12,000	5	9,700	25,000	-	20,000	4,200	11	140	2,000	-
Maximum		3.3	1,201	31	-	5	-	4	1,500	-	2,300	5	6	1,300	17	70	69	33	3	19,000	7	13,000	27,000	-	36,000	6,000	60	170	2,900	-
Mean		3.0	1,081	31	-	4	-	4	1,453	-	2,300	5	6	1,300	17	70	69	33	3	15,500	6	11,350	26,000	-	28,000	5,100	36	155	2,450	-
Median		3.0	1,081	31	-	4	-	4	1,453	-	2,300	5	6	1,300	17	70	69	33	3	15,500	6	11,350	26,000	-	28,000	5,100	36	155	2,450	-
Standard Deviation		0.4	170	0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	4,950	1	2,333	1,414	-	11,314	1,273	35	21	636	-
80th Percentile		3.2	1,153	31	-	5	-	4	1,481	-	2,300	5	6	1,300	17	70	69	33	3	17,600	6	12,340	26,600	-	32,800	5,640	50	164	2,720	-

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C4. Groundwater Quality Results for Bore BH4A and BH4B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH4D	1/12/2016	3.4	299	30.1	7	0		3.8	481											2000	1.4	2600	2900		6100	1200	12	13.0	460	
BH4D	2/23/2016	3.7	384	31.2	7	1		4.2	390							10	13			1500	1.2	1700	2000		4400	820	12	6.6	440	
BH4D	8/3/2016	3.5	503	30.7		4	459		420		74	5	6	240	8	14	16	19	3	1800	1.3	2000	1800		5100	960	4	1.4	530	42%
BH4D	10/7/2016	3.5	517	33.7		2	446		480		5	5	6	210	8	13	16	22	3	1500	1.2	2000	1600		4900	890	1	5	470	29%
BH4D	1/4/2017										2	20	24	170	11	11	15	21		1800	1.1	2000	2000	180	5700	930	9	8.0	430	
BH4D	4/17/2017	3.8	709	30.7		0	480				5	5	6	280	8	24	27	22	3	2600	1.6	3300	2900	50	7300	1400	5	5	700	15%
BH4D	8/1/2017	3.5	530	31.2		0	440				18	20	24	210	17	20	20	24	3	2300	1.3	2400	2300	70	6800	1100	16	11.0	550	16%
BH4D	10/10/2017	3.5	400	31.8		0	284				8	20	24	150	11	10	12	22	3	1200	0.8	1400	1200	50	3700	670	7	6.0	310	28%
BH4D	11/15/2017	4.1	288	29.0	16	1		4.6	320											1200	1.0	1400	1200		3700	630	5	5.4	360	
BH4D	1/5/2018	3.6	381	30.8		0	381				3	20		120	7	9	12	25	3	1200	0.8	1400	1200	80	3700	640	9	5	370	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		9	9	9	3	9	6	3	5	0	7	7	6	7	7	8	8	7	6	10	10	10	10	5	10	10	10	10	10	5
% of samples analyzed		90%	90%	90%	30%	90%	60%	30%	50%	0%	70%	70%	60%	70%	70%	80%	80%	70%	60%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	50%
Minimum		3.4	288	29	7	0	284	3.8	320	-	2	5	6	120	7	9	12	19	3	1,200	0.8	1,400	1,200	50	3,700	630	1	1	310	15%
Maximum		4.1	709	34	16	4	480	4.6	481	-	74	20	24	280	17	24	27	25	3	2,600	1.6	3,300	2,900	180	7,300	1,400	16	13	700	42%
Mean		3.6	446	31	10	1	415	4.2	418	-	16	14	15	197	10	14	16	22	3	1,710	1.2	2,020	1,910	86	5,140	924	8	7	462	26%
Median		3.5	400	31	7	0	443	4.2	420	-	5	20	15	210	8	12	16	22	3	1,650	1.2	2,000	1,900	70	5,000	910	8	6	450	28%
Standard Deviation		0.2	133	1	5	1	72	0.4	67	-	26	8	10	55	3	5	5	2	0	484	0.3	612	645	54	1,312	254	4	3	112	11%
80th Percentile		3.8	522	31	12	1	459	4.4	480	-	16	20	24	234	11	18	18	24	3	2,060	1.3	2,440	2,420	100	6,240	1,120	12	9	534	32%
BH4E	1/12/2016	3.5	114	29.3	4	0		4.8	142											130	0.5	170	140		470	83	5	0.7	75	
BH4E	2/23/2016	4.1	134	31	16	1		4.8	130							2	3			60	0.2	110	89		320	62	1	0.4	44	
BH4E	8/3/2016	4.2	272	31.1			346		250		10	5	6	140	120	8	11	14	2	330	0.6	550	110		1600	240	1	0.2	170	
BH4E	10/7/2016	4.2	248	32.1		1	333		240		5	5	6	100	5	6	10	15	2	290	0.6	520	280		1300	250	1	5	190	
BH4E	1/15/2017	5.0	149	32.8		1	201				7	5	6		5	3	5	11	1		0.2	210	31		510	110	1	5	90	
BH4E	4/17/2017	4.8	154	30.8		0	160				10	5	6	42	6	3	5	11	1	60	0	150	17	140	410	67	1	5	46	8%
BH4E	8/1/2017	4.5	176	31.8		1	224				2	20	24	49	11	4	5	15	1	80	0.3	170	58	50	520	100	3	5	260	25%
BH4E	10/10/2017	4.5	183	30.9		0	211				1	20	24		18	3	5	14	1	100	0.2	210	85	110	610	140	2	5	76	
BH4E	11/15/2017	4.2	127	29.3	10	1		5.0	120											50	0.4	160	100		440	79	1	0.5	85	
BH4E	1/5/2018	5.7	327	30.7		0	64				10	40		88	31	12	16	22	3	50	0.5	990	19	13000	2800	460	1	5	220	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		10	10	10	3	9	7	3	5	0	7	7	6	5	7	8	8	7	7	9	10	10	10	4	10	10	10	10	10	2
% of samples analyzed		100%	100%	100%	30%	90%	70%	30%	50%	0%	70%	70%	60%	50%	70%	80%	80%	70%	70%	90%	100%	100%	100%	40%	100%	100%	100%	100%	100%	20%
Minimum		3.5	114	29	4	0	64	5	120	-	1	5	6	42	5	2	3	11	1	50	0.2	110	17	50	320	62	1	0	44	25%
Maximum		5.7	327	33	16	1	346	5	250	-	10	40	24	140	120	12	16	22	3	330	0.6	990	280	13000	2800	460	5	5	260	54%
Mean		4.5	189	31	10	1	220	5	176	-	6	14	12	84	28	5	7	15	2	128	0.4	324	93	3325	898	159	2	3	126	42%
Median		4.4	165	31	10	1	211	5	142	-	7	5	6	88	11	4	5	14	1	80	0.4	190	87	125	515	105	1	5	88	53%
Standard Deviation		0.6	71	1	6	0	98	0	63	-	4	13	9	40	42	3	4	4	1	107	0.2	281	77	6450	790	125	1	2	77	64%
80th Percentile		4.9	253	32	13	1	311	5	242	-	10	20	24	108	28	7	10	15	2	194	0.5	526	116	5284	1360	242	2	5	196	40%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C5. Groundwater Quality Results for Bore BH4F and BH4G, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH4F	1/6/2016	6.1	113	29.6	10	1		6.6	151											40	0.1	30	41		100	15	1	0.6	8	
BH4F	2/17/2016	7.5	138	30.3	6	0		6.8	140											30	0.1	1	1		19	1	1	0.1	5	
BH4F	8/3/2016	7.1	163	30.8			-152		150		30	73	89	2	4	4	5	15	7	20	0.1	1	1		160	2	1	0.1	7	13%
BH4F	10/7/2016	7.0	180	31.1		2	-183		150		13	54	66	2	4	4	5	14	6	50	0.2	1	1		280	1	1	5	5	10%
BH4F	4/17/2017	7.2	163	31.1		0	-207				21	62	76	2	4	4	5	16	6	50	0.2	1	1	6100	240	1	1	5	5	26%
BH4F	8/1/2017	6.8	161	30.3		0	-102				14	77	94	5	13	4	5	16	6	50	0.2	2	1	1300	260	1	1	5	5	28%
BH4F	10/10/2017	7.1	138	31.0		0	-131				8	66		5	5	4	4	16	6	50	0.2	1	1	3400	250	2	1	5	18	
BH4F	12/28/2017	7.3	147	30.3		0	-181				8	69		5	32	4	4	11	5	50	0.2	1	1	2900	220	1	1	5	6	
No. of sampling campaigns		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of measurements		8	8	8	2	7	6	2	4	0	6	6	4	6	6	6	6	6	6	8	8	8	8	4	8	8	8	8	8	4
% of samples analyzed		100%	100%	100%	25%	88%	75%	25%	50%	0%	75%	75%	50%	75%	75%	75%	75%	75%	75%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	50%
Minimum		6.1	112.6	29.6	5.9	0.0	-207.0	6.6	140.0	-	7.5	54.0	65.9	2.0	3.8	3.6	4.0	11.0	4.5	20.0	0.1	1.0	1.0	1300.0	19.0	1.0	1.0	0.1	5.0	10%
Maximum		7.5	180.0	31.1	9.5	1.6	-101.8	6.8	151.0	-	30.0	77.0	93.9	5.0	32.0	4.1	5.2	16.0	6.5	50.0	0.2	30.0	41.0	6100.0	280.0	15.0	1.0	5.0	18.0	28%
Mean		7.0	150.3	30.6	7.7	0.5	-159.4	6.7	147.8	-	15.5	66.8	81.1	3.6	10.3	3.9	4.6	14.7	5.9	42.5	0.2	4.8	6.0	3425.0	191.1	3.0	1.0	3.2	7.4	19%
Median		7.1	154.0	30.6	7.7	0.4	-166.8	6.7	150.0	-	13.5	67.5	82.4	3.7	4.7	4.0	4.6	15.5	6.0	50.0	0.2	1.0	1.0	3150.0	230.0	1.0	1.0	5.0	5.5	19%
Standard Deviation		0.4	20.9	0.5	2.5	0.5	38.6	0.1	5.2	-	8.7	8.2	12.8	1.6	11.2	0.2	0.4	2.0	0.7	11.6	0.1	10.2	14.1	1995.6	91.2	4.9	0.0	2.5	4.4	9%
80th Percentile		7.3	162.9	31.1	8.8	0.6	-131.2	6.8	150.4	-	21.0	73.0	91.0	5.0	13.0	4.0	4.8	16.0	6.4	50.0	0.2	1.6	1.0	4480.0	256.0	2.0	1.0	5.0	7.6	27%
BH4G	1/6/2016	3.0	100	29	20	2		4	1519											11,000	6.4	13,000	17,000		35,000	5,400	36	100	2,400	
BH4G	2/17/2016	3.9	1104	29	111	8		3	1200											7,100	3.9	7,200	6,200		20,000	3,200	14	40	1,600	
BH4G	7/6/2016	3.6	932	31	66		458				5	5	6	710	14	52	52	27	4	7,600	3.6	6,500	8,900		17,000	2,900	8	17	1,400	
BH4G	10/7/2016	3.5	987	30		5	451		860		5	5	6	450	10	40	43	24	4	6,600	3.4	5,600	7,800		1,100	2,400	7	13	1,300	
BH4G	1/4/2017	3.8	930	32		4	493				3	20	24	420	12	35		20		6,800	2.9	6,600	9,500	1,600	18,000	2,400	24	38	1,200	
BH4G	4/6/2017	3.7	895	30		5	280		1000		5	5	6	610	11	55	49	26	3	8,000	3.5	6,200	9,200		19,000	2,900	27	51	1,500	
BH4G	7/20/2017	3.8	830	30		4	467				5	5	6	390	13	44	35	20	4	8,100	3.3	6,100	8,500	1,700	16,000	2,800	28	45	1,300	4%
BH4G	10/5/2017	3.4	910	33		3	310				3	5	6	410	21	48	42	24	4	8,800	2.9	6,600	8,900	2,100	18,000	2,500	25	47	1,300	2%
BH4G	1/9/2018	3.8	877	32		5	439				4	5	6	370	15	43	40	24	3.8	6,900	2.9	5,400	7,700	1,800	15,000	2,100	43	39	1,100	4%
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		9	9	9	3	8	7	2	4	0	7	7	7	7	7	7	6	7	6	9	9	9	9	4	9	9	9	9	9	3
% of samples analyzed		100%	100%	100%	33%	89%	78%	22%	44%	0%	78%	78%	78%	78%	78%	78%	67%	78%	67%	1	100%	1	1	0	1	1	100%	100%	100%	33%
Minimum		3.0	100	29	20	2	280	3	860	-	3	5	6	370	10	35	35	20	3	6,600	3	5,400	6,200	1,600	1,100	2,100	7	13	1100	2%
Maximum		3.9	1104	33	111	8	493	4	1519	-	5	20	24	710	21	55	52	27	4	11,000	6	13,000	17,000	2,100	35,000	5,400	43	100	2400	4%
Mean		3.6	841	31	66	4	414	3	1145	-	4	7	9	480	14	45	44	24	4	7,878	4	7,022	9,300	1,800	17,678	2,956	24	43	1456	3%
Median		3.7	910	30	66	4	451	3	1100	-	5	5	6	420	13	44	43	24	4	7,600	3	6,500	8,900	1,750	18,000	2,800	25	40	1300	4%
Standard Deviation		0.3	288	1	46	2	83	0.3	286	-	1	6	7	129	4	7	6	3	0	1,374	1	2,307	3,056	216	8,607	976	12	25	384	1%
80th Percentile		3.8	954	32	93	5	465	3	1328	-	5	5	6	578	15	51	49	26	4	8,380	4	6,840	9,320	1,920	19,400	3,020	31	49	1540	4%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C6. Groundwater Quality Results for Bore BH4H, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH4H	1/11/2016	6.0	222					6.2	177											10	0.1	3	1		1,500	5	1	0.05	5	
BH4H	1/20/2016	6.7	306					6.3	220											10	0.1	1	1		2,200	2	1	0.05	5	
BH4H	3/30/2016	6.5	148	29.8		1										9				10	0.1	2	4		2,100	2	1	0.05	17	
BH4H	4/29/2016	7.0	192	33.0		0.1										11				10	0.1	1	1		1,300	1	1	0.05	6	
BH4H	6/30/2016	6.9	244	31.0		0.2	-199				37	76	93	2	9	7		15	1	10	0.1	1	1		620	2	1	0.05	5	
BH4H	7/31/2016	6.8	211	29.7		0.1	-151				21	85	104	5	12	11		19	1	10	0.1	1	1		550	1	1	0.05	5	40%
BH4H	8/30/2016										76	78	95	2	9	1		11	1	10	0.1	1	1		610	1	1	0.05	5	103%
BH4H	9/30/2016	6.5	270	31.3		0.2	-162		200		24	58	71	2	9	2		11	1	10	0.2	1	1		630	1	1	5	5	
BH4H	10/17/2016	6.4	189	36.8		1	-179		140		33	64	78	2	10	2		13	1	10	0.2	1	1		630	1	1	5	5	76%
BH4H	1/4/2017										42	94	115	5	9			12		10	0.2	1	1	60,000	580	1	1	5	7	
BH4H	4/17/2017	6.8	3	29.1		0.2	-134				98	89	109	2	8	2		16	1	10	0.2	1	1	35,000	580	1	1	5	5	27%
BH4H	8/2/2017	6.5	235	28.0		0.3	-13				57	51	62	5	15	3		20	1	10	0.2	1	1	32,000	810	1	1	5	8	
BH4H	10/10/2017	6.6	169	29.6		7	-98				31	46	56	5	28	7			1	10	0.2	1	1	9,900	870	3	1	5	40	66%
BH4H	1/5/2018	6.4	214	29.4		3	-64				45	66	81	5	24	3		17	1	10	0.2	1	1	40,000	1,600	1	1	5	12	
No. of sampling campaigns		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
No. of measurements		12	12	10	0	10	8	2	4	0	10	10	10	10	10	11	0	9	9	14	14	14	14	5	14	14	14	14	14	5
% of samples analyzed		86%	1	71%	0%	71%	1	14%	0	0%	71%	71%	1	71%	1	1	0	1	1	1	100%	1	1	0	1	1	1	100%	100%	36%
Minimum		6.0	3	28.0	-	0.1	-199	6.2	140	-	21	46	56	2	8	1	-	11	1	10	0.1	1	1	9,900	550	1	1	0	5	27%
Maximum		7.0	306	36.8	-	6.6	-13	6.3	220	-	98	94	115	5	28	11	-	20	1	10	0.2	3	4	60,000	2,200	5	1	5	40	103%
Mean		6.6	200	30.8	-	1.3	-125	6.3	184	-	46	71	86	4	13	5	-	15	1	10	0.2	1	1	35,380	1,041	2	1	3	9	62%
Median		6.6	213	29.8	-	0.3	-143	6.3	189	-	40	71	87	4	10	3	-	15	1	10	0.2	1	1	35,000	720	1	1	3	5	66%
Standard Deviation		0.3	76	2.5	-	2.1	63	0.1	34	-	24	16	20	2	7	4	-	3	0	0	0.1	1	1	17,946	589	1	0	3	10	30%
80th Percentile		6.8	242	31.6	-	1.4	-77	6.3	208	-	61	86	105	5	17	9	-	18	1	10	0.2	1	1	44,000	1,540	2	1	5	10	81%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C7. Groundwater Quality Results for Bore BH5A and BH5B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH5A	5/9/2017										5	20	24	2	2	4	6	5		50	0.2	1	2	50	100	2	1	5	5	
BH5A	7/8/2017	6.3	265	30.9		4	151				290	70	85	20	3	8	10	13	1	50	0.2	210	17	60	3000	83	2	5	27	2%
No. of sampling campaigns		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
No. of measurements		1	1	1	0	1	1	0	0	0	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1
% of samples analyzed		50%	50%	50%	0%	50%	50%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%
Minimum		-	-	-	-	-	-	-	-	-	5	20	24	2	2	4	6	5	-	50	0.2	1	2	50	100	2	1	5	5	-
Maximum		-	-	-	-	-	-	-	-	-	290	70	85	20	3	8	10	13	-	50	0.2	210	17	60	3000	83	2	5	27	-
Mean		-	-	-	-	-	-	-	-	-	148	45	55	11	2	6	8	9	-	50	0.2	106	10	55	1550	43	2	5	16	-
Median		-	-	-	-	-	-	-	-	-	148	45	55	11	2	6	8	9	-	50	0.2	106	10	55	1550	43	2	5	16	-
Standard Deviation		-	-	-	-	-	-	-	-	-	202	35	43	13	0	2	3	6	-	0	0.0	148	11	7	2051	57	1	-	16	-
80th Percentile		-	-	-	-	-	-	-	-	-	233	60	73	16	2	7	9	11	-	50	0.2	168	14	58	2420	67	2	5	23	-
BH5B	1/6/2016	4.8	87	29.4	57	4		5.7	118											10	0.3	110	430		300	56	1	0.4	39	
BH5B	2/17/2016	5.6	96	29.7	23	2		6.0	90											10	0.1	1	3		8	3	1	5	6	
BH5B	10/11/2016	5.5	95	30.9		0.1	77		77		54	29	35	2	3	4	4	5	1	50	0.2	1	1		64	6	1	5	9	14%
BH5B	1/13/2017	5.9	91	30.6		1	121				8	5	6		2	4	4	3	1		0.2	1	1		17	5	1	5	12	
BH5B	4/17/2017	6.0	140	30.6		0.4	144				200	25	31	2	3	4	5	4	1	50	0.2	6	4	50	42	7	1	5	5	27%
BH5B	8/2/2017	5.9	123	34.9		2	106				5	29	35	5	16	5	7	5	1	50	0.2	1	4	50	35	21	1	5	43	7%
BH5B	12/28/2017	5.9	98	31.9		2	138				3	37	45	5	34	5	4	3	1	50	0.2	2	9	50	41	32	1	5	47	
No. of sampling campaigns		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
No. of measurements		7	7	7	2	7	5	2	3	0	5	5	5	4	5	5	5	5	5	6	7	7	7	3	7	7	7	7	7	3
% of samples analyzed		100%	100%	100%	29%	100%	71%	29%	43%	0%	71%	71%	71%	57%	71%	71%	71%	71%	71%	86%	100%	100%	100%	43%	100%	100%	100%	100%	100%	43%
Minimum		4.8	87	29	23	0	77	6	77	-	3	5	6	2	2	4	4	3	1	10	0.1	1	1	50	8	3	1	0.4	5	7%
Maximum		6.0	140	35	57	4	144	6	118	-	200	37	45	5	34	5	7	5	1	50	0.3	110	430	50	300	56	1	5	47	27%
Mean		5.7	104	31	40	2	117	6	95	-	54	25	31	4	11	4	5	4	1	37	0.2	17	65	50	72	19	1	4	23	16%
Median		5.9	96	31	40	2	121	6	90	-	8	29	35	4	3	4	4	4	1	50	0.2	1	4	50	41	7	1	5	12	14%
Standard Deviation		0.4	20	2	24	1	27	0	21	-	84	12	15	2	14	1	1	1	0.1	21	0.1	41	161	0.0	102	20	0.0	2	19	10%
80th Percentile		5.9	118	32	50	2	139	6	107	-	83	31	37	5	20	5	5	5	1	50	0.2	5	8	50	60	30	1	5	42	22%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C8. Groundwater Quality Results for Bore BH7A and BH7B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH7A	1/12/2016	5.4	80	29.0	67	5		6.2	102											1600	**0.5**	**5**	21		38	10	6	1.7	37	
BH7A	2/23/2016	5.5	93	30.8	63	5		6.0	94							1	9			**10**	**0.1**	1	1		4	5	**1**	**0.1**	8	
BH7A	1/16/2017	5.9	91	31.4		2	194				130	**5**	6		4	1	7	2	**1**		**0.2**	1	**1**		**5**	17	**1**	**5.0**	31	115%
BH7A	5/1/2017	6.1	132	30.9		1	180				100	39	48	**5**	12	2	9	5	**1**	**50**	**0.2**	7	3	**50**	51	19	**1**	**5.0**	33	
BH7A	7/27/2017	5.8	117	33.6		5	258				130	34	41	**5**	17	1	8	5	**1**	**50**	**0.2**	1	11	**50**	**5**	22	**1**	**5.0**	170	
No. of sampling campaigns		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
No. of measurements		5	5	5	2	5	3	2	2	0	3	3	3	2	3	4	4	3	3	4	5	5	5	2	5	5	5	5	5	1
% of samples analyzed		100%	1	100%	40%	100%	60%	40%	40%	0%	60%	60%	60%	40%	60%	80%	80%	60%	60%	80%	100%	100%	100%	40%	100%	100%	100%	100%	100%	20%
Minimum		5.4	80	29.0	63.1	1.3		6.0	94	-	100	5	6	5	4	1	7	2	1	10	0.1	1	1	50	4	5	1	0.1	8	-
Maximum		6.1	132	33.6	66.6	5.0		6.2	102	-	130	39	48	5	17	2	9	5	1	1600	0.5	7	21	50	51	22	6	5.0	170	-
Mean		5.7	103	31.1	64.9	3.6		6.1	98	-	120	26	32	5	11	1	8	4	1	428	0.2	3	7	50	21	15	2	3.4	56	-
Median		5.8	93	30.9	64.9	4.7		6.1	98	-	130	34	41	5	12	1	9	5	1	50	0.2	1	3	50	5	17	1	5.0	33	-
Standard Deviation		0.3	21	1.6	2.5	1.7		0.1	6	-	17	18	22	-	7	-	1	2	-	782	0.2	3	9	-	22	7	2	2.3	65	-
80th Percentile		5.9	120	31.8	65.9	4.9		6.2	100	-	130	37	45	5	15	2	9	5	1	670	0.3	5	13	50	41	20	2	5.0	64	-
BH7B	1/12/2016	5.5	117	29.4	28	2		6.3	140											**50**	**0.5**	**5**	8		24	**5**	**5**	**0.5**	14	
BH7B	2/23/2016	5.6	141	29.6	10	1		6.1	140							4	12			**10**	0.1	**1**	8		9	4	**1**	0.2	27	
BH7B	8/14/2016								130		10	88	107	2	16	5	11	5	1	**10**	0.2	4	2		10	9	**1**	**0.1**	19	
BH7B	10/13/2016	5.8	159	29.6		0.1	119		140		11	54	66	**2**	3	6	12	5	**1**	**50**	**0.2**	**1**	**1**		11	11	**1**	**5**	55	
BH7B	1/16/2017	6.1	143	30.5		0.2	143				6	**5**	6		4	6	12	3	**1**		**0.2**	**1**	**1**		7	3	**1**	**5**	12	
BH7B	5/1/2017	6.2	170	31.2		0.1	97				13	66	81	**5**	12	7	13	5	1	**50**	0.3	3	4	140	29	9	**1**	**5**	50	5%
BH7B	7/27/2017										7	69	84	**5**	13	8	13	5	1	**50**	0.5	7	11	**50**	13	23	4	**5**	160	8%
BH7B	10/25/2017	5.8	159	30.4		1	107				4	67	82	**5**	12	6	12	5	1	**50**	**0.2**	**1**	**1**	**50**	10	26	**1**	**5**	41	
BH7B	11/15/2017	5.5	134	27.1	18	1		6.2	140											**10**	0.1	2	20		23	5	**1**	0.1	40	
BH7B	1/5/2018	6.3	145	29.9		5	173				5	72		**5**	32	6	13	5	1	**50**	**0.2**	2	4	**50**	9	6	**1**	**5**	33	
BH7B	1/11/2018										52	77	94	**5**	7	7	12	5	1	**50**	**0.2**	**1**	**1**	60	13	2	**1**	**5**	**5**	17%
No. of sampling campaigns		11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
No. of measurements		8	8	8	3	8	5	3	5	0	8	8	7	7	8	9	9	8	8	10	11	11	11	5	11	11	11	11	11	3
% of samples analyzed		73%	1	73%	27%	73%	45%	27%	0	0	1	1	1	1	1	1	1	1	1	1	100%	1	1	0	1	1	1	100%	1	27%
Minimum		5.5	117	27	10	0	97	6.1	130	-	4	5	6	2	3	4	11	3	1	10	0.1	1	1	50	7	2	1	0	5	5%
Maximum		6.3	170	31	28	5	173	6.3	140	-	52	88	107	5	32	8	13	5	1	50	0.5	7	20	140	29	26	5	5	160	17%
Mean		5.9	146	30	19	1	128	6.2	138	-	13	62	74	4	12	6	12	5	1	38	0.2	3	6	70	14	9	2	3	41	10%
Median		5.8	144	30	18	1	119	6.2	140	-	8	68	82	5	12	6	12	5	1	50	0.2	2	4	50	11	6	1	5	33	8%
Standard Deviation		0.3	17	1	9	2	31	0.1	4	-	16	25	33	1	9	1	1	1	0	19	0.1	2	6	39	7	8	1	2	42	7%
80th Percentile		6.2	159	30	24	2	149	6.3	140	-	12	75	92	5	15	7	13	5	1	50	0.3	4	8	76	23	11	1	5	50	13%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C9. Groundwater Quality Results for Bore BH8A and BH8B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH8A	1/12/2016	5.1	61	28.9	33	2		6.1	72											8000	0.500	12	22		190	19	15	1.1	50	
BH8A	2/23/2016	5.1	44	30.1	68	5		5.9	39							1	2			20	0.100	1	3		1	1	1	0.1	8	
No. of sampling campaigns		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
No. of measurements		2	2	2	2	2	0	2	2	0	0	0	0	0	0	1	1	0	0	2	2	2	2	0	2	2	2	2	2	0
% of samples analyzed		100%	100%	100%	100%	100%	0%	100%	100%	0%	0%	0%	0%	0%	0%	50%	50%	0%	0%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%	0%
Minimum		5.1	44	29	33	2.5	-	5.9	39	-	-	-	-	-	-	1	2	-	-	20	0.1	1	3	-	1	1	1	0.1	8	-
Maximum		5.1	61	30	68	4.9	-	6.1	72	-	-	-	-	-	-	1	2	-	-	8,000	0.5	12	22	-	190	19	15	1.1	50	-
Mean		5.1	52	30	50	3.7	-	6.0	56	-	-	-	-	-	-	1	2	-	-	4,010	0.3	7	13	-	96	10	8	0.6	29	-
Median		5.1	52	30	50	3.7	-	6.0	56	-	-	-	-	-	-	1	2	-	-	4,010	0.3	7	13	-	96	10	8	0.6	29	-
Standard Deviation		0.0	12	1	24	1.7	-	0.1	23	-	-	-	-	-	-	-	-	-	-	5,643	0.3	8	13	-	134	13	10	0.7	30	-
80th Percentile		5.1	58	30	61	4.4	-	6.1	65	-	-	-	-	-	-	1	2	-	-	6,404	0.4	10	18	-	152	15	12	0.9	42	-
BH8B	1/12/2016	6.4	225	28.4	16	1		7.0	290											**50**	**0.5**	**5**	**5**		6	**5**	**5**	**0.5**	7	
BH8B	2/23/2016	6.4	301	29.6	20	1		7	290							15	26			**10**	0.1	**1**	3		**1**	1	**1**	0.1	15	
BH8B	8/4/2016	6.8	326	29.5			80		320		25	563	687	2	3	22	23	4	2	**10**	0.1	**1**	**1**		2	3	**1**	**0.1**	6	
BH8B	10/13/2016								260		**5**	120	146	2	3	21	25	4	2	**50**	**0.2**	**1**	**1**		**5**	4	**1**	**5**	11	
BH8B	1/19/2017										**5**	120	146	2	3	21	25	3	2		**0.2**	**1**	**1**		**5**	**1**	**1**	**5**	6	
BH8B	5/1/2017	6.9	350	33		0	115				4	140	171	5	11	20	23	4	2	**50**	**0.2**	**1**	**1**	**50**	**5**	**1**	**1**	**5**	6	
BH8B	7/27/2017										5	190	232	5	15	25	26	4	2	**50**	**0.2**	**1**	2	**50**	**5**	2	**1**	**5**	21	18%
BH8B	10/26/2017										1	150	183	5	3	23	25	4	2	**50**	**0.2**	**1**	2	**50**	**5**	4	**1**	**5**	16	
BH8B	11/15/2017	6.4	222	26.6	28	2		7	250											**10**	0.1	**1**	6		8	2	**1**	0.1	11	
BH8B	1/4/2018	6.9	291	29.7		1	132				1	170		5	36	19	25	4	2	**50**	**0.2**	**1**	1	**50**	**5**	1	**1**	**5**	9	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		6	6	6	3	5	3	3	5	0	7	7	6	7	7	8	8	7	7	9	10	10	10	4	10	10	10	10	10	1
% of samples analyzed		60%	60%	60%	30%	50%	30%	30%	50%	0%	70%	70%	60%	70%	70%	80%	80%	70%	70%	90%	100%	100%	100%	40%	100%	100%	100%	100%	100%	10%
Minimum		6.4	222	27	16	0	80	6.5	250	-	1	120	146	2	3	15	23	3	2	10	0.1	1	1	50	1	1	1.0	0.1	6	-
Maximum		6.9	350	33	28	2	132	7.0	320	-	25	563	687	5	36	25	26	4	2	50	0.5	5	6	50	8	5	5.0	5	21	-
Mean		6.6	286	29	22	1	109	6.8	282	-	7	208	261	4	10	21	25	4	2	37	0.2	1	2	50	5	2	1.4	3	11	-
Median		6.6	296	30	20	1	115	7.0	290	-	5	150	177	5	3	21	25	4	2	50	0.2	1	2	50	5	2	1.0	5	10	-
Standard Deviation		0.3	52	2	6	1	27	0.3	28	-	8	159	211	2	12	3	1	0.2	0.1	20	0.1	1	2	0	2	2	1.3	2	5	-
80th Percentile		6.9	326	30	25	2	125	7.0	296	-	5	186	232	5	14	23	26	4	2	50	0.2	1	3	50	5	4	1.0	5	15	-

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C10. Groundwater Quality Results for Bore BH9A and BH9B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH9A	1/12/2016	6.9	600	28.6	25	2		7.1	780											2200	**0.5**	**5**	**5**			7	**5**	1.1	**5**	
BH9A	2/23/2016	6.5	326	30.1	21	2		6.8	560							7	73			**10**	**0.1**	**1**	2			**1**	**1**	0.2	8	
BH9A	7/19/2016	6.8	552	30.2		10	236					360	439			8	65	18	**1**	**10**	**0.1**	**1**	**1**			**1**	**1**	**0.1**	**5**	
BH9A	10/13/2016	6.6	586	30.1			132		460		270	240	293	**2**	4	8	66	17	**1**	**50**	**0.2**	2	**1**			6	**1**	**5.0**	10	
BH9A	1/19/2017										230	360	439	**2**	3	9	98	27	**1**		**0.2**	3	**1**			3	**1**	**5.0**	**5**	
BH9A	5/1/2017	6.9	610	31.5		0.1	129				210	290	354	**5**	4	8	60	16	**1**	**50**	**0.2**	4	**1**	50		6	**1**	**5.0**	6	
BH9A	7/27/2017	6.6	550	30.4		0.2	-15				45	280	342	**5**	15	9	66	16	1	**50**	**0.2**	2	2	140		2	**1**	**5.0**	14	
BH9A	10/25/2017	6.6	521	31.4		0.0	-34				17	290	354	**5**	13	8	64	16	1	**50**	**0.2**	2	**1**	920	72	15	**1**	**5.0**	28	
BH9A	11/15/2017	6.5	444	27.2	22	2		6.9	530											**10**	**0.1**	6	**1**			1	**1**	0.3	**5**	
BH9A	1/4/2018	6.7	640	29.5		1	-47				37	340		**5**	7	8	68	19	1	**50**	**0.2**	5	**1**	2400	100	8	**1**	**5.0**	**73**	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		9	9	9	3	8	6	3	4	0	6	7	6	6	6	8	8	7	7	9	10	10	10	4	2	10	10	10	10	0
% of samples analyzed		90%	90%	90%	30%	80%	60%	30%	40%	0%	60%	70%	60%	60%	60%	80%	80%	70%	70%	90%	100%	100%	100%	40%	20%	100%	100%	100%	100%	0%
Minimum		6.5	326	27	21	0	-47	6.8	460	-	17	240	293	2	3	7	60	16	1	10	0.1	1	1	50	72	1	1	0.1	5	-
Maximum		6.9	640	32	25	10	236	7.1	780	-	270	360	439	5	15	9	98	27	1	2200	0.5	6	5	2400	100	15	5	5.0	73	-
Mean		6.7	537	30	23	2	67	6.9	583	-	135	309	370	4	8	8	70	18	1	276	0.2	3	2	878	86	5	1	3.2	16	-
Median		6.6	552	30	22	1	57	6.9	545	-	128	290	354	5	6	8	66	17	1	50	0.2	3	1	530	86	5	1	5.0	7	-
Standard Deviation		0.2	98	1	2	3	115	0.2	138	-	114	46	58	2	5	1	12	4	0	722	0.1	2	1	1088	20	4	1	2.4	21	-
80th Percentile		6.8	604	31	24	2	132	7.0	648	-	230	356	439	5	13	8	71	19	1	50	0.2	5	2	1512	94	7	1	5.0	17	-
BH9B	1/12/2016	6.5	326	28.6	15	2		7.2	405											**50**	**0.5**	**5**	7		39	**5**	**5**	**0.5**	5	
BH9B	2/23/2016	6.7	431	29.6	31	2		7	400							9	41			**10**	**0.1**	**1**	1		17	**1**	**1**	0.1	**5**	
BH9B	8/17/2016	6.8	450	29.7		3	245		380		52	240	293	2	3	10	36	13	3	20	**0.1**	2	3		28	7	**1**	0.1	26	
BH9B	10/13/2016	6.7	309	30.1		0	126		360		11	180	220	**2**	3	12	44	15	3	**50**	**0.2**	**1**	**1**		38	**1**	**1**	**5**	**5**	
BH9B	1/19/2017										**5**	170	207	**2**	3	12	41	14	4		**0.2**	**1**	**1**		30	**1**	**1**	**5**	**5**	
BH9B	5/17/2017	7.2	455	29.1		2	85				**5**	170	207	**2**	3	13	41	14		**50**	**0.2**	**1**	**1**	**50**	25	1	**1**	**5**	9	
BH9B	7/27/2017	6.7	405	29.6		1	97				14	260	317	**5**	17	12	40	14	3	**50**	**0.2**	**1**	**1**	**50**	31	4	1	**5**	36	23%
BH9B	10/25/2017	6.6	399	29.5		0	43				5	220	268		11	12	41	14	3	**50**	**0.2**	**1**	**1**	**50**	33	9	**1**	**5**	28	
BH9B	11/15/2017	6.6	331	27.3	15	1		7	370											**10**	**0.1**	**1**	**1**		31	**1**	**1**	0.1	6	
BH9B	1/4/2018	7.0	403	29.5		1	31				5	240	293		33	12	45	16	4	**50**	**0.2**	**1**	**1**	**50**	32	3	**1**	**5**	9	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		9	9	9	3	9	6	3	5	0	7	7	7	5	7	8	8	7	6	9	10	10	10	4	10	10	10	10	10	1
% of samples analyzed		90%	90%	90%	30%	90%	60%	30%	50%	0%	70%	70%	70%	50%	70%	80%	80%	70%	60%	90%	100%	100%	100%	40%	100%	100%	100%	100%	100%	10%
Minimum		6.5	309	27	15	0	-	6.9	360	-	5	170	207	2	3	9	36	13	3	10	0.1	1	1	50	17	1	1	0.1	5	-
Maximum		7.2	455	30	31	3	-	7.2	405	-	52	260	317	5	33	13	45	16	4	50	0.5	5	7	50	39	9	5	5.0	36	-
Mean		6.7	390	29	21	1	-	7.1	383	-	14	211	258	3	11	11	41	14	3	38	0.2	2	2	50	30	3	1	3.1	13	-
Median		6.7	403	30	15	1	-	7.1	380	-	5	220	268	2	3	12	41	14	3	50	0.2	1	1	50	31	2	1	5.0	8	-
Standard Deviation		0.2	55	1	9	1	-	0.2	19	-	17	38	46	1	11	1	3	1	0.3	19	0.1	1	2	-	6	3	1	2.5	12	-
80th Percentile		6.9	439	30	25	2	-	7.2	401	-	13	240	293	3	16	12	43	15	4	50	0.2	1	1	50	34	5	1	5.0	26	-

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C11. Groundwater Quality Results for Bore BH10 and BH11, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH10	1/12/2016	6.9	370	29.6	52	4		7.2	463											70	**0.5**	5	11		14	**5**	**5**	**0.5**	29	
BH10	2/23/2016	7.0	455	31.2	10	11		7.2	440							5	65			**10**	**0.1**	1	6		1	**1**	**1**	0.2	**5**	
BH10	8/17/2016								430		220	300	366	3	2	6	56	2	1	**10**	**0.1**	1	1		3	2	**1**	**0.1**	**5**	
BH10	10/13/2016	7.1	505	32.7		0	101		400		99	210	256	**2**	3	6	66	2	1	**50**	**0.2**	1	1		**5**	3	**1**	**5.0**	**5**	
BH10	1/16/2017	7.2	494	30.2		0	161				180	11	13		3	6	63	**1**	1		**0.2**	1	1		17	3	**1**	**5.0**	6	
BH10	5/17/2017	7.2	515	34.5		2	143				71	200	244	**2**	3	7	64	2		**50**	**0.2**	1	3	**50**	**5**	2	**1**	**5.0**	10	
BH10	7/27/2017	7.1	491	34.7		2	100				63	320	390	**5**	13	8	69	2	1	**50**	**0.2**	1	1	**50**	**5**	3	**1**	**5.0**	7	10%
BH10	10/25/2017	7.1	472	34.5		1	112				66	260	317	**5**	11	7	65	2		**50**	**0.2**	1	3	**50**	**5**	18	**1**	**5.0**	33	
BH10	11/15/2017	6.9	372	27.9	41	3		7.4	420											**10**	**0.1**	1	2		6	**1**	**1**	0.3	**5**	
BH10	1/4/2018	7.3	485	32.5		122	152				31	290	354	**5**	22	6	67	2		**50**	**0.2**	1	1	**50**	**5**	4	**1**	**5.0**	11	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		9	9	9	3	9	6	3	5	0	7	7	7	6	7	8	8	7	4	9	10	10	10	4	10	10	10	10	10	1
% of samples analyzed		90%	90%	90%	30%	90%	60%	30%	50%	0%	70%	70%	70%	60%	70%	80%	80%	70%	40%	90%	100%	100%	100%	40%	100%	100%	100%	100%	100%	10%
Minimum		6.9	370.0	27.9	10.2	0.1	-	7.2	400.0	-	31.0	11.0	13.4	2.0	1.8	5.4	56.0	0.5	0.5	10.0	0.1	1.0	1.0	50.0	1.0	1.0	1.0	0.1	5.0	-
Maximum		7.3	515.0	34.7	51.6	122.0	-	7.4	463.0	-	220.0	320.0	390.4	5.0	22.0	8.4	69.0	2.0	0.8	70.0	0.5	5.0	11.0	50.0	17.0	18.0	5.0	5.0	33.0	-
Mean		7.1	462.1	32.0	34.2	16.2	-	7.3	430.6	-	104.3	227.3	277.3	3.6	7.9	6.5	64.4	1.7	0.7	38.9	0.2	1.4	3.0	50.0	6.6	4.2	1.4	3.1	11.6	-
Median		7.1	485.0	32.5	40.7	2.3	-	7.2	430.0	-	71.0	260.0	317.2	3.9	2.7	6.4	65.0	2.0	0.7	50.0	0.2	1.0	1.5	50.0	5.0	3.0	1.0	5.0	6.5	-
Standard Deviation		0.1	54.5	2.4	21.5	39.8	-	0.1	23.4	-	69.3	105.4	128.6	1.5	7.7	0.9	3.9	0.6	0.1	22.6	0.1	1.3	3.2	0.0	4.9	5.0	1.3	2.4	10.5	-
80th Percentile		7.2	498.4	34.5	47.2	6.8	-	7.3	444.6	-	163.8	298.0	363.6	5.0	12.6	6.7	66.6	2.0	0.7	50.0	0.2	1.0	3.6	50.0	7.6	4.2	1.0	5.0	14.6	-
BH11	1/12/2016	5.7	109	29.9	45	3		6.5	123											220	**0.5**	**5**	**5**		30	**5**	**5**	**0.5**	5	
BH11	2/23/2016	5.9	121	30.6	39	3		6.8	130							7	10			**10**	0.2	**1**	**1**		**1**	2	**1**	0.1	**5**	
BH11	8/17/2016								210		130	130	159	61	57	14	18	4	**1**	**10**	0.6	**1**	**1**		15	3	**1**	**0.1**	8	
BH11	10/13/2016	6.2	222	32.6		1	146		190		210	82	100	**2**	2	13	18	3	**1**	**50**	**0.2**	**1**	**1**		35	1	**1**	**5.0**	**5**	
BH11	1/16/2017	6.4	144	30.8		1	196				15	**5**	6		2	9	10	**1**	**1**		0.3	**1**	**1**		7	6	**1**	**5.0**	12	
BH11	5/17/2017	6.4	122	31.8		3	225				19	38	46	**2**	2	8	8	3		**50**	0.3	4	5	**50**	12	7	**1**	**5.0**	21	
BH11	7/27/2017	6.3	162	29.9		2	183				5	81	99	**5**	2	10	13	4	**1**	**50**	0.3	**1**	2	**50**	**5**	3	**1**	**5.0**	11	2%
BH11	10/26/2017	6.0	178	31.3		1	149				46	88	107	**5**	2	13	15	3	**1**	**50**	0.6	**1**	2	**50**	19	9	**1**	**5.0**	17	
BH11	11/15/2017	6.1	203	28.6	34	3		6.7	210											**10**	1.5	**1**	**1**		850	5	**1**	0.3	**5**	
BH11	1/4/2018	6.7	213	31		6	178				120	110	134	**5**	32	21	20	4	**1**	**50**	0.6	**1**	**1**	**50**	40	3	**1**	**5.0**	8	
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		9	9	9	3	9	6	3	5	0	7	7	7	6	7	8	8	7	6	9	10	10	10	4	10	10	10	10	10	1
% of samples analyzed		90%	90%	90%	30%	90%	60%	30%	50%	0%	70%	70%	70%	60%	70%	80%	80%	70%	60%	90%	100%	100%	100%	40%	100%	100%	100%	100%	100%	10%
Minimum		5.7	109	29	34	1	-	6.5	123	-	5	5	6	2	2	7	8	1	1	10	0.2	1	1	50	1	1	1	0.1	5	-
Maximum		6.7	222	33	45	6	-	6.8	210	-	210	130	159	61	57	21	20	4	1	220	1.5	5	5	50	850	9	5	5	21	-
Mean		6.2	164	31	39	3	-	6.7	173	-	78	76	93	13	14	12	14	3	1	56	0.5	2	2	50	101	4	1	3	10	-
Median		6.2	162	31	39	3	-	6.7	190	-	46	82	100	5	2	12	14	3	1	50	0.4	1	1	50	17	4	1	5	8	-
Standard Deviation		0.3	43	1	6	2	-	0.2	43	-	77	42	52	23	22	5	4	1	0.0	65	0.4	1	2	0.0	263	2	1	2	6	-
80th Percentile		6.4	207	32	43	3	-	6.8	210	-	128	106	129	5	26	14	18	4	1	50	0.6	2	3	50	36	6	1	5	13	-

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C12. Groundwater Quality Results for Bore BH12A and BH12B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH12A	1/6/2016	5.6	475	29.8	68	5		6.5	608											10	0.1	6	18		16	5	1	0	8	
BH12A	2/22/2016	6.2	483	31	79	6		6.2	430											10	0.1	2	3		16	2	1	0	17	
BH12A	7/10/2017	5.9	486	29.7		2					5	86	105	150	3	5	56	10	1	50	0.2	78	1	50	5	1	1	7	21	7%
No. of sampling campaigns		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
No. of measurements		3	3	3	2	3	0	2	2	0	1	1	1	1	1	1	1	1	1	3	3	3	3	1	3	3	3	3	3	1
% of samples analyzed		100%	100%	100%	67%	100%	0%	67%	67%	0%	33%	33%	33%	33%	33%	33%	33%	33%	33%	100%	100%	100%	100%	33%	100%	100%	100%	100%	100%	33%
Minimum		5.6	475	29.7	68	2.0		6.2	430	-	5	86	105	150	3	5	56	10	1	10	0.1	2	1	50	5	1	1	0.2	8	-
Maximum		6.2	486	31.0	79	5.7		6.5	608	-	5	86	105	150	3	5	56	10	1	50	0.2	78	18	50	16	5	1	7	21	-
Mean		5.8	229	24.0	25	5.2		5.4	206	-	52	126	152	7	10	8	26	6	2	372	1.2	4	5	142	38	6	3	4	21	-
Median		5.9	483	29.8	74	5.0		6.4	519	-	5	86	105	150	3	5	56	10	1	10	0.1	6	3	50	16	2	1	0	17	-
Standard Deviation		0.3	6	0.7	8	2.0		0.2	126	-	-	-	-	-	-	-	-	-	-	23	0.1	43	9	-	6	2	0	4	7	-
80th Percentile		6.1	485	30.5	77	5.4		6.4	572	-	5	86	105	150	3	5	56	10	1	34	0.2	49	12	50	16	4	1	4	19	-
BH12B	1/6/2016	5.6	505	29.4	47	3		6.7	656											10	0.1	2	25		5	2	1	0.4	5	
BH12B	2/22/2016							6.6	380											10	0.1	1	3		2	1	1	0.3	5	
BH12B	6/30/2016										14	5	6	2	3	1	1	2	1	10	0.1	1	2		9	7	1	0.1	5	30%
BH12B	10/12/2016								1,000		61	210	256	630	7	28	200	8	1	50	0.2	1	1		18	1	1	5	5	4%
BH12B	1/14/2017	6.6	1,096	30.4		1	26				11	9	11		10	20	150	5	1		0.2	1	1		16	4	1	5	10	187%
BH12B	4/18/2017	6.7	930	31.7		1	-75				40	190	232	270	5	16	100	6	1	50	0.2	1	1	50	32	2	1	5	6	2%
BH12B	8/2/2017	6.4	889	30.1		1	-15				7	280	342	290	15	18	120	7	1	50	0.2	1	1	50	14	10	1	5	17	8%
BH12B	1/12/2018	6.5	643	29.9		2	35				33	220	268	370	4	18	160	8	1	50	0.2	1	1	50	16	1	1	5	5	17%
No. of sampling campaigns		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of measurements		5	5	5	1	5	4	2	3	0	6	6	6	5	6	6	6	6	6	7	8	8	8	3	8	8	8	8	8	6
% of samples analyzed		63%	63%	63%	13%	63%	50%	25%	38%	0%	75%	75%	75%	63%	75%	75%	75%	75%	75%	88%	100%	100%	100%	38%	100%	100%	100%	100%	100%	75%
Minimum		5.6	505	29.4	47	0.6	-75.0	6.6	380	-	7	5	6	2	3	1	1	2	1	10	0.1	1	1	50	2	1	1	0.1	5	2%
Maximum		6.7	1,096	31.7	47	3.4	35.1	6.7	1,000	-	61	280	342	630	15	28	200	8	1	50	0.2	2	25	50	32	10	1	5	17	187%
Mean		6.4	813	30.3	47	1.6	-7.2	6.7	679	-	28	152	186	312	7	17	122	6	1	33	0.2	1	4	50	14	4	1	3	7	41%
Median		6.5	889	30.1	47	1.1	5.5	6.7	656	-	24	200	244	290	6	18	135	7	1	50	0.2	1	1	50	15	2	1	5	5	12%
Standard Deviation		0.4	236	0.9	-	1.1	50.1	0.1	311	-	21	116	142	225	5	9	69	2	0.2	21	0.1	-	8	-	9	3	-	2	4	72%
80th Percentile		6.6	963	30.7	47	2.1	29.4	6.7	862	-	40	220	268	422	10	20	160	8	1	50	0.2	1	3	50	17	6	1	5	8	30%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C13. Groundwater Quality Results for Bore BH12C, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH12C	1/6/2016	6.2	521	29.3	8	0.6		6.8	680											**10**	**0.1**	1	3		1500	1	**1**	0.1	**5**	
BH12C	2/22/2016	7.3	716	33.5	116	8.0		7.0	650											**10**	**0.1**	**1**	**1**		7	3	**1**	0.2	**5**	
BH12C	7/6/2016	7.9	945	32	87		89				5	220	268	330	5	20	140	6	1	**10**	**0.1**	**1**	**1**		3	3	**1**	**0.1**	**5**	11%
BH12C	7/8/2016										5	290	354	390	5	23	150	7	1	**10**	**0.1**	**1**	1		4	4	**1**	**0.1**	13	2%
BH12C	1/4/2017										2	190	232	400	4	17	130	5		**50**	**0.2**	**1**	**1**	**50**	11	3	**1**	**5**	**5**	4%
BH12C	4/6/2017	7.4	751	31.5		3.4	106		720		5	150	183	280	5	13	94	6	**1**	**50**	**0.2**	**1**	**1**		**5**	2	**1**	**5**	**5**	4%
BH12C	7/20/2017	6.7	816	31.5		3.7	190				5	190	232	270	6	18	100	6	1	**50**	**0.2**	3	1	**50**	10	5	**1**	**5**	14	2%
BH12C	10/5/2017	8.1	1,008	33.6		2.1	63				3	210	256	380	18	19	140	7	1	**50**	**0.2**	1	**1**	**50**	**5**	2	**1**	**5**	**5**	1%
BH12C	1/9/2018	7.6	454	29.8		4.6	104				6	94	115	140	8	6	56	3	**1**	**50**	**0.2**	**1**	**1**	**50**	24	**1**	**1**	**5**	**5**	1%
BH12C	1/12/2018	6.7	995	29.5		2.0	74				5	120	146	230	3	10	99	5	**1**	**50**	**0.2**	**1**	**1**	100	18	3	**1**	**5**	**5**	20%
No. of sampling campaigns		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
No. of measurements		8	8	8	3	7	6	2	3	0	8	8	8	8	8	8	8	8	7	10	10	10	10	5	10	10	10	10	10	8
% of samples analyzed		80%	80%	80%	30%	70%	1	20%	30%	0%	80%	80%	80%	80%	80%	80%	80%	80%	70%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	80%
Minimum		6.2	454	29.3	8	0.6	63	6.8	650	-	2	94	115	140	3	6	56	3	1	10	0.1	1	1	50	3	1	1	0	5	1%
Maximum		8.1	1,008	33.6	116	8.0	190	7.0	720	-	6	290	354	400	18	23	150	7	1	50	0.2	3	3	100	1500	5	1	5	14	20%
Mean		7.2	776	31.3	70	3.5	104	6.9	683	-	5	183	223	303	7	16	114	6	1	34	0.2	1	1	60	159	3	1	3	7	6%
Median		7.4	784	31.5	87	3.4	97	6.9	680	-	5	190	232	305	5	18	115	6	1	50	0.2	1	1	50	9	3	1	5	5	3%
Standard Deviation		0.7	209	1.7	56	2.4	45	0.1	35	-	1	62	75	90	5	6	32	1	0	21	0.1	1	1	22	471	1	0	3	4	7%
80th Percentile		7.8	975	32.9	104	4.4	106	7.0	704	-	5	216	264	386	7	20	140	6	1	50	0.2	1	1	60	19	3	1	5	7	8%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C14. Groundwater Quality Results for Bore BH13A and BH13B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH13A	9/1/2016								2,100		10	550	671	940	13	90	170	210	6	**10**	**0.1**	**1**	3		9	4	**1**	38.0	**5**	11%
No. of sampling campaigns		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
No. of measurements		0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
% of samples analyzed		0%	0%	0%	0%	0%	0%	0%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%	100%
Minimum		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Median		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Standard Deviation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80th Percentile		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13B	1/6/2016	5.3	959	30.0	38	3		6.0	1302											10	5.500	45	730		770	210	1	0.7	140	
BH13B	2/22/2016							6.1	1300											10	4.300	63	470		1000	230	1	0.9	190	
BH13B	10/11/2016	5.8	2,692	35.1		0	178		1600		5	150	183	2300	12	47	350	5	1	50	3.600	170	250		3500	400	1	5.0	180	48%
BH13B	1/15/2017	5.7	1,280	34.8		0	214				15	5	6		10	19	190	5	1		3.500	45	460		570	230	1	5.0	200	191%
BH13B	8/3/2017	5.8	1,910	29.5		2	165				8	210	256	1500	18	52	400	11	2	50	3.100	120	380	50	3000	370	1	5.0	230	1%
BH13B	1/9/2018	5.7	1,181	31.8		1	213				3.8	66	81	580	8.4	17	170	6	0.8	50	1.9	15	380	50	170	150	1	5	140	11%
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		5	5	5	1	5	4	2	3	0	4	4	4	3	4	4	4	4	4	5	6	6	6	2	6	6	6	6	6	4
% of samples analyzed		83%	83%	83%	17%	83%	67%	33%	50%	0%	67%	67%	67%	50%	67%	67%	67%	67%	67%	83%	100%	100%	100%	33%	100%	100%	100%	100%	100%	67%
Minimum		5.3	959	29.5	-	-0.1	164.7	6.0	1,300	-	4	5	6	580	8	17	170	5	1	10	2	15	250	50	170	150	1	1	140	1%
Maximum		5.8	2,692	35.1	-	2.8	214.0	6.1	1,600	-	15	210	256	2300	18	52	400	11	2	50	6	170	730	50	3500	400	1	5	230	191%
Mean		5.6	1,604	32.2	-	1.0	192.5	6.1	1,401	-	8	108	131	1460	12	34	278	7	1	34	4	76	445	50	1502	265	1	4	180	62%
Median		5.7	1,280	31.8	-	0.5	195.6	6.1	1,302	-	7	108	132	1500	11	33	270	5	1	50	4	54	420	50	885	230	1	5	185	29%
Standard Deviation		0.2	703	2.6	-	1.2	25.0	0.1	173	-	5	90	110	861	4	18	115	3	0.4	22	1	58	160	-	1390	98	-	2	35	88%
80th Percentile		5.8	2,066	34.9	-	1.9	213.5	6.1	1,481	-	11	174	212	1980	14	49	370	8	1	50	4	120	470	50	3000	370	1	5	200	105%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C15. Groundwater Quality Results for Bore BH14A and BH14B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH14A	1/6/2016	4.4	991	30.7	21	2		6.7	146											20	0.4	36	78		310	27	2	1.0	32	
BH14A	2/22/2016							5.9	210											**10**	0.2	19	42		590	17	**1**	0.2	24	
BH14A	8/4/2016	7	2,612	30.5			61		2400		**5**	350	427	1400	7	17	400	5	**1**	**10**	0.1	2	**1**		230	14	**1**	0.1	8	7%
BH14A	10/13/2016								420		**5**	74	90	160	3	4	60	5	**1**	**50**	**0.2**	10	**1**		720	9	**1**	**5**	15	10%
BH14A	1/14/2017	7	1,553	33.4		0.4	93				**5**	11	13		10	10	260	6	**1**		**0.2**	2	**1**		160	8	**1**	**5**	14	191%
BH14A	4/18/2017	6	1,816	32.1		0.3	86				**5**	260	317	790	6	10	270	4	**1**	**50**	**0.2**	**1**	**1**	**50**	72	4	**1**	**5**	**5**	5%
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		4	4	4	1	3	3	2	4	0	4	4	4	3	4	4	4	4	4	5	6	6	6	1	6	6	6	6	6	4
% of samples analyzed		67%	67%	67%	17%	50%	50%	33%	67%	0%	67%	67%	67%	50%	67%	67%	67%	67%	67%	83%	100%	100%	100%	17%	100%	100%	100%	100%	100%	67%
Minimum		4.4	991	30.5	21.2	0.3	61.1	5.9	146	-	5	11	13	160	3	4	60	4	1	10	0.1	1	1	50	72	4	1	0	5	5%
Maximum		6.6	2,612	33.4	21.2	1.5	92.7	6.7	2400	-	5	350	427	1,400	10	17	400	6	1	50	0.4	36	78	50	720	27	2	5	32	191%
Mean		6.0	1,743	31.7	21.2	0.7	79.9	6.3	794	-	5	174	212	783	6	10	248	5	1	28	0.2	12	21	50	347	13	1	3	16	53%
Median		6.5	1,685	31.4	21.2	0.4	86.0	6.3	315	-	5	167	204	790	7	10	265	5	1	20	0.2	6	1	50	270	12	1	3	15	8%
Standard Deviation		1.1	674	1.4	-	0.7	16.7	0.6	1077	-	0	158	193	620	3	5	140	1	0	20	0.1	14	33	#DIV/0!	254	8	0	3	10	92%
80th Percentile		6.5	2,134	32.6	21.2	1.1	90.0	6.5	1212	-	5	296	361	1,156	8	13	322	5	1	50	0.2	19	42	50	590	17	1	5	24	82%
BH14B	4/18/2017										30	170	207	1,200	7	37	330	9	1	**50**	2	76	220	**50**	1,800	240	**1**	**5**	110	3%
BH14B	7/9/2017	6.0	1,322	29.7		0.2	38				**5**	290	354	760	6	8	220	9	**1**	**50**	**0.2**	3	**1**	190	240	6	**1**	**5**	8	14%
BH14B	10/4/2017	6.3	1,407	34.6		0.2	-13				3	270	329	780	17	10	240	6	**1**	**50**	**0.2**	5	**1**	430	390	31	**1**	**5**	25	7%
BH14B	1/11/2018	6.6	474	30.9		2	141				1	120	146	230	4	4	96	7	**1**	**50**	**0.2**	6	3	110	420	9	**1**	**5**	19	14%
No. of sampling campaigns		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
No. of measurements		3	3	3	0	3	3	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
% of samples analyzed		75%	75%	75%	0%	75%	75%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Minimum		6.0	474	29.7	-	0.2	-12.9	-	-	-	1	120	146	230	4	4	96	6	1	**50**	0.2	3	1	50	240	6	1	5	8	3%
Maximum		6.6	1,407	34.6	-	2.4	140.8	-	-	-	30	290	354	1,200	17	37	330	9	1	**50**	2	76	220	430	1,800	240	1	5	110	14%
Mean		6.3	1,068	31.7	-	0.9	55.3	-	-	-	10	213	259	743	9	15	222	7	1	**50**	1	23	56	195	713	72	1	5	41	10%
Median		6.3	1,322	30.9	-	0.2	38.0	-	-	-	4	220	268	770	7	9	230	8	1	**50**	0.2	6	2	150	405	20	1	5	22	11%
Standard Deviation		0.3	516	2.6	-	1.2	78.3	-	-	-	14	81	99	397	6	15	96	2	-	-	1	36	109	167	729	113	-	-	47	6%
80th Percentile		6.5	1,373	33.1	-	1.5	99.7	-	-	-	15	278	339	948	11	21	276	9	1	**50**	1	34	90	286	972	115	1	5	59	14%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C16. Groundwater Quality Results for Bore BH15A and BH15B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH15A	1/6/2016	4.3	49	30.0	51	4		5.9	56											20	2.400	13	40		49	23	57	0.3	510	
BH15A	2/22/2016							5.7	77											10	3.300	14	14		35	30	120	0.1	820	
BH15A	7/19/2016	5.1	68	30.7			215					18	22			2	2	8	1	20	3.900	14	8		8	41	38	0.1	1000	53%
BH15A	10/12/2016	5.0	89	31.6		0.8	223		60		5	11	13	5	3	1	2	7	1	50	3.500	13	3		7	38	29	5	920	20%
BH15A	1/14/2017	5.4	73	31.9		0.5	213				5	5	6		2	1	2	7	1		3.900	16	6		7	37	160	5	950	107%
BH15A	4/24/2017	5.5	93	31.8		0.2	216				5	12	15	4	3	1	2	9		50	3.600	16	21	50	16	33	110	5	900	37%
BH15A	7/9/2017	5.3	86	32.4		0.8	209				5	13	16	5	3	1	2	14	1	50	4.500	22	12	50	8	40	210	5	1100	61%
BH15A	10/4/2017	5.5	78	30.2		0.4	94				4	5	5	6	15	1	2	8	1	50	3.300	18	17	50	18	58	120	5	830	8%
BH15A	1/11/2018	5.1	55	31.4		0.2	245				4.2	5	5	5	8.4	0.5	2	5.7	0.5	50	3.7	16	10	50	10	50	180	5	980	12%
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		8	8	8	1	7	7	2	3	0	6	7	7	5	6	7	7	7	6	8	9	9	9	4	9	9	9	9	9	7
% of samples analyzed		89%	89%	89%	11%	78%	78%	22%	33%	0%	67%	78%	78%	56%	67%	78%	78%	78%	67%	89%	100%	100%	100%	44%	100%	100%	100%	100%	100%	78%
Minimum		4.3	49	30.0	51.4	0.2	94.3	5.7	56.0	-	4	5	5	4	2	1	2	6	1	10	2	13	3	50	7	23	29	0	510	8%
Maximum		5.5	93	32.4	51.4	3.8	244.8	5.9	77.0	-	5	18	22	6	15	2	2	14	1	50	5	22	40	50	49	58	210	5	1,100	107%
Mean		5.1	74	31.3	51.4	1.0	202.1	5.8	64.3	-	5	10	12	5	6	1	2	8	1	38	4	16	15	50	18	39	114	3	890	43%
Median		5.2	76	31.5	51.4	0.5	214.9	5.8	60.0	-	5	11	13	5	3	1	2	8	1	50	4	16	12	50	10	38	120	5	920	37%
Standard Deviation		0.4	16	0.9	-	1.3	49.0	0.1	11.2	-	0	5	7	1	5	0	0	3	0	18	1	3	11	0	15	10	63	2	167	35%
80th Percentile		5.4	88	31.9	51.4	0.8	221.6	5.9	70.2	-	5	13	16	5	8	1	2	9	1	50	4	17	19	50	25	45	168	5	988	60%
BH15B	1/6/2016	5.7	168	30.0	45	3		6.5	215											10	1	21	28		280	18	9	0.4	440	
BH15B	2/22/2016							6.4	220											10	1	23	31		280	18	8	0.3	370	
BH15B	8/4/2016	6.5	282	31.1		0.3	-52		270		5	110	134	20	3	12	10	19	4	10	0	7	1		190	10	1	0.1	270	14%
BH15B	10/12/2016	6.4	232	32.2		0.1	-53		210		24	73	89	13	3	12	9	19	4	50	0	7	1		190	10	1	5	180	21%
BH15B	1/14/2017	6.5	215	33.8		0.2	-47				16	5	6		2	11	8	20	4		0	7	1		160	8	3	5	620	172%
BH15B	4/24/2017	6.6	248	35.4		0.1	-53				5	100	122	6	4	13	8	21		50	0	7	1	2,100	190	10	4	5	680	8%
BH15B	7/9/2017	6.3	226	31.3		0.3	-27				28	98	120	6	4	10	8	26	4	50	0	9	1	2,500	220	8	6	5	1,100	15%
BH15B	10/19/2017										1	20		7	16	1	2	9	1	50	4	17	6	80	12	170	160	5	870	
BH15B	1/18/2018	6.6	196	30.7		2	32				27	79		10	27	10	7	16	4	50	0	10	4	1,200	150	9	3	5	540	
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		7	7	7	1	7	6	2	4	0	7	7	5	6	7	7	7	7	6	8	9	9	9	4	9	9	9	9	9	5
% of samples analyzed		78%	78%	78%	11%	78%	67%	22%	44%	0%	78%	78%	56%	67%	78%	78%	78%	78%	67%	89%	100%	100%	100%	44%	100%	100%	100%	100%	100%	56%
Minimum		5.7	168	30.0	-	0.1	-53.3	6.4	210.0	-	1	5	6	6	2	1	2	9	1	10	0	7	1	80	12	8	1	0	180	8%
Maximum		6.6	282	35.4	-	3.3	32.3	6.5	270.0	-	28	110	134	20	27	13	10	26	4	50	4	23	31	2,500	280	170	160	5	1,100	172%
Mean		6.4	224	32.1	-	0.9	-33.3	6.5	228.8	-	15	69	94	10	8	10	7	19	3	35	1	12	8	1,470	186	29	22	3	563	46%
Median		6.5	226	31.3	-	0.3	-49.5	6.5	217.5	-	16	79	120	8	4	11	8	19	4	50	0	9	1	1,650	190	10	4	5	540	15%
Standard Deviation		0.3	36	1.9	-	1.3	33.7	0.1	27.8	-	11	41	52	6	9	4	3	5	1	21	1	7	12	1,074	80	53	52	2	293	71%
80th Percentile		6.6	245	33.5	-	1.7	-27.0	6.5	240.0	-	26	100	124	13	14	12	9	21	4	50	1	19	15	2,260	244	18	8	5	756	51%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C17. Groundwater Quality Results for Bore BH16B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH16B	1/6/2016	5.4	1711	29.0	10	1		6.0	2550											10	2.600	15	25		430	68	5	0.5	140	
BH16B	2/22/2016							5.9	2200											10	1.800	7	17		76	78	3	0.2	100	
BH16B	7/19/2016											43	52			300	280	16	1	10	1.400	1	1		130	50	1	0.1	51	191%
BH16B	10/12/2016	5.7	2794	32.8		0	165		1700		5	26	32	11000	3	300	290	14	1	50	1.200	1	1		150	43	1	5	10	141%
BH16B	1/15/2017	6.3	6			0	30		2400		9	5	6	2000	4	300	300	13	1	50	1.300	1	1		150	42	1	5	16	4%
BH16B	10/26/2017	5.7	2271	30.4		0	187				1	29		1,500	3.7	260	260	14	0.6	50	1.2	1	2	50	140	50	1	5	31	
BH16B	4/29/2017	6.0	2797	30.8		0	107				15	30	37	1600	17	260	260	14	1	50	0.700	1	1	50	120	53	1	5	18	2%
BH16B	7/9/2017	5.6	1943	30.8		0	153				8600	33	40	1800	6	250	250	19	1	50	1.400	1	1	50	170	61	4	5	27	12%
BH16B	1/17/2018										1	36		1,400	22	260	250	13	0.6	50	1.2	1	2	50	190	38	1	5	33	
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		6	6	5	1	6	5	2	4	0	6	7	5	6	6	7	7	7	7	9	9	9	9	4	9	9	9	9	9	5
% of samples analyzed		67%	67%	56%	11%	67%	56%	22%	0	0%	67%	78%	56%	67%	67%	78%	78%	78%	78%	100%	100%	100%	100%	44%	100%	100%	100%	100%	100%	56%
Minimum		5.4	6	29.0	-	-0.4	30.1	5.9	1700	-	1	5	6	1,400	3	250	250	13	1	10	1	1	1	50	76	38	1	0	10	2%
Maximum		6.3	2797	32.8	-	0.7	187.1	6.0	2550	-	8,600	43	52	11,000	22	300	300	19	1	50	3	15	25	50	430	78	5	5	140	191%
Mean		5.8	1920	30.8	-	0.1	128.4	6.0	2213	-	1,439	29	33	3,217	9	276	270	15	1	37	1	3	6	50	173	54	2	3	47	70%
Median		5.7	2107	30.8	-	0.1	153.0	6.0	2300	-	7	30	37	1,700	5	260	260	14	1	50	1	1	1	50	150	50	1	5	31	12%
Standard Deviation		0.3	1036	1.4	-	0.4	62.3	0.1	371	-	3,508	12	17	3,819	8	23	20	2	0	20	1	5	9	0	102	13	2	2	44	90%
80th Percentile		6.0	2794	31.2	-	0.2	169.4	6.0	2460	-	15	35	43	2,000	17	300	288	16	1	50	2	3	8	50	178	64	3	5	71	151%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C18. Groundwater Quality Results for Bore BH18A and BH18B, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
BH18A	2/22/2016							5.9	210											10	0.2	4	12		15	8	1	0.1	49	
BH18A	7/10/2017	5.65	332	33		2	207.1				5	73	89	76	5	2	36	10	1	50	0.2	2	15	50	10	21	2	5	190	10%
No. of sampling campaigns		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
No. of measurements		1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	2	2	2	2	1	2	2	2	2	2	1
% of samples analyzed		50%	50%	50%	0%	50%	50%	50%	50%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	50%
Minimum		-	-	-	-	-	-	-	-	-	-	73.0	89.1	76.0	5.3	2.1	36.0	10.0	0.5	10.0	0.2	2.0	12.0	50.0	10.0	8.0	1.0	0.1	49.0	-
Maximum		-	-	-	-	-	-	-	-	-	-	73.0	89.1	76.0	5.3	2.1	36.0	10.0	0.5	50.0	0.2	4.0	15.0	50.0	15.0	21.0	2.0	5.0	190.0	-
Mean		-	-	-	-	-	-	-	-	-	-	73.0	89.1	76.0	5.3	2.1	36.0	10.0	0.5	30.0	0.2	3.0	13.5	50.0	12.5	14.5	1.5	2.6	119.5	-
Median		-	-	-	-	-	-	-	-	-	-	73.0	89.1	76.0	5.3	2.1	36.0	10.0	0.5	30.0	0.2	3.0	13.5	50.0	12.5	14.5	1.5	2.6	119.5	-
Standard Deviation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.3	0.0	1.4	2.1	-	3.5	9.2	0.7	3.5	99.7	-
80th Percentile		-	-	-	-	-	-	-	-	-	-	73.0	89.1	76.0	5.3	2.1	36.0	10.0	0.5	42.0	0.2	3.6	14.4	50.0	14.0	18.4	1.8	4.0	161.8	-
BH18B	1/6/2016	4.9	1728	30.5	9	1		5.9	2,291											10	1.2	610	220		5,500	580	1	1.1	170	
BH18B	2/22/2016							5.9	2,000											10	0.4	91	58		720	130	1	0.5	83	
BH18B	7/19/2016	5.4	2,865	31.9		9	244					100	122			100	430	16	1	10	0.8	940	270		7,200	1,100	1	0.1	130	
BH18B	10/12/2016	5.4	3,038	30.7		0	220		1,900		5	57	70	2,200	7	98	440	15	1	50	1.0	1,100	370		8,200	1,100	1	5	150	11%
BH18B	1/15/2017	5.7	2,405	31.5		0	152		2,400		7	5	6	1,900	6	91	470	27	1	50	0.3	200	74		1,700	240	1	5	49	11%
BH18B	4/29/2017	5.6	2,191	30.5		0	187				3	49	60	1,100	12	78	240	12	2	50	0.7	1,000	190	50	8,700	980	2	5	130	2%
BH18B	7/20/2017										5	57	70	1,200	4	85	230	11	1	50	0.4	470	140	50	4,100	490	1	5	220	9%
BH18B	1/11/2018	5.7	1,924	30.7		0	196				1.9	88	107	1,200	4.1	77	290	12	1	50	0.2	220	74	50	1,900	240	1	5	70	5%
No. of sampling campaigns		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of measurements		6	6	6	1	6	5	2	4	0	5	6	6	5	5	6	6	6	6	8	8	8	8	3	8	8	8	8	8	5
% of samples analyzed		75%	75%	75%	13%	75%	63%	25%	50%	0%	63%	75%	75%	63%	63%	75%	75%	75%	75%	100%	100%	100%	100%	38%	100%	100%	100%	100%	100%	63%
Minimum		4.9	1,728	30.5	-	-0.5	152	5.9	1,900	-	1.9	5	6	1,100	4	77	230	11	1	10	0.2	91	58	50	720	130	1	0	49	2%
Maximum		5.7	3,038	31.9	-	8.5	244	5.9	2,400	-	6.5	100	122	2,200	12	100	470	27	2	50	1.2	1,100	370	50	8,700	1,100	2	5	220	11%
Mean		5.5	2,359	31.0	-	1.5	200	5.9	2,148	-	4.3	59	72	1,520	7	88	350	16	1	35	0.6	579	175	50	4,753	608	1	3	125	8%
Median		5.5	2,298	30.7	-	0.3	196	5.9	2,146	-	5.0	57	70	1,200	6	88	360	14	1	50	0.6	540	165	50	4,800	535	1	5	130	9%
Standard Deviation		0.3	517	0.6	-	3.4	35	0.0	236	-	1.8	33	41	497	3	10	109	6	0.2	21	0.4	397	110	0	3,120	403	0	2	56	4%
80th Percentile		5.7	2,865	31.5	-	0.7	225	5.9	2,335	-	5.3	88	107	1,960	8	98	440	16	1	50	0.9	976	250	50	7,800	1,052	1	5	162	11%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C19. Groundwater Quality Results for Bore TPB4 and TPB5, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
TPB4	1/11/2016	7.1	344					7.2	449											10	0.1	1	1		140	1	1	0.1	5	
TPB4	1/20/2016	6.7	502					6.7	430											30	0.1	1	1		220	3	1	0.1	8	
TPB4	3/30/2016	7.5	376	30.1		2										15	50			10	0.1	8	2		150	6	1	0.1	13	
TPB4	4/29/2016	7.5	375	30.8		0										18	51			10	0.1	1	1		68	1	1	0.1	7	
TPB4	6/30/2016	7.3	491	30.9		0	-185				8	270	329	5	3	20	55	3	1	10	0.1	1	1		190	1	1	0.1	5	
TPB4	7/31/2016	7.3	510	30.4		0	-185				8	290	354	5	4	20	55	3	1	10	0.1	1	1		21	1	1	0.1	5	
TPB4	8/30/2016	7.4	502	30		0	-206				12	290	354	2	4	13	46	2	1	10	0.1	1	1		16	1	1	0.1	5	
TPB4	9/30/2016	7.2	480	30.1		0	-19		400		7	200	244	2	4	17	48	2	1	50	0.2	1	1		150	1	1	5	5	
TPB4	10/17/2016								430		5	210	256	2	5	19	57	3	1	50	0.2	1	1		180	1	1	5	5	
TPB4	1/13/2017	7.3	492	30.1		0	-160				6	11	13	2	3	18	54	2	1		0.2	1	1		140	1	1	5	6	
TPB4	4/5/2017	7.5	434	29.4		0	-6		410		5	220	268	2	4	17	49	2	1	50	0.2	1	1		93	1	1	5	5	
TPB4	7/27/2017	7.2	476	30.6		0	-151				5	320	390	5	13	18	50	3	1	50	0.2	1	1	1500	91	1	1	5	5	
TPB4	10/9/2017	7.2	476	30.2		0	-149				6	280	342	5	19	19	49	3	1	50	0.2	1	1	1800	200	2	1	5	5	18%
TPB4	1/9/2018	7.4	455	29.8		0	-169				4	270	329	5	8.7	17	46	2.5	0.6	50	0.2	2	2	1,500	100	1	1	5	7	
DPTPB4	1/9/2018										4.3	260	317	5	8.3	17	46	2.4	0.6	50	0.2	1	1	1,500	100	1	1	5	5	
No. of sampling campaigns		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
No. of measurements		13	13	11	0	11	9	2	5	0	11	11	11	11	11	13	13	11	11	14	15	15	15	4	15	15	15	15	15	1
% of samples analyzed		87%	87%	73%	0%	73%	60%	13%	33%	0%	73%	73%	73%	73%	73%	87%	87%	73%	73%	93%	100%	100%	100%	27%	100%	100%	100%	100%	100%	7%
Minimum		6.7	344	29.4	-	-0.1	-206.0	6.7	400	-	4	11	13	2	3	13	46	2	1	10	0.1	1	1	1,500	16	1	1	0.1	5	-
Maximum		7.5	510	30.9	-	2.0	-6.3	7.2	449	-	12	320	390	5	19	20	57	3	1	50	0.2	8	2	1,800	220	6	1	5.0	13	-
Mean		7.3	455	30.2	-	0.3	-136.8	7.0	424	-	6	238	291	4	7	18	50	2	1	31	0.2	2	1	1,575	124	2	1	2.7	6	-
Median		7.3	476	30.1	-	0.3	-160.0	7.0	430	-	6	270	329	5	4	18	50	3	1	40	0.2	1	1	1,500	140	1	1	5.0	5	-
Standard Deviation		0.2	56	0.4	-	0.6	72.7	0.4	19	-	2	84	102	2	5	2	4	0.2	0.0	20	0.1	2	0	150	62	1	-	2.6	2	-
80th Percentile		7.4	498	30.6	-	0.4	-97.1	7.1	434	-	8	290	354	5	9	19	55	3	1	50	0.2	1	1	1,620	182	1	1	5.0	7	-
TPB5	1/11/2016	8.5	559					7.6	736											40	0.1	10	84		55	12	1	0.1	5	
TPB5	7/31/2016										5	100	122	540	11	63	120	8	2	10	0.1	1	1		9	1	1	0.1	5	
TPB5	8/30/2016										5	95	116	270	5	50	110	9	2	10	0.1	1	1		25	6	1	0.1	5	
TPB5	9/30/2016	7.2	1,112	30.5		2	54									55	100	8	2	50	0.2	2	1		23	8	1	5	9	
TPB5	10/25/2016								1000		5	67	82	510	10	62	120	9	2	50	0.2	1	1		19	3	1	5	5	
TPB5	1/26/2017										5	67	82	620	11	63	130	10	1		0.2	1	1		16	3	1	5	5	
TPB5	5/9/2017	7.9	1,265	30.6		2	28				5	71	87	610	10	63	140	9		50	0.2	1	1	50	17	2	1	5	5	
TPB5	7/8/2017	7.6	1,004	30.3		3	50				5	88	107	570	12	55	120	15	2	50	0.2	1	1	50	35	4	1	5	5	5%
TPB5	10/27/2017	7.9	996	30.3		0	-31				1	20	24	450	18	55	110	9	2	50	0.2	2	1	50	140	4	1	5	5	
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		5	5	4	0	4	4	1	2	0	7	7	7	7	7	8	8	8	7	8	9	9	9	3	9	9	9	9	9	1
% of samples analyzed		56%	56%	44%	0%	44%	44%	11%	22%	0%	78%	78%	78%	78%	78%	89%	89%	89%	78%	89%	100%	100%	100%	33%	100%	100%	100%	100%	100%	11%
Minimum		7.2	559	30.3	-	0	-	7.6	736	-	1	20	24	270	5	50	100	8	1	10	0.1	1	1	50	9	1	1	0.1	5	-
Maximum		8.5	1,265	30.6	-	3	-	7.6	1000	-	5	100	122	620	18	63	140	15	2	50	0.2	10	84	50	140	12	1	5.0	9	-
Mean		7.8	987	30.4	-	2	-	7.6	868	-	4	73	89	510	11	58	119	10	2	39	0.2	2	10	50	38	5	1	3.4	5	-
Median		7.9	1,004	30.4	-	2	-	7.6	868	-	5	71	87	540	11	59	120	9	2	50	0.2	1	1	50	23	4	1	5.0	5	-
Standard Deviation		0.4	263	0.2	-	1	-	-	187	-	2	27	33	121	4	5	12	2	0	18	0.1	3	28	0	41	3	0	2.5	1	-
80th Percentile		8.0	1,143	30.5	-	2	-	7.6	947	-	5	94	114	602	12	63	126	10	2	50	0.2	2	1	50	43	7	1	5.0	5	-

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C20. Groundwater Quality Results for Bore RN023137, January 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
RN023137	1/6/2016	5.9	346	28.6	35	3		5.5	456											10	0.300	25	61		62	14	1	0.7	25	
RN023137	2/17/2016	6.2	370	28.8	7	1		6.3	460											10	0.700	3	2		180	4	1	0.2	6	
RN023137	8/3/2016	6.2		29.2			-46		460		5	130	159	140	4	47	31	7	2	10	0.1	2	1		220	9	1	0.1	5	6%
RN023137	10/17/2016	6.1	511	29.2		0.5	-35		410		5	94	115	130	5	49	32	8	3	50	0.2	3	1		180	5	1	5	6	
RN023137	1/4/2017	6.3	509	30.6		0.3	35				4	120	146	140	5	44	30	7		50	0.2	2	1	320	160	5	1	5	17	
RN023137	4/5/2017	6.5	500	29.2		0.01	62		450		5	120	146	140	4	55	29	7	2	50	0.2	1	1		340	2	1	5	13	
RN023137	7/20/2017	6.4	563	28.8		0.3	28				5	160	195	130	5	64	28	7	3	50	0.2	4	1	190	560	3	1	5	24	2%
RN023137	10/9/2017	6.5	568	30.9		0.02	-11				2	190	232	130	12	64	30	7	3	50	0.2	1	1	450	550	3	1	5	11	12%
RN023137	1/17/2018										1	220	268	130	24	72	32	7	3	50	0.2	1	3	470	560	2	1	5	11	
No. of sampling campaigns		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of measurements		8	7	8	2	7	6	2	5	0	7	7	7	7	7	7	7	7	6	9	9	9	9	4	9	9	9	9	9	3
% of samples analyzed		89%	78%	89%	22%	78%	67%	22%	56%	0%	78%	78%	78%	78%	78%	78%	78%	78%	67%	100%	100%	100%	100%	44%	100%	100%	100%	100%	100%	33%
Minimum		5.9	346	29	7	0	-46	5.5	410	-	1	94	115	130	4	44	28	7	2	10	0.1	1	1	190	62	2	1	0.1	5	2%
Maximum		6.5	568	31	35	3	62	6.3	460	-	5	220	268	140	24	72	32	8	3	50	0.7	25	61	470	560	14	1	5.0	25	12%
Mean		6.3	481	29	21	1	5	5.9	447	-	4	148	180	134	8	56	30	7	2	37	0.3	5	8	358	312	5	1	3.4	13	7%
Median		6.3	509	29	21	0	8	5.9	456	-	5	130	159	130	5	55	30	7	3	50	0.2	2	1	385	220	4	1	5.0	11	6%
Standard Deviation		0.2	88	1	20	1	43	0.6	21	-	2	45	54	5	7	10	1	0.3	0.3	20	0.2	8	20	130	197	4	-	2.3	8	5%
80th Percentile		6.4	553	30	30	1	35	6.1	460	-	5	184	224	140	11	64	32	7	3	50	0.2	3	2	458	554	7	1	5.0	20	10%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table C21. Groundwater Quality Results for the Thompson and Thompson-Mango bores, August 2016 to January 2018

Bore ID	Sampling Date	Field pH	Field EC	Temp	DO	DO	Redox	Lab pH	Lab EC	Turbidity	TSS	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Co-f	Cu-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	oC	% sat.	mg/L	mV	-	uS/cm	NTU	mg/L	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	ug/L	
Thompson	8/30/2016								304		5	180	220	2	2	27	22	3	1	10	0.1	1	1		55	1	1	0.4	5	
Thompson	10/24/2016								300		5	140	171	2	2	33	27	3	1	50	0.2	1	1		45	1	1	5	5	
Thompson	2/23/2017										5	92	112	2	3	22	18	3	1	50	0.2	1	1	60	50	1	1	5	5	33%
Thompson	2/23/2017	6.6	243	30.0		2	49				5	89	109	2	3	22	18	3	1	50	0.2	1	1	50	48	1	1	5	11	36%
Thompson	5/10/2017	6.8	354	30.1		1	-40				5	130	159	2	2	29	23	3		50	0.2	1	1	110	62	1	1	5	5	25%
Thompson	7/7/2017	6.7	330	30.0		2	-34				5	170	207	2	3	24	22	8	1	50	0.2	1	1	370	56	1	1	5	5	3%
Thompson	10/11/2017	6.7	336	30.3		1	-3				31	180	220	5	16	29	23	3		50	0.2	1	1	430	16	1	1	5	5	
No. of sampling campaigns		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
No. of measurements		4	4	4	0	4	4	0	2	0	7	7	7	7	7	7	7	7	5	7	7	7	7	5	7	7	7	7	7	4
% of samples analyzed		57%	57%	57%	0%	57%	57%	0%	29%	0%	100%	100%	100%	100%	100%	100%	100%	100%	71%	100%	100%	100%	100%	71%	100%	100%	100%	100%	100%	57%
Minimum		6.6	243	30	-	1	-40	-	300	-	5	89	109	2	2	22	18	3	1	10	0.1	1	1	50	16	1	1	0	5	3%
Maximum		6.8	354	30	-	2	49	-	304	-	31	180	220	5	16	33	27	8	1	50	0.2	1	1	430	62	1	1	5	11	36%
Mean		6.7	316	30	-	2	-7	-	302	-	9	140	171	2	4	27	22	4	1	44	0.2	1	1	204	47	1	1	4	6	24%
Median		6.7	333	30	-	2	-19	-	302	-	5	140	171	2	3	27	22	3	1	50	0.2	1	1	110	50	1	1	5	5	29%
Standard Deviation		0.1	50	0	-	0	41	-	3	-	10	39	48	1	5	4	3	2	0	15	0.0	0	0	182	15	0	0	2	2	15%
80th Percentile		6.7	343	30	-	2	18	-	303	-	5	178	217	2	3	29	23	3	1	50	0.2	1	1	382	56	1	1	5	5	34%
ThompsonMango	8/30/2016								132		5	68	83	4	4	3	9	5	2	10	0.1	2	1		140	7	1	0.1	7	31%
ThompsonMango	10/24/2016								130		5	47	57	5	3	3	9	5	3	50	0.2	1	1		89	2	1	5	6	9%
ThompsonMango	2/22/2017										5	39	48	8	8	7	14	11	1	50	0.2	2	1	7600	140	6	1	5	5	70%
ThompsonMango	5/10/2017	6.2	167	29.9		0	-38				5	40	49	8	3	3	9	6		50	0.2	2	1	5400	100	5	1	5	5	28%
ThompsonMango	7/7/2017	6.1	146	30.0		0	-45				9	48	59	4	3	3	9	10	3	50	0.2	2	1	7200	130	6	1	5	6	43%
ThompsonMango	10/11/2017	6.1	140	30.6		1	-33				7	54	66	5	20	3	9	6	3	50	0.2	2	1	9500	140	6	1	5	7	3%
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		3	3	3	0	3	3	0	2	0	6	6	6	6	6	6	6	6	5	6	6	6	6	4	6	6	6	6	6	6
% of samples analyzed		50%	50%	50%	0%	50%	50%	0%	33%	0%	100%	100%	100%	100%	100%	100%	100%	100%	83%	100%	100%	100%	100%	67%	100%	100%	100%	100%	100%	100%
Minimum		6.1	140	29.9	-	0.1	-45	-	130	-	5	39	48	4	3	3	9	5	1	10	0.1	1	1	5,400	89	2	1	0.1	5	3%
Maximum		6.2	167	30.6	-	0.7	-33	-	132	-	9	68	83	8	20	7	14	11	3	50	0.2	2	1	9,500	140	7	1	5.0	7	70%
Mean		6.1	151	30.2	-	0.3	-39	-	131	-	6	49	60	6	7	4	10	7	2	43	0.2	2	1	7,425	123	5	1	4.2	6	31%
Median		6.1	146	30.0	-	0.1	-38	-	131	-	5	48	58	5	4	3	9	6	3	50	0.2	2	1	7,400	135	6	1	5.0	6	30%
Standard Deviation		0.0	14	0.4	-	0.3	6	-	1	-	2	11	13	2	7	2	2	3	1	16	0.0	0.4	0.0	1,682	23	2	-	2.0	1	24%
80th Percentile		6.1	159	30.4	-	0.5	-35	-	132	-	7	54	66	8	8	3	9	10	3	50	0.2	2	1	8,360	140	6	1	5.0	7	43%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

APPENDIX D

ADDITIONAL GROUNDWATER QUALITY TIME TRENDS

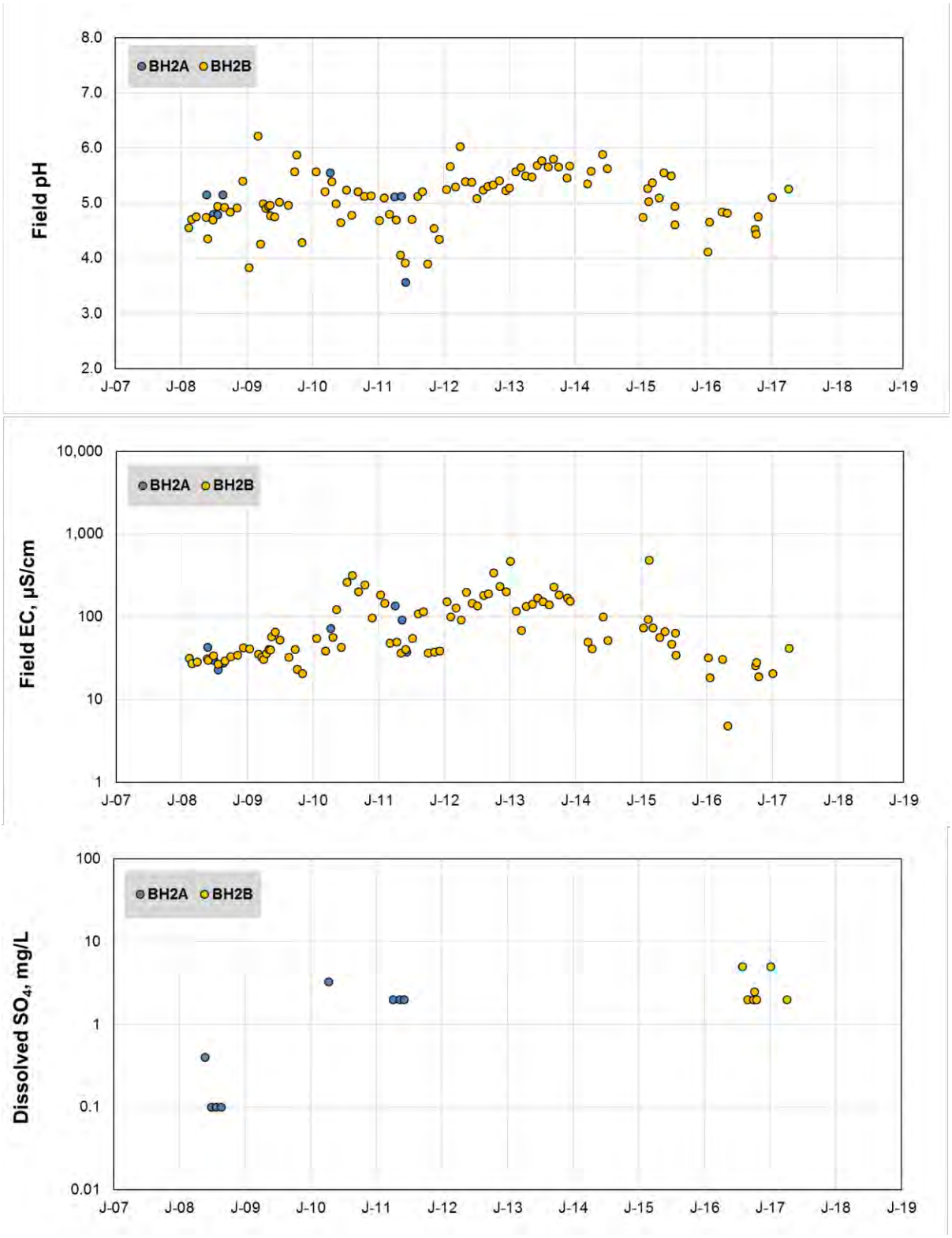


Figure D20. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH2A and BH2B, 2008 to 2018

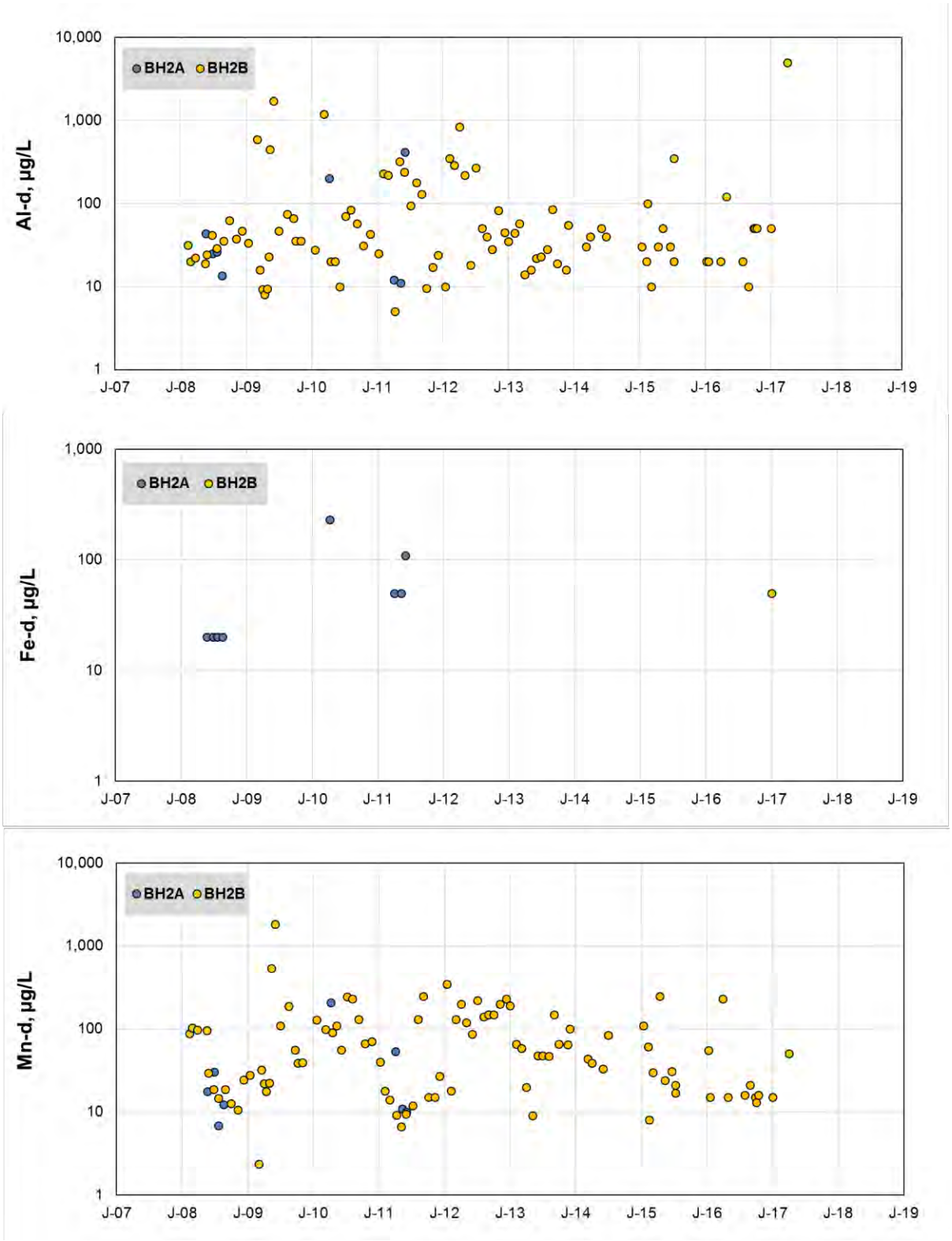


Figure D21. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH2A and BH2B, 2008 to 2018

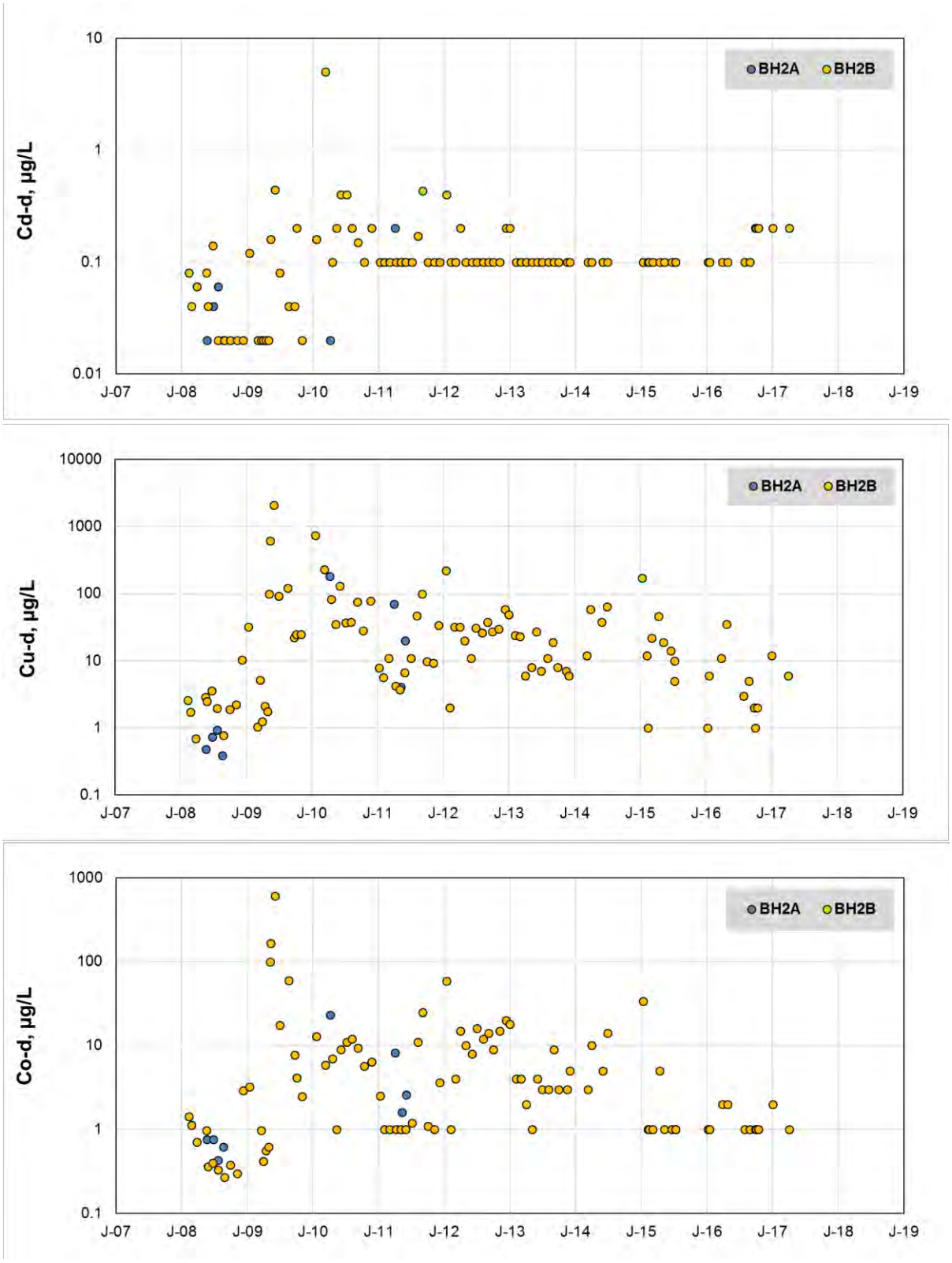


Figure D22. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH2A and BH2B, 2008 to 2018

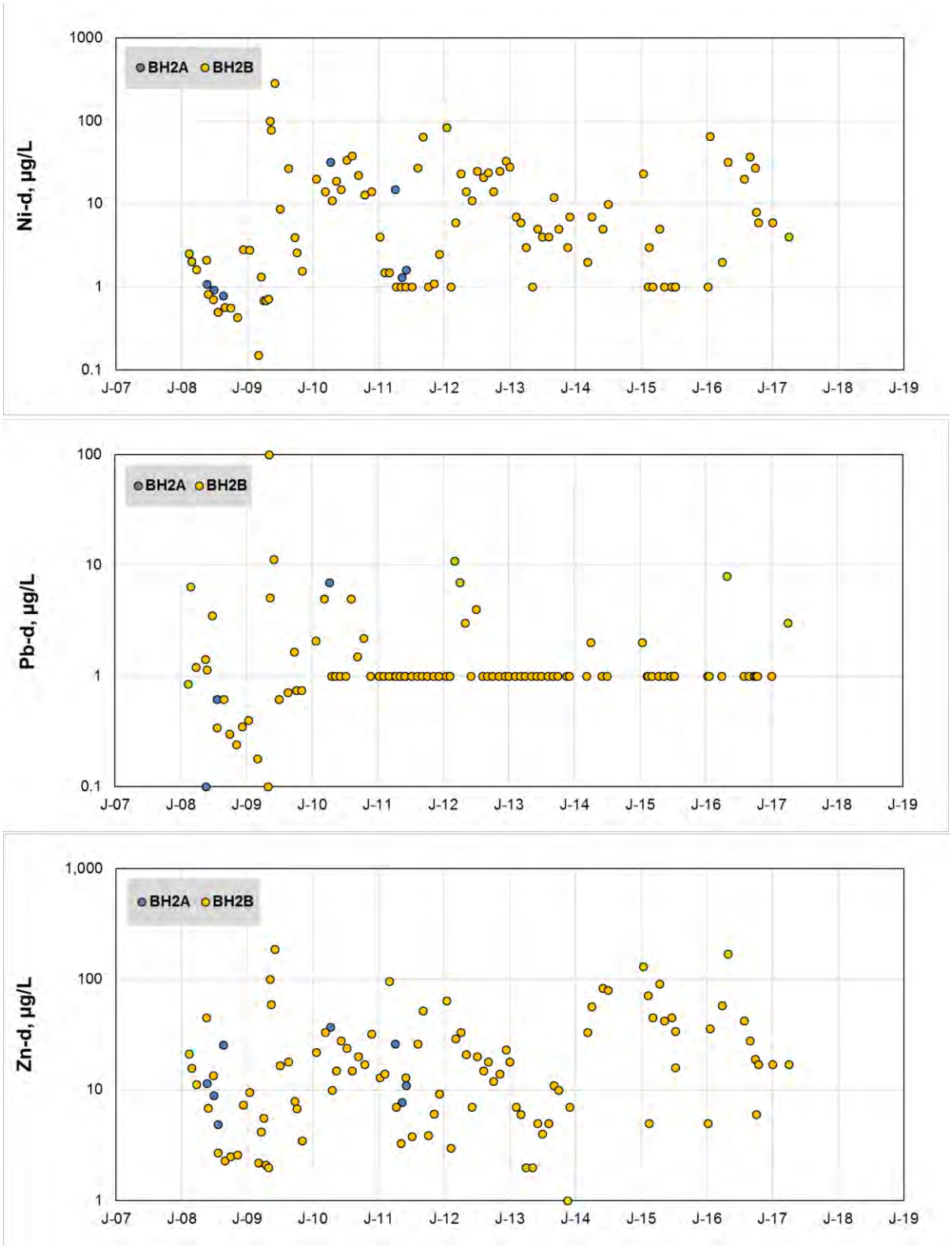


Figure D23. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH2A and BH2B, 2008 to 2018

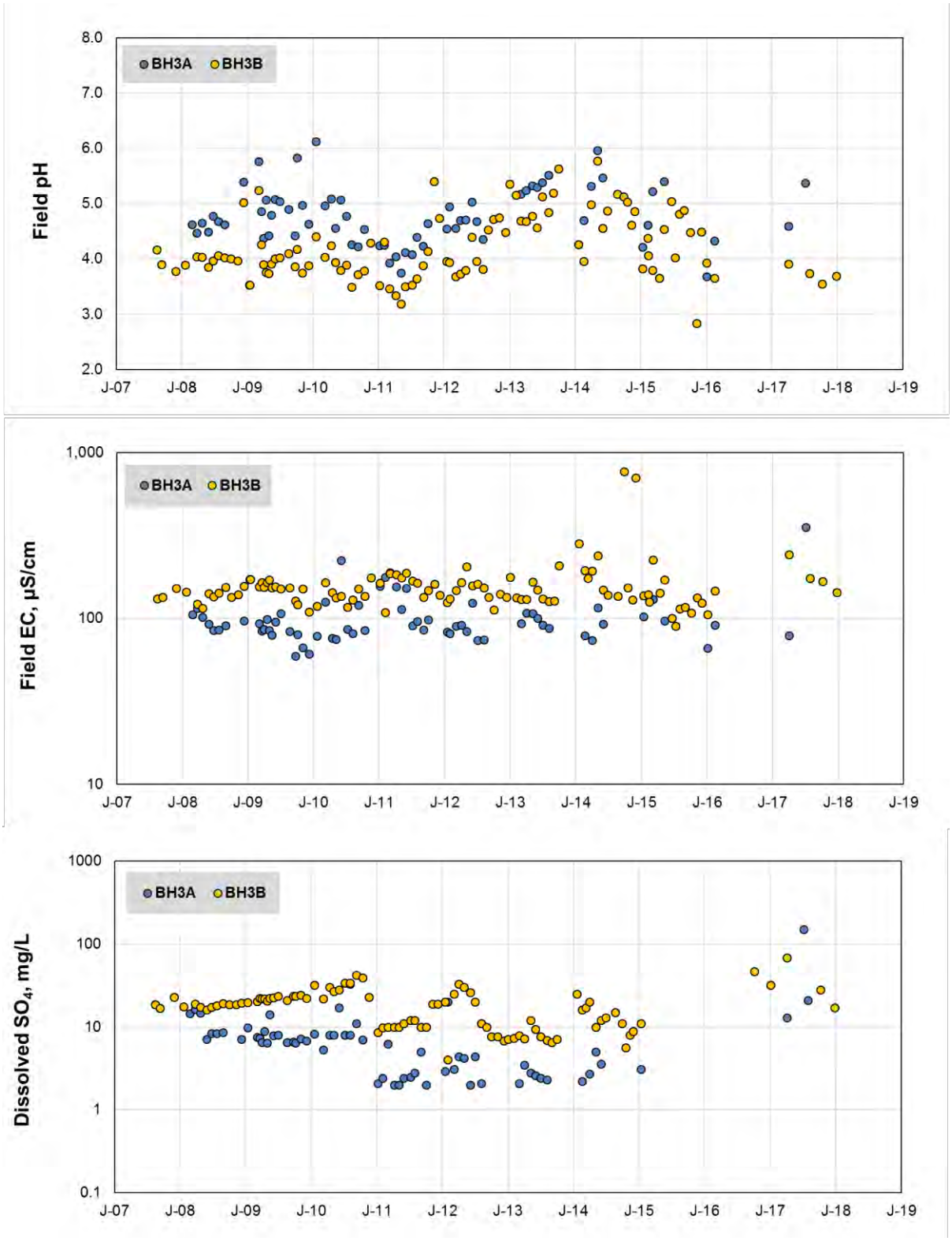


Figure D24. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH3A and BH3B, 2007 to 2018

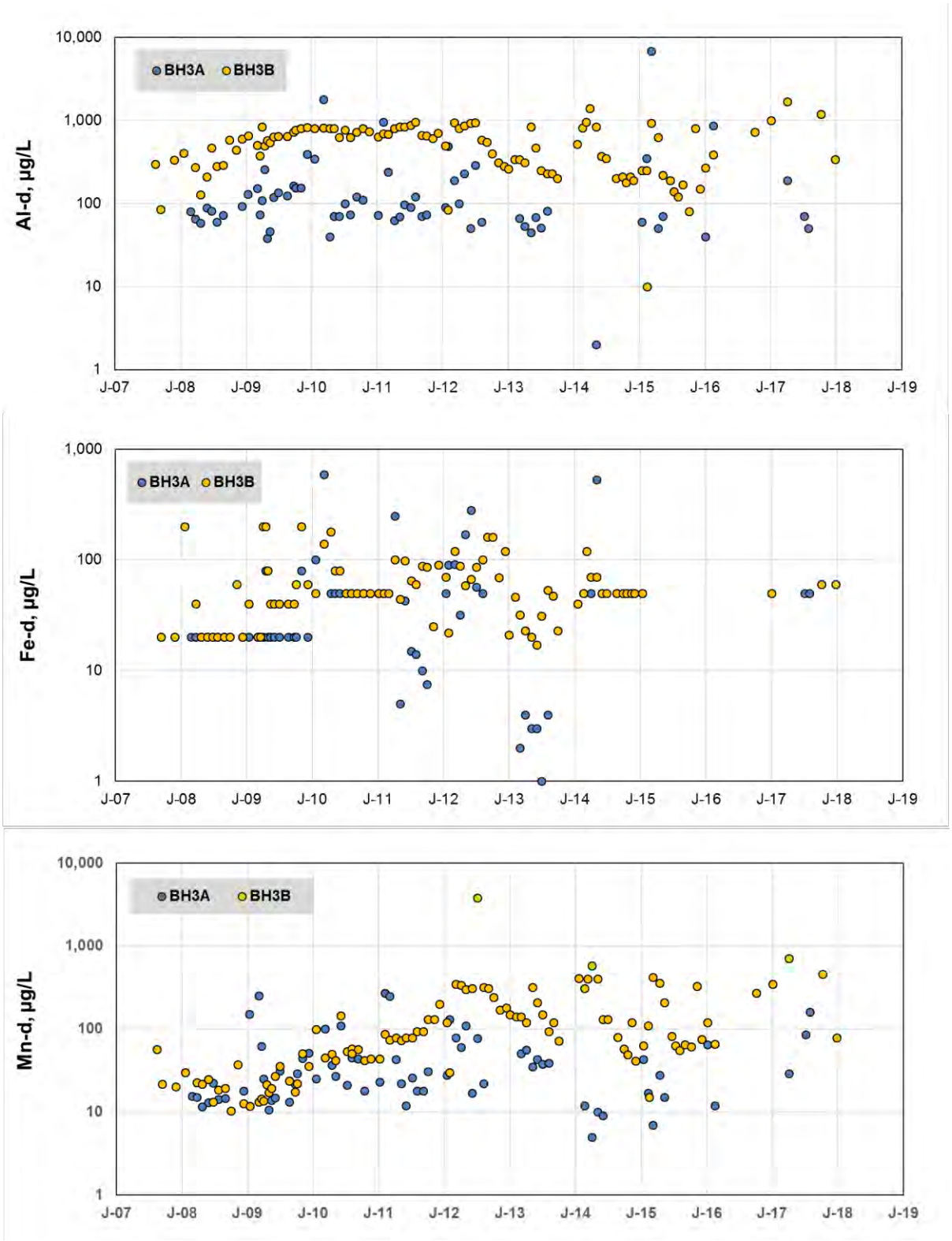


Figure D25. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH3A and BH3B, 2007 to 2018

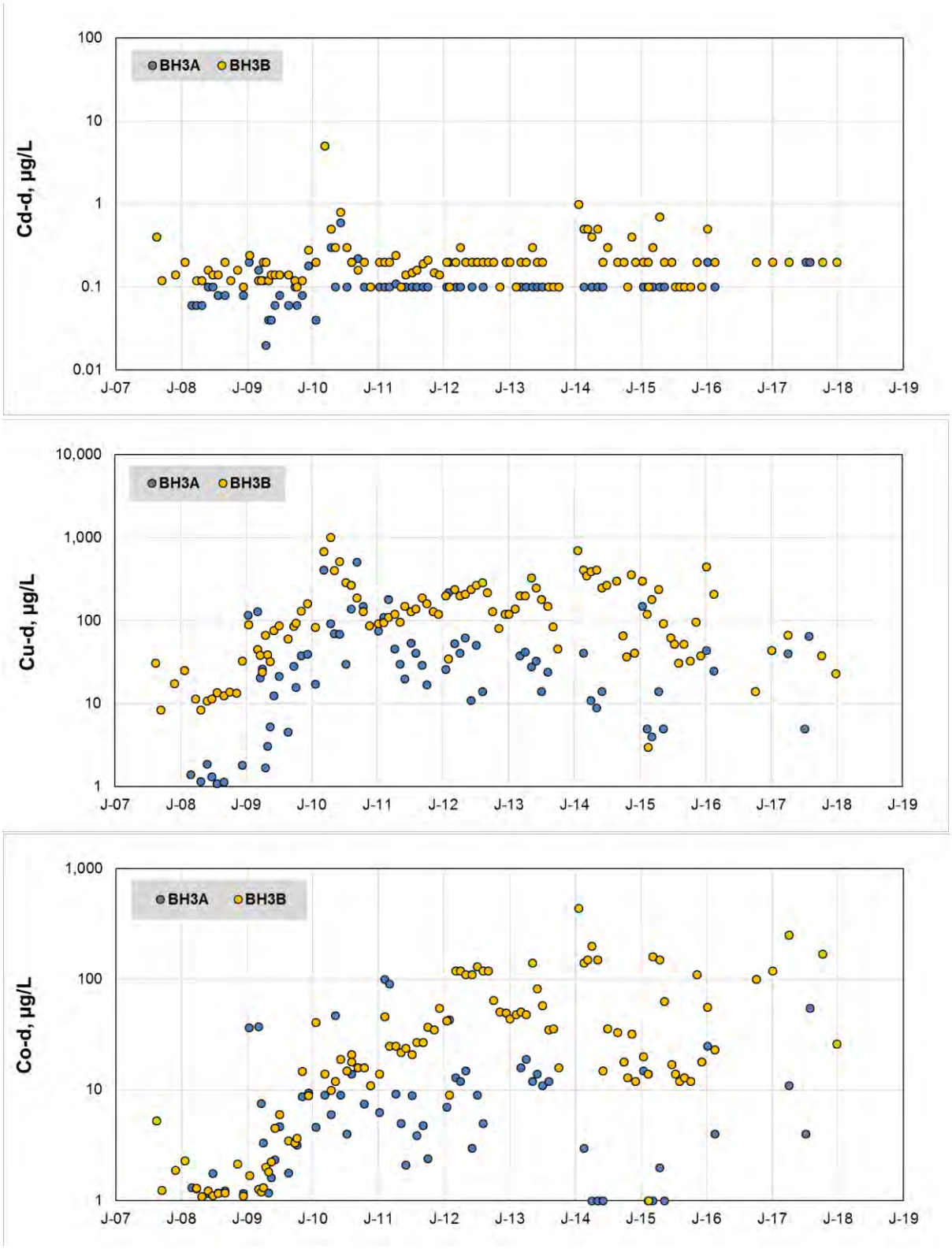


Figure D26. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH3A and BH3B, 2007 to 2018

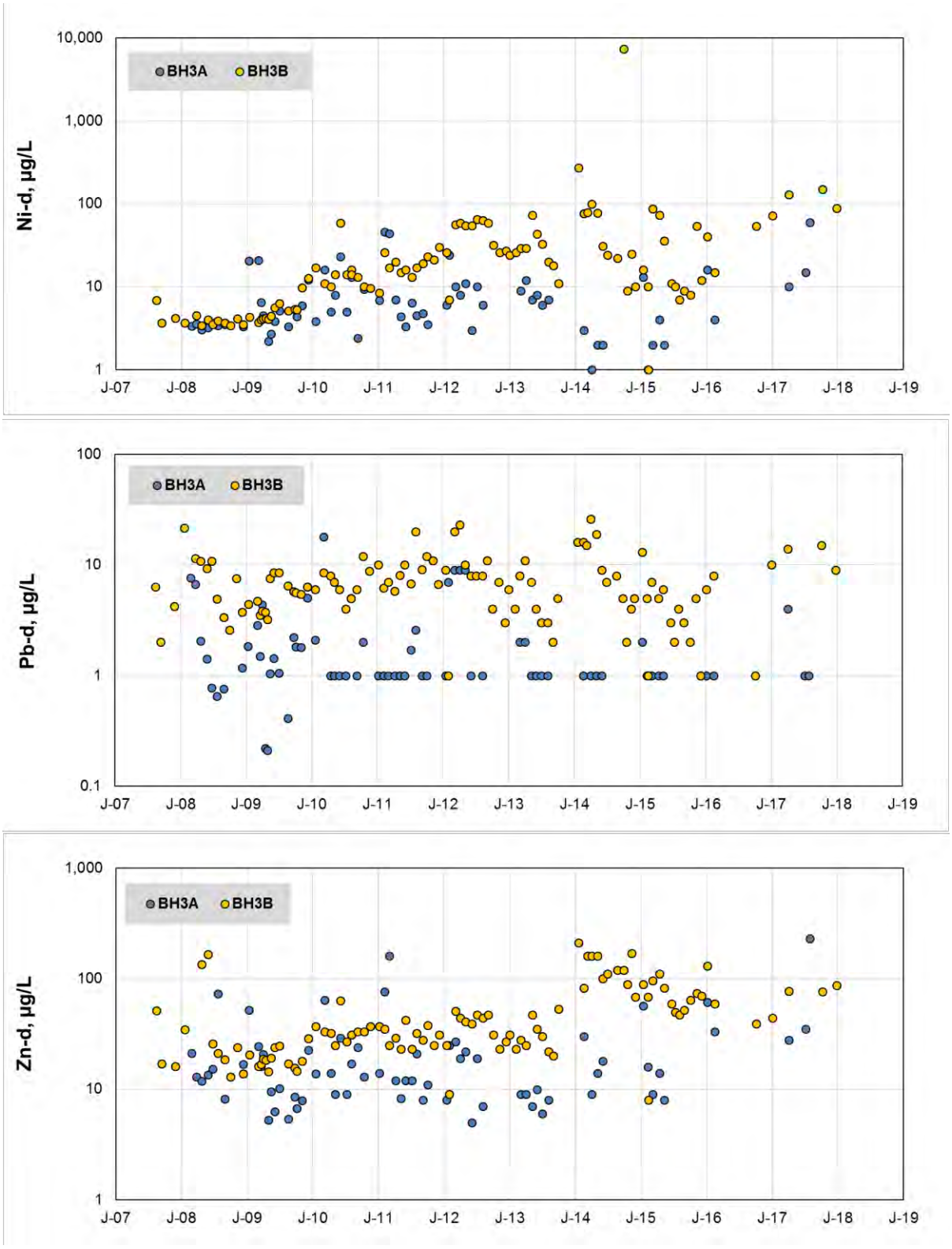


Figure D27. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH3A and BH3B, 2007 to 2018

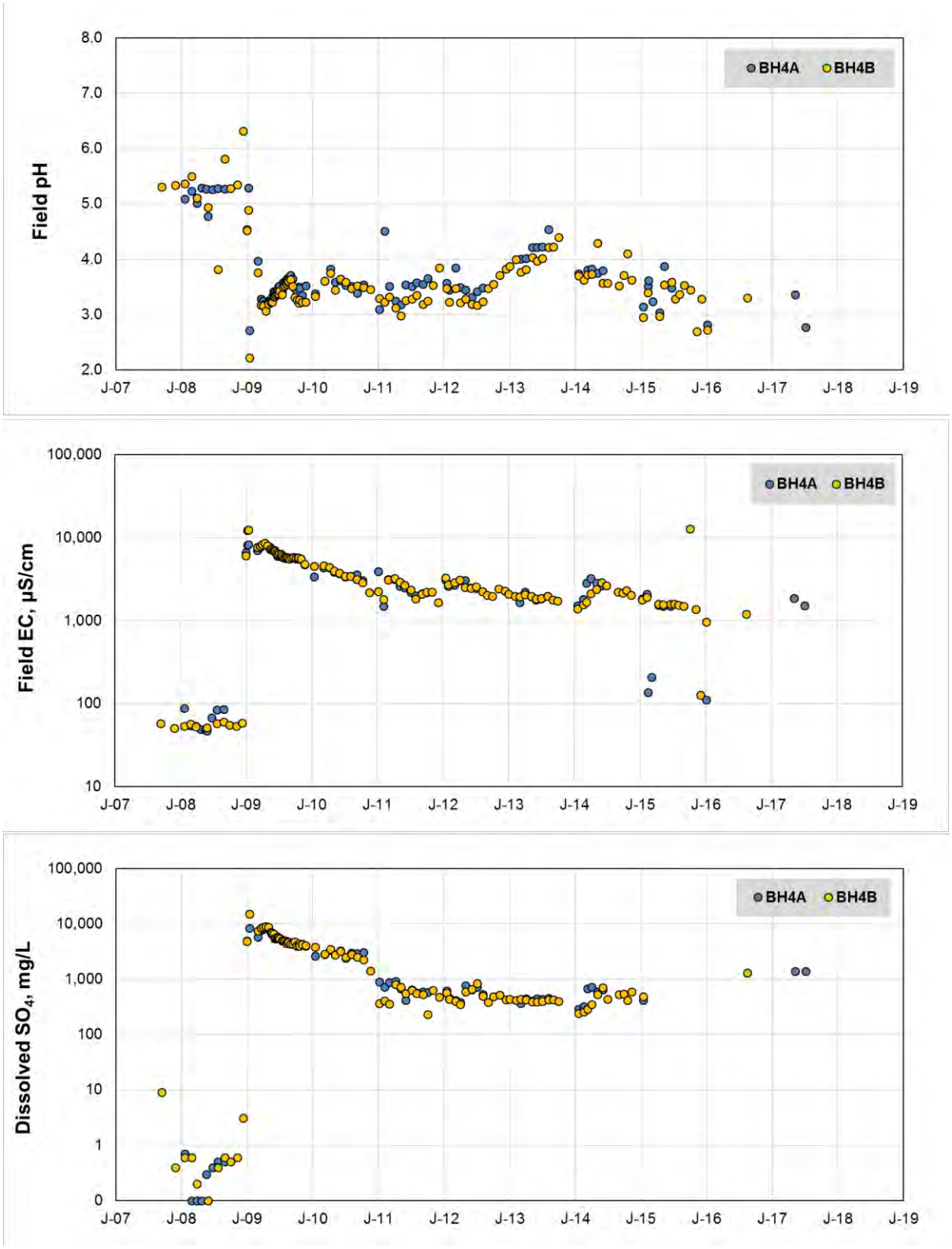


Figure D28. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH4A and BH4B, 2007 to 2018

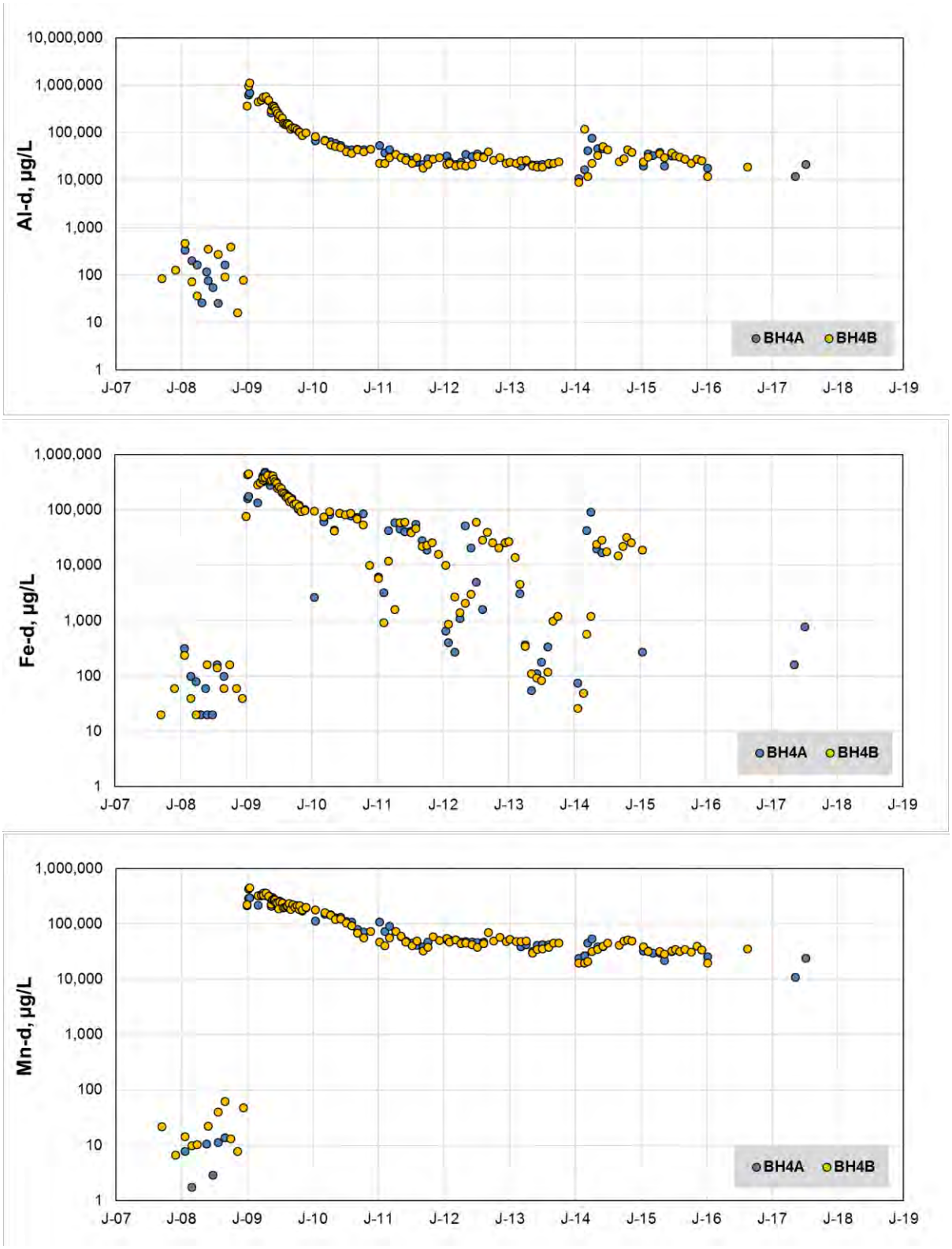


Figure D29. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH4A and BH4B, 2007 to 2018

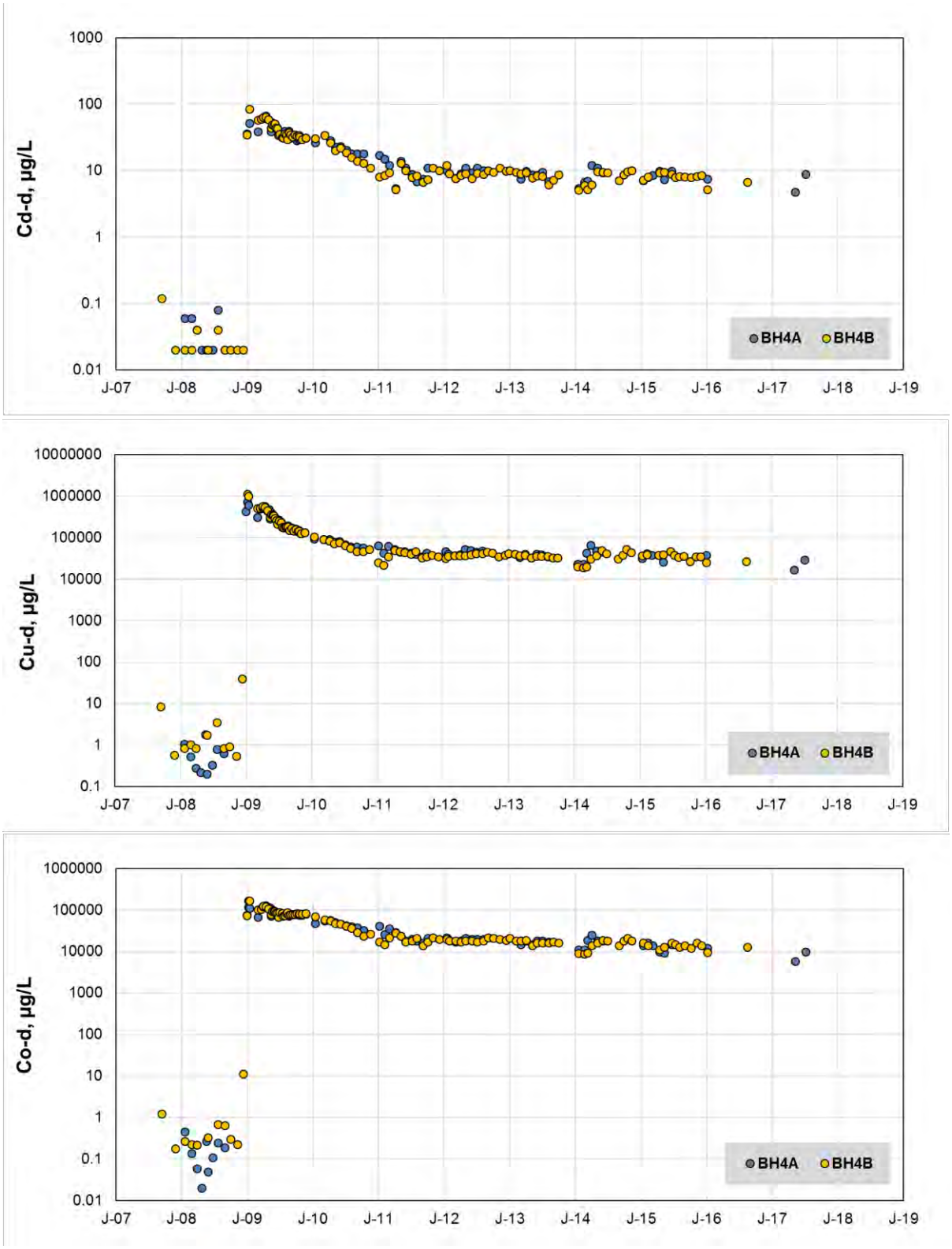
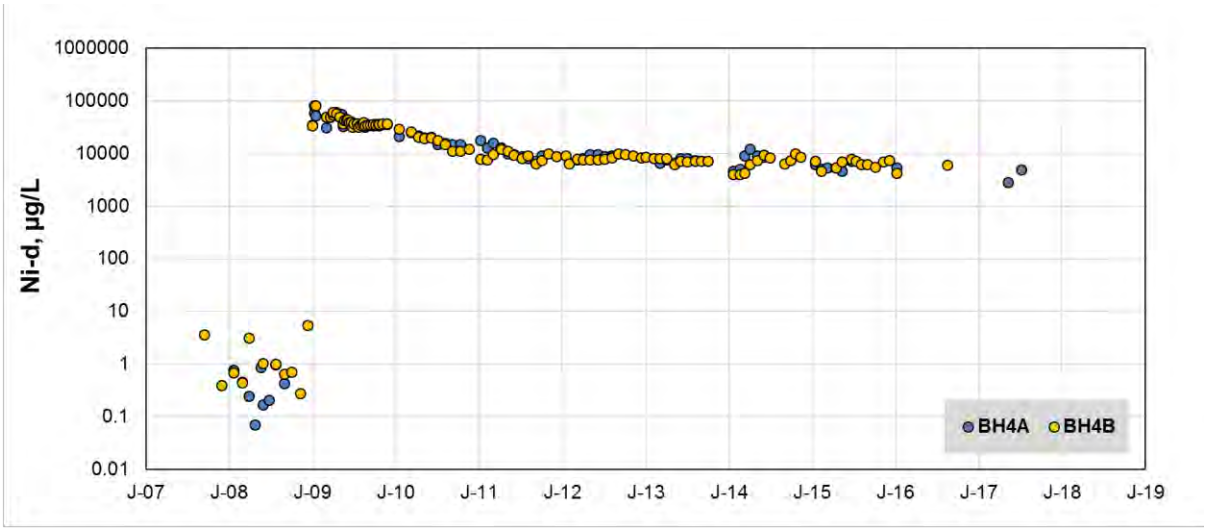
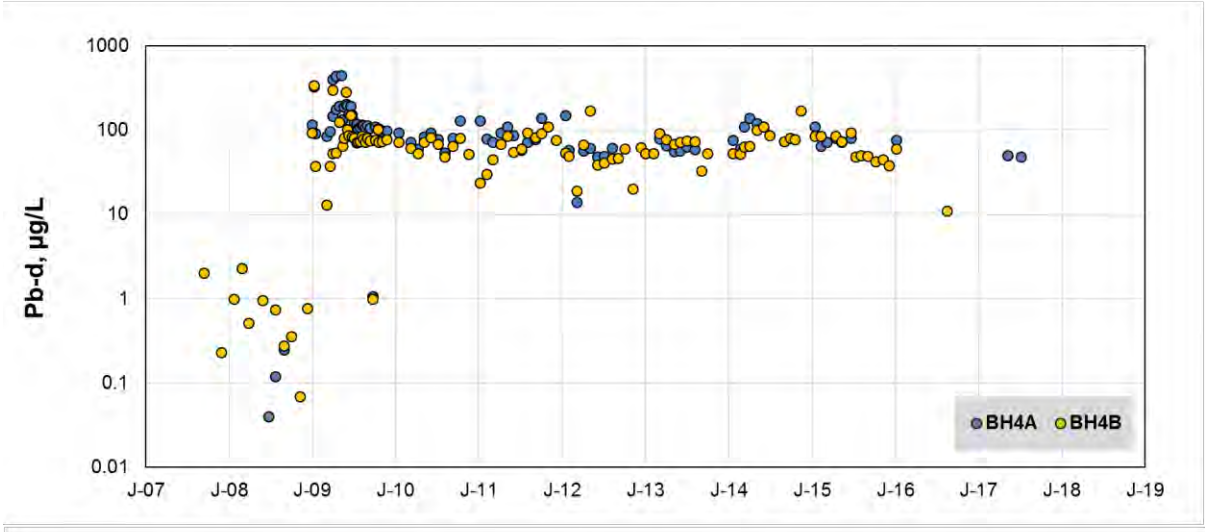


Figure D30. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH4A and BH4B, 2007 to 2018





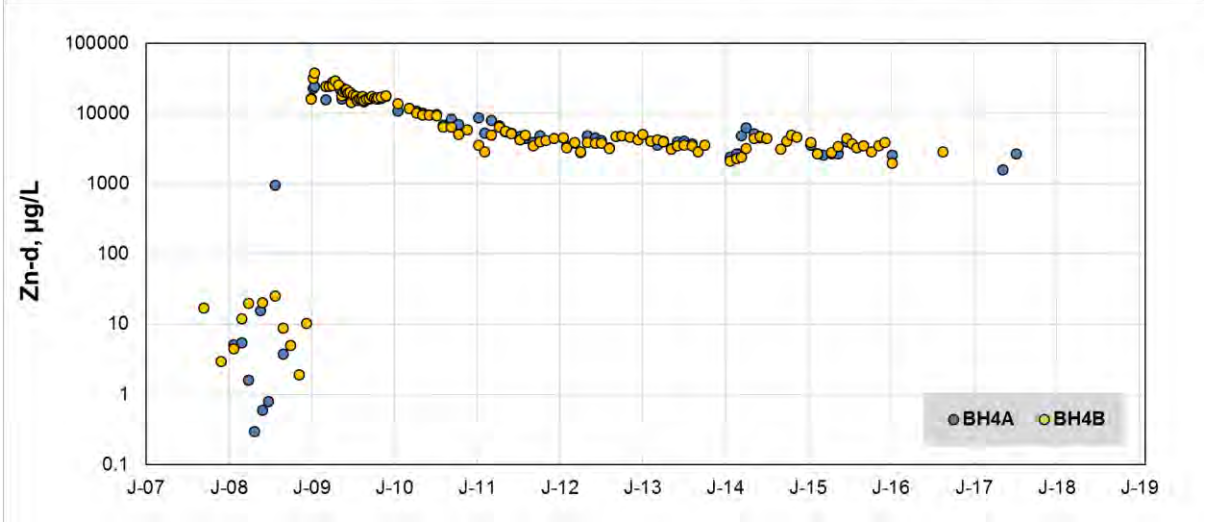


Figure D31. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH4A and BH4B, 2007 to 2018

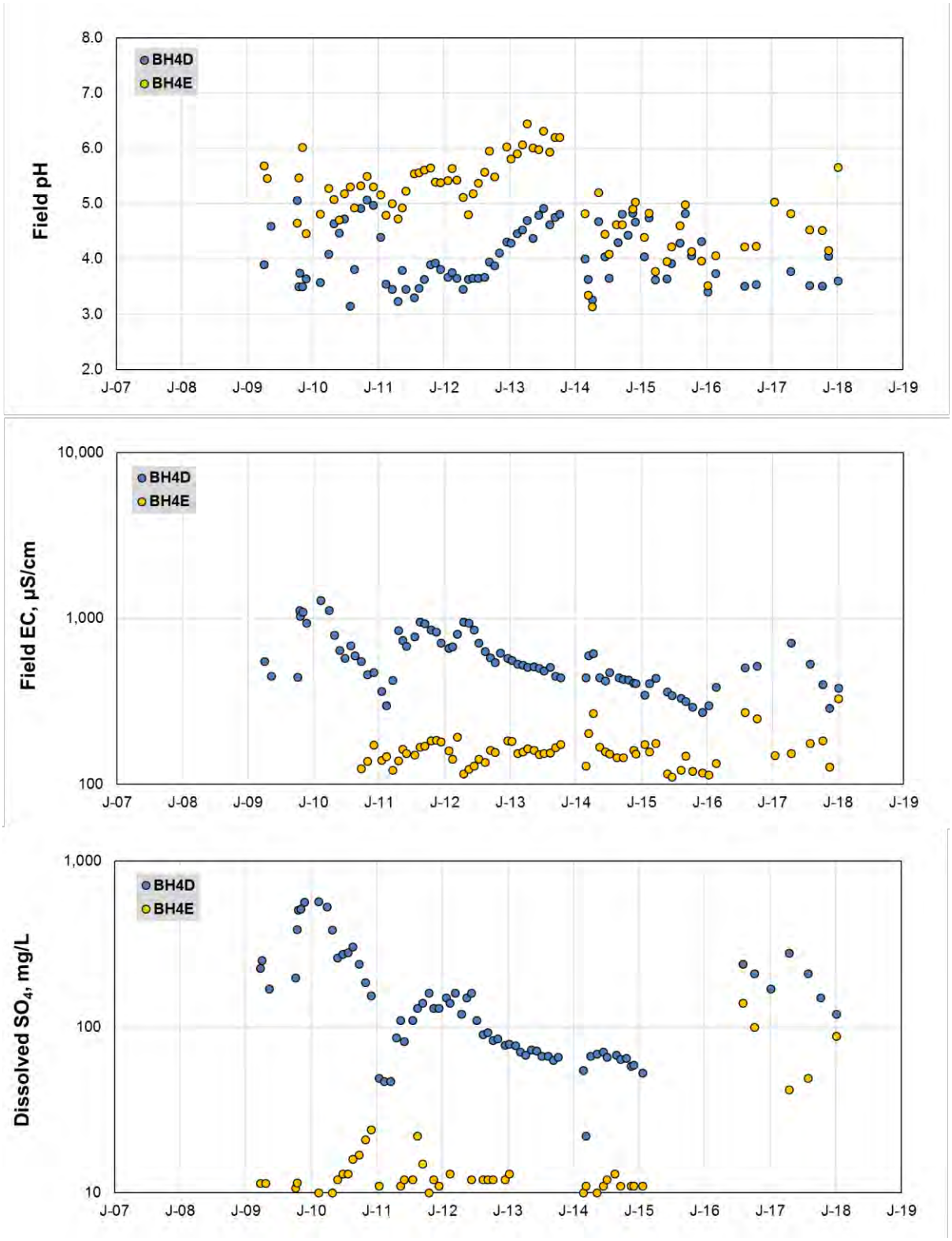


Figure D32. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH4D and BH4E, 2009 to 2018

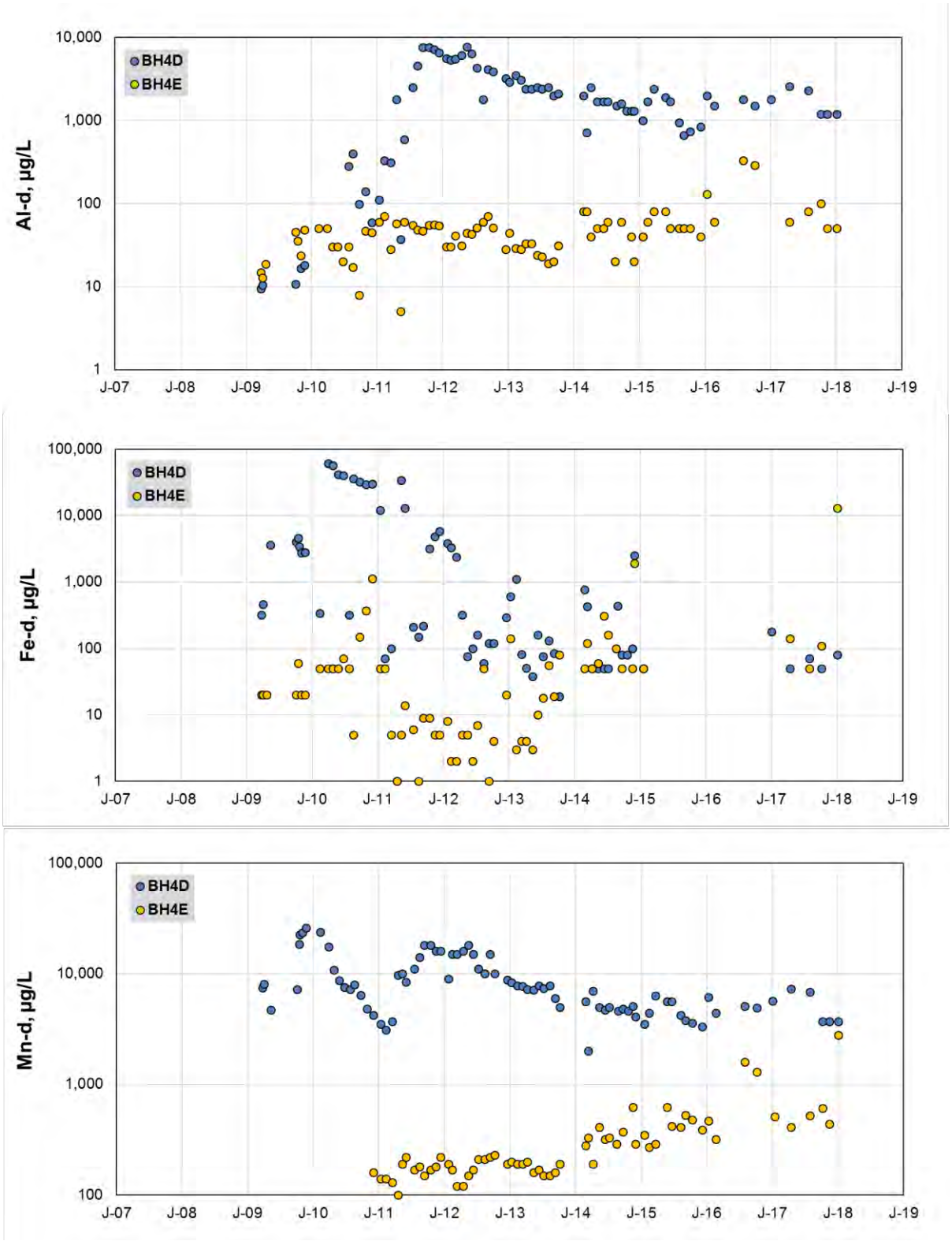


Figure D33. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH4D and BH4E, 2009 to 2018

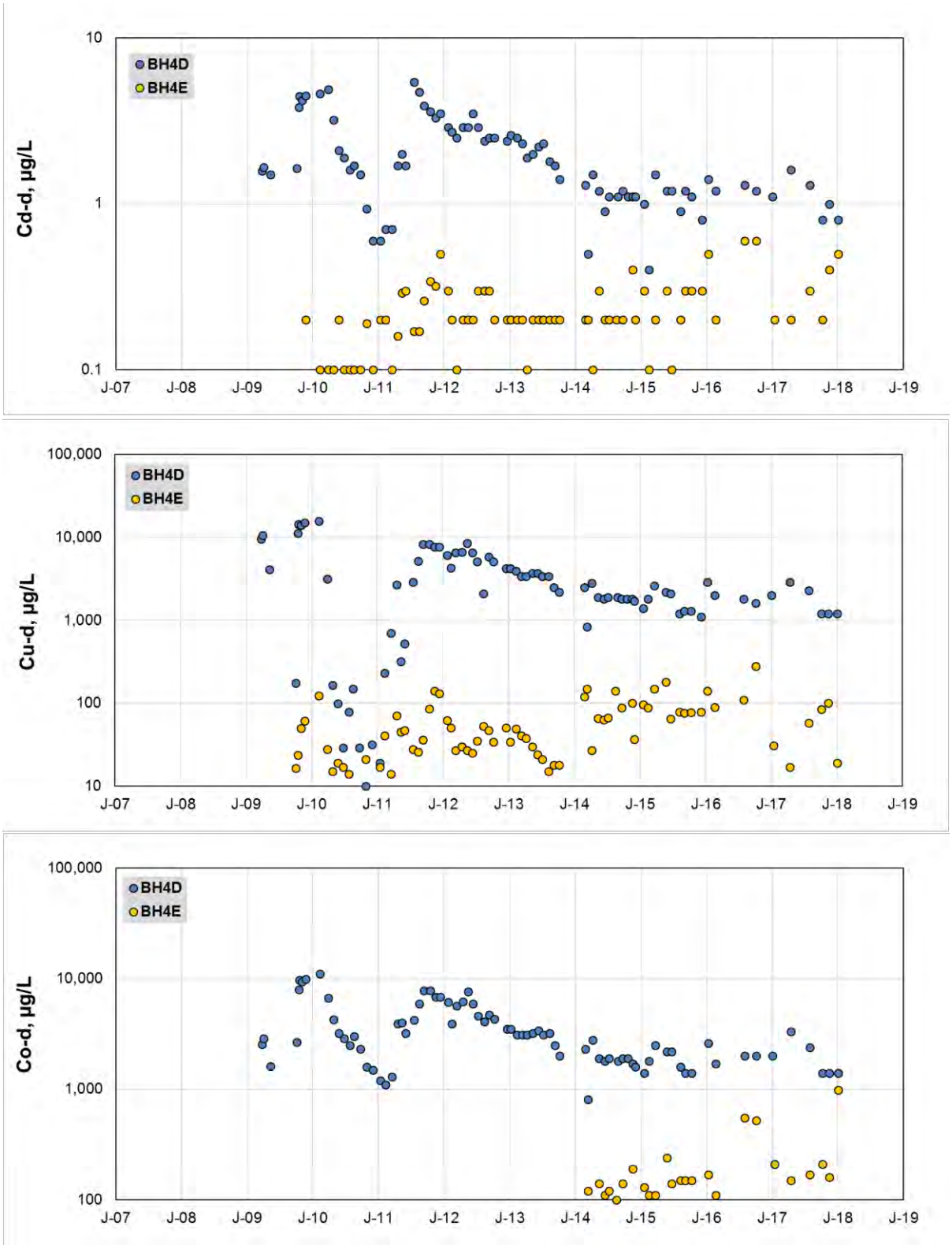


Figure D34. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH4D and BH4E, 2009 to 2018

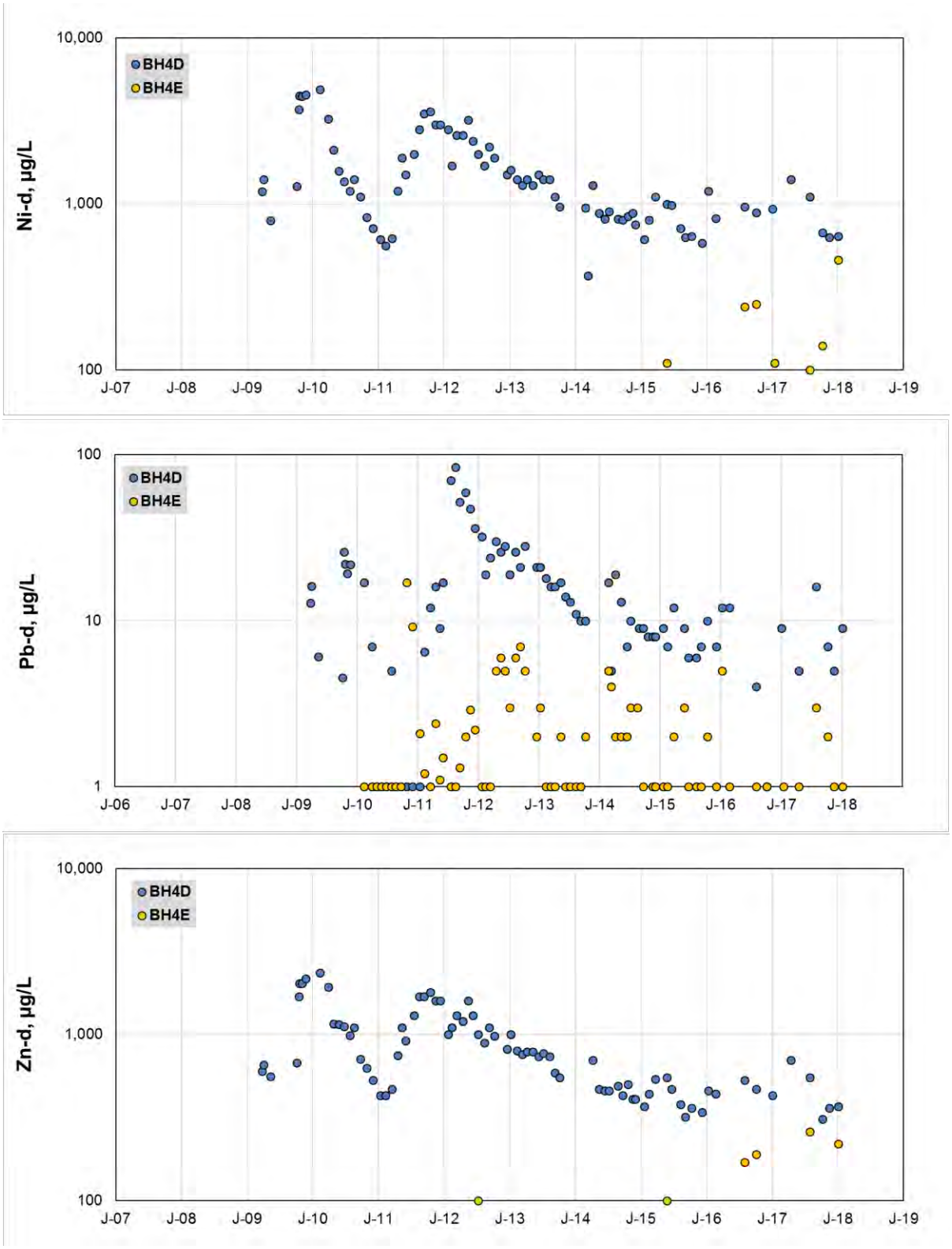


Figure D35. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH4D and BH4E, 2009 to 2018

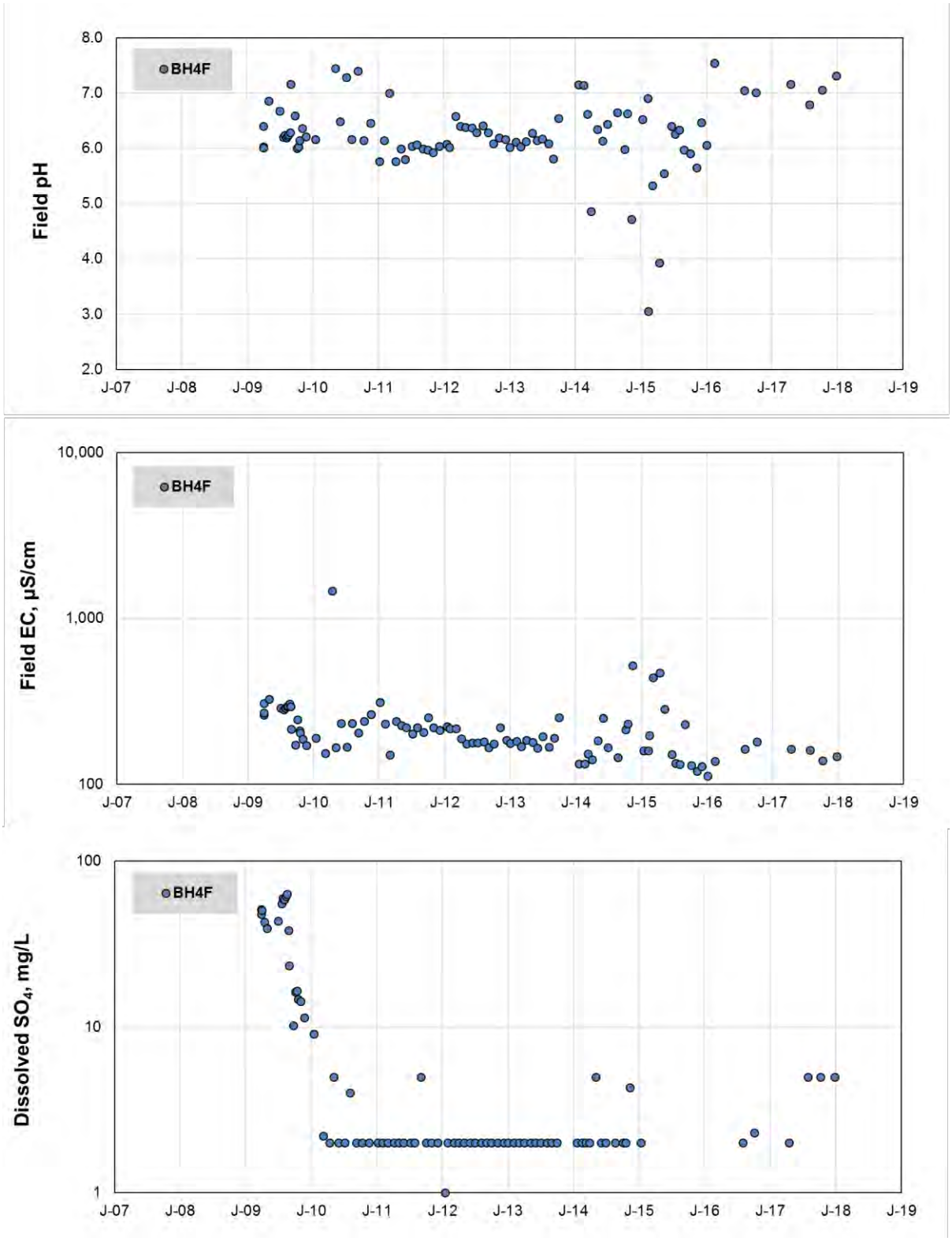


Figure D36. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH4F, 2009 to 2018

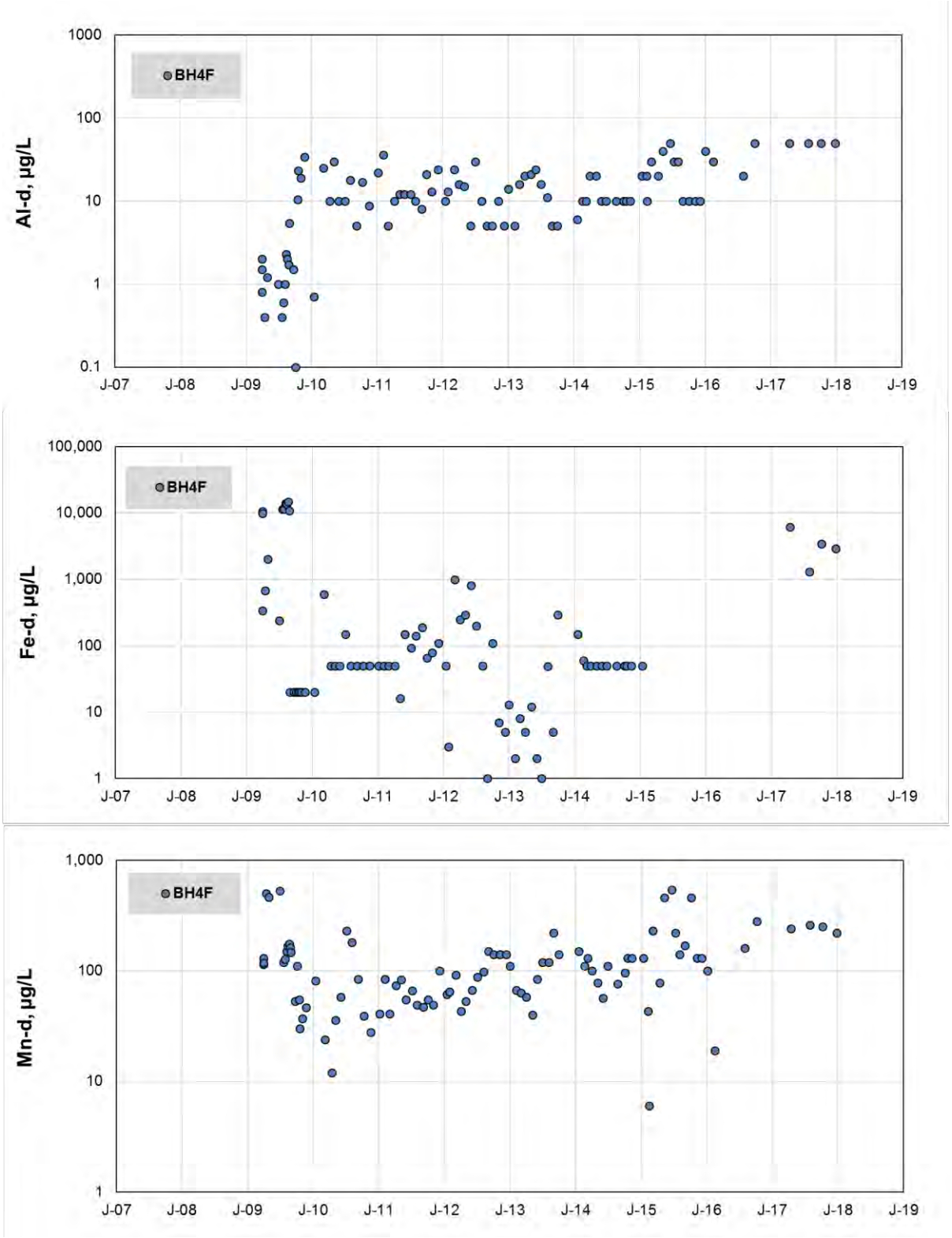
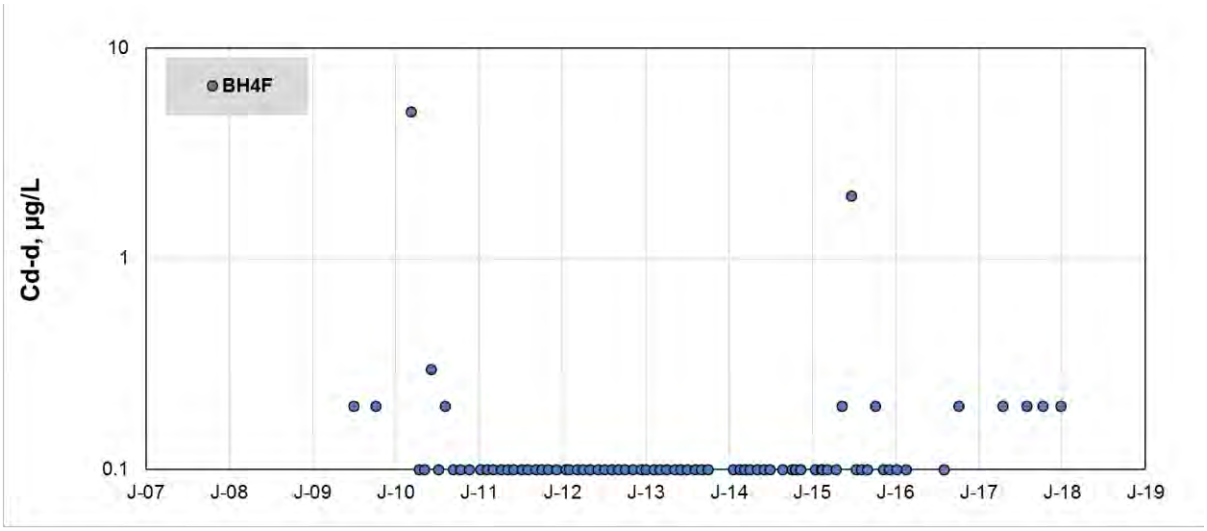
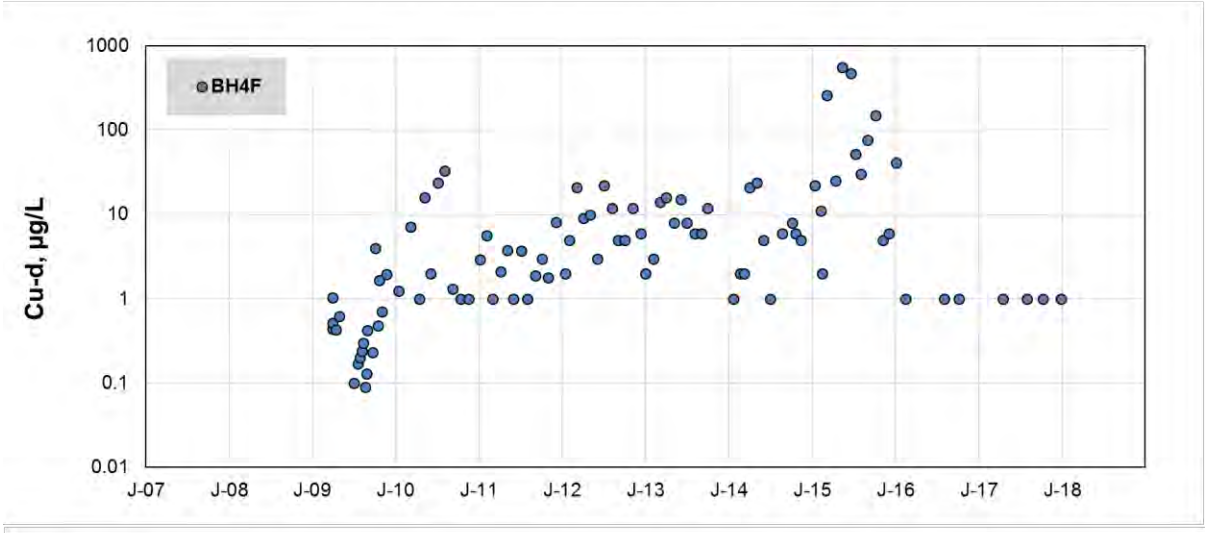


Figure D37. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH4F, 2009 to 2018





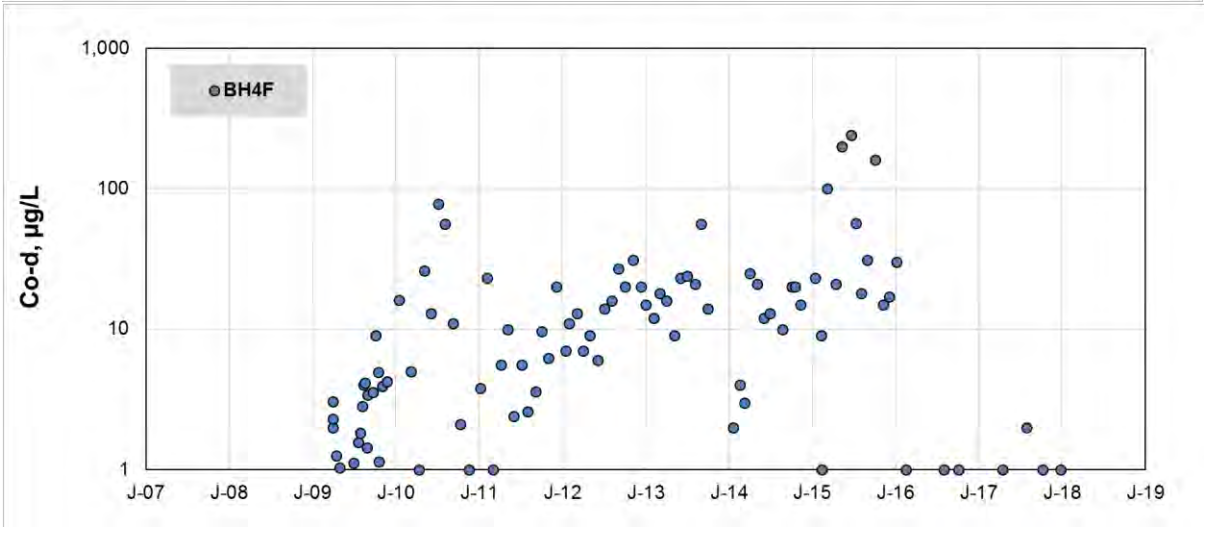


Figure D38. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH4F, 2009 to 2018

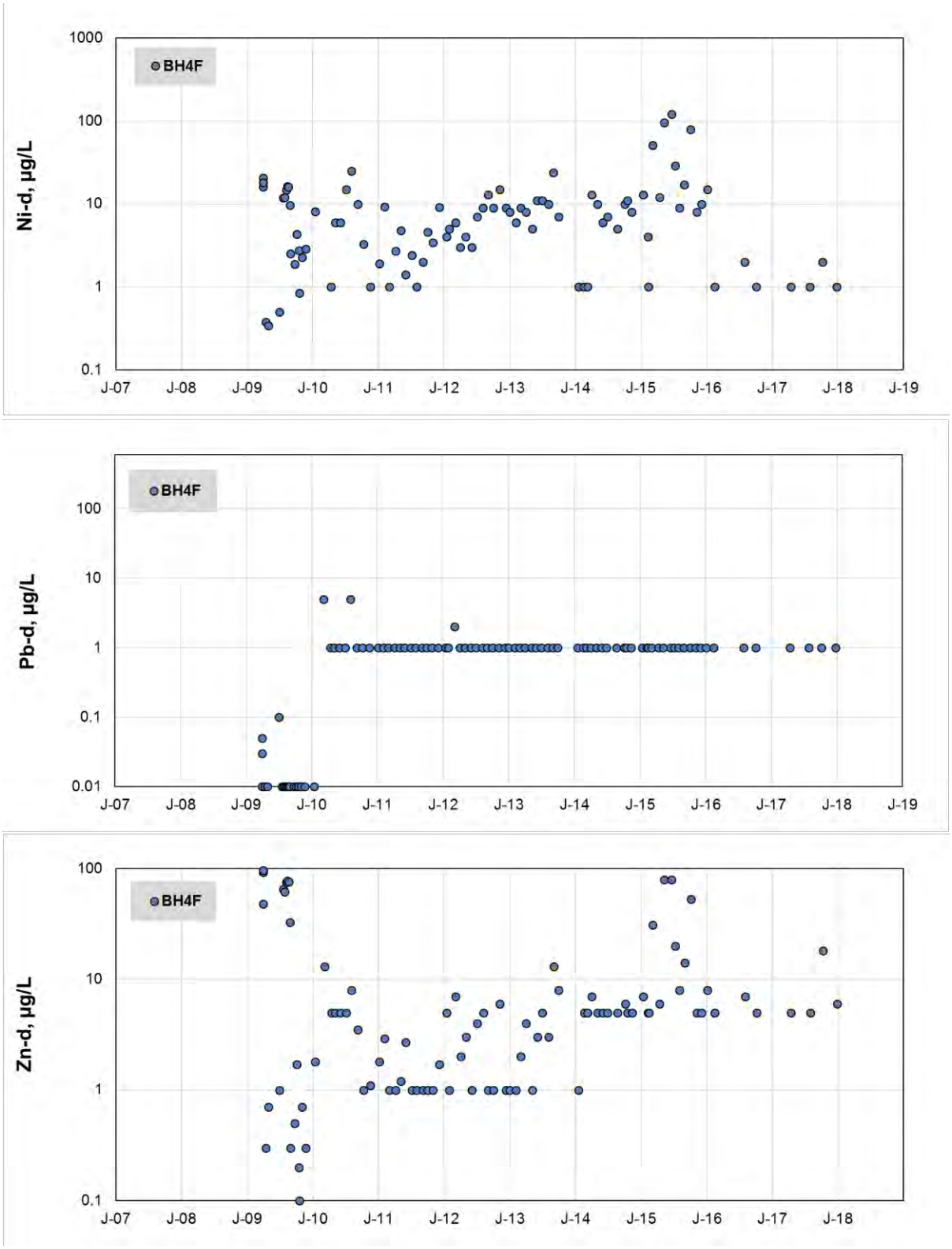


Figure D39. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH4F, 2009 to 2018

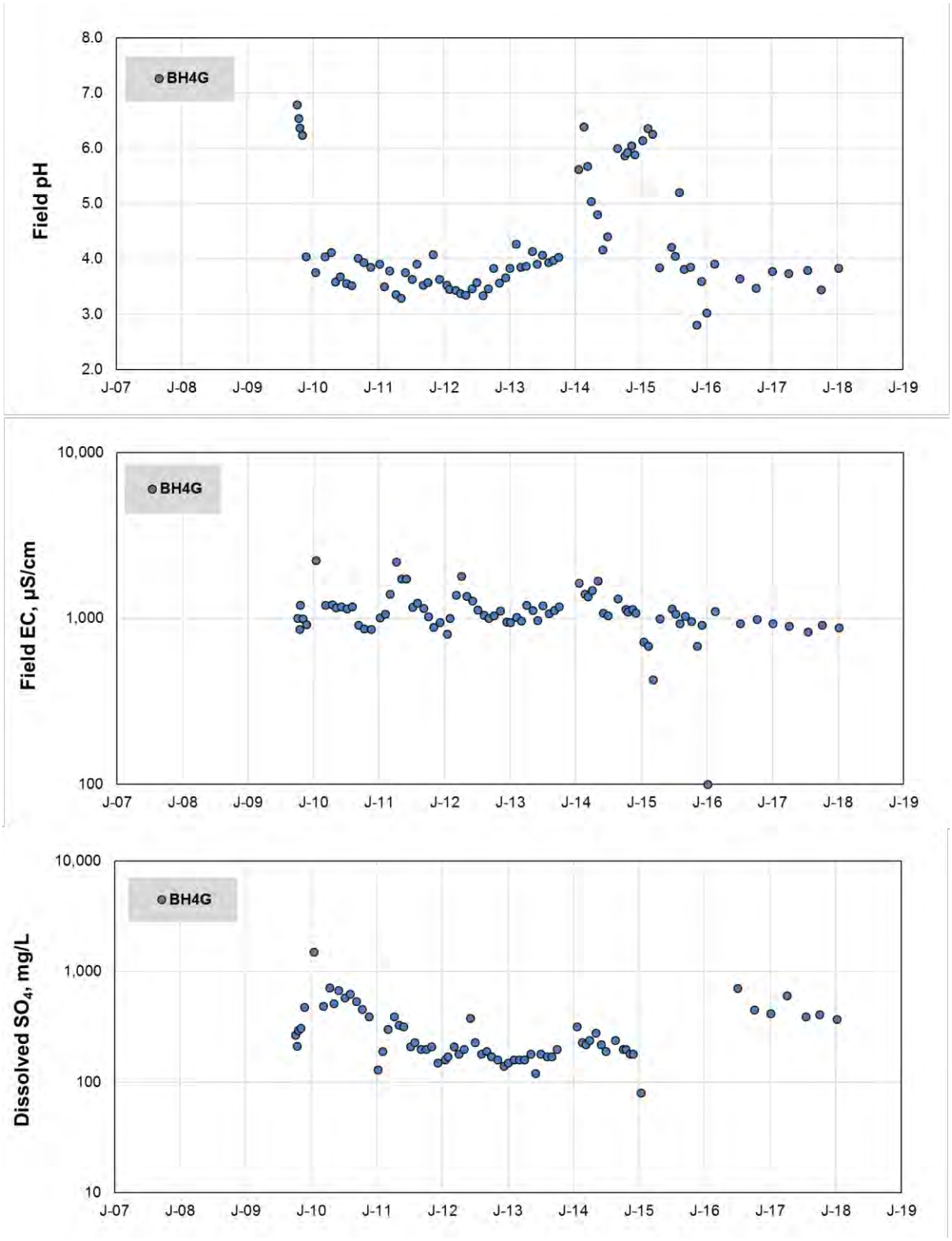


Figure D40. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH4G, 2009 to 2018

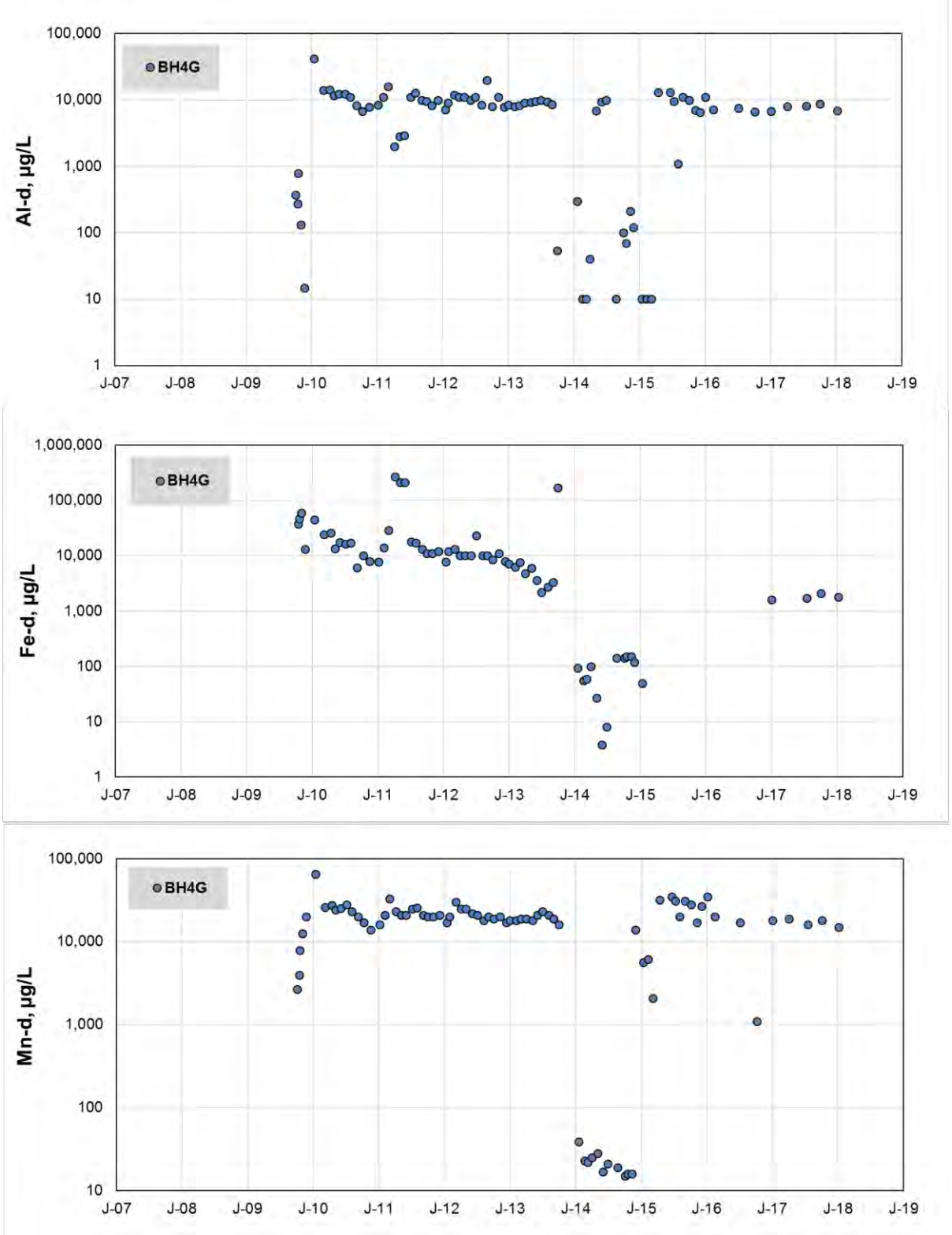


Figure D41. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH4G, 2009 to 2018

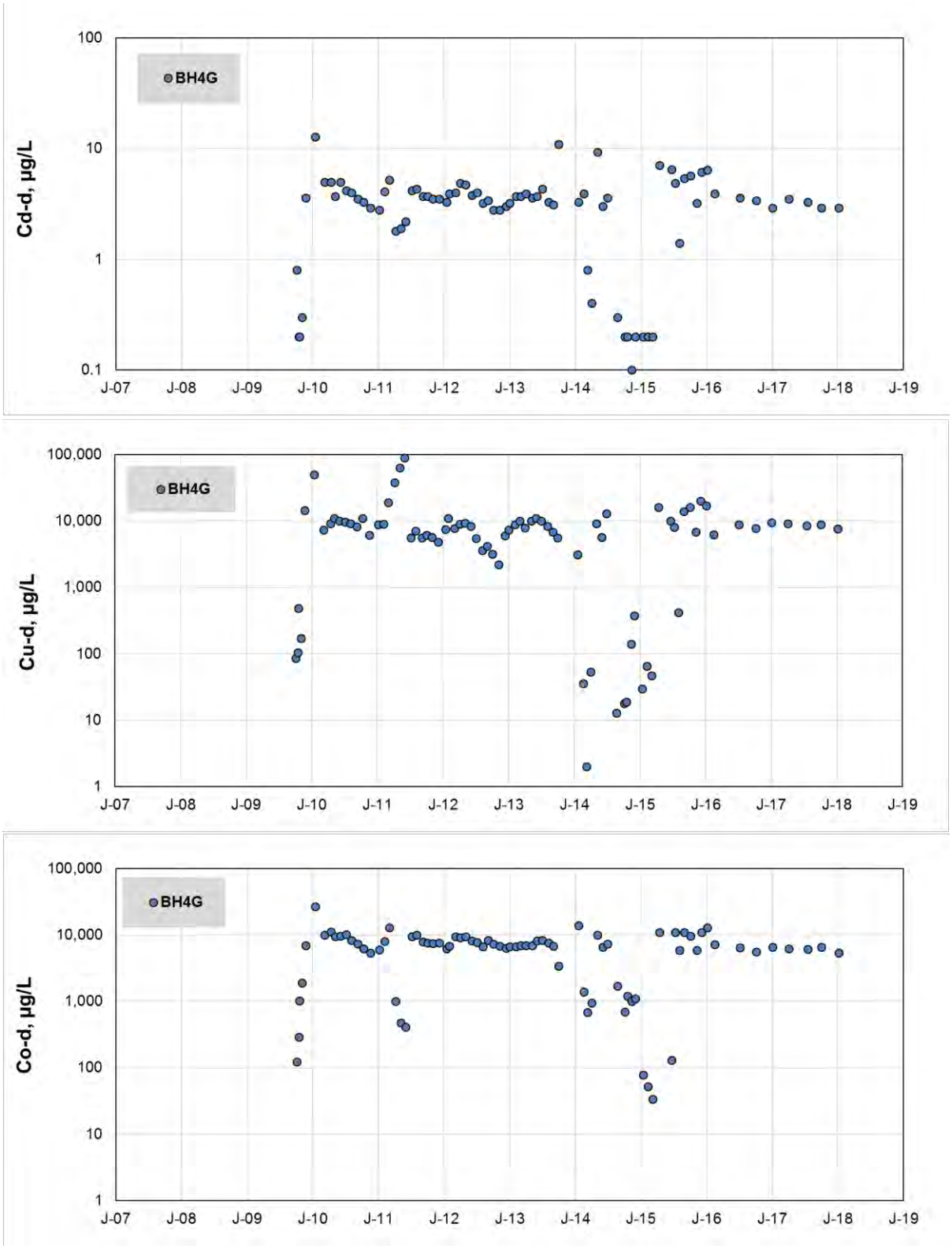


Figure D42. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH4G, 2009 to 2018

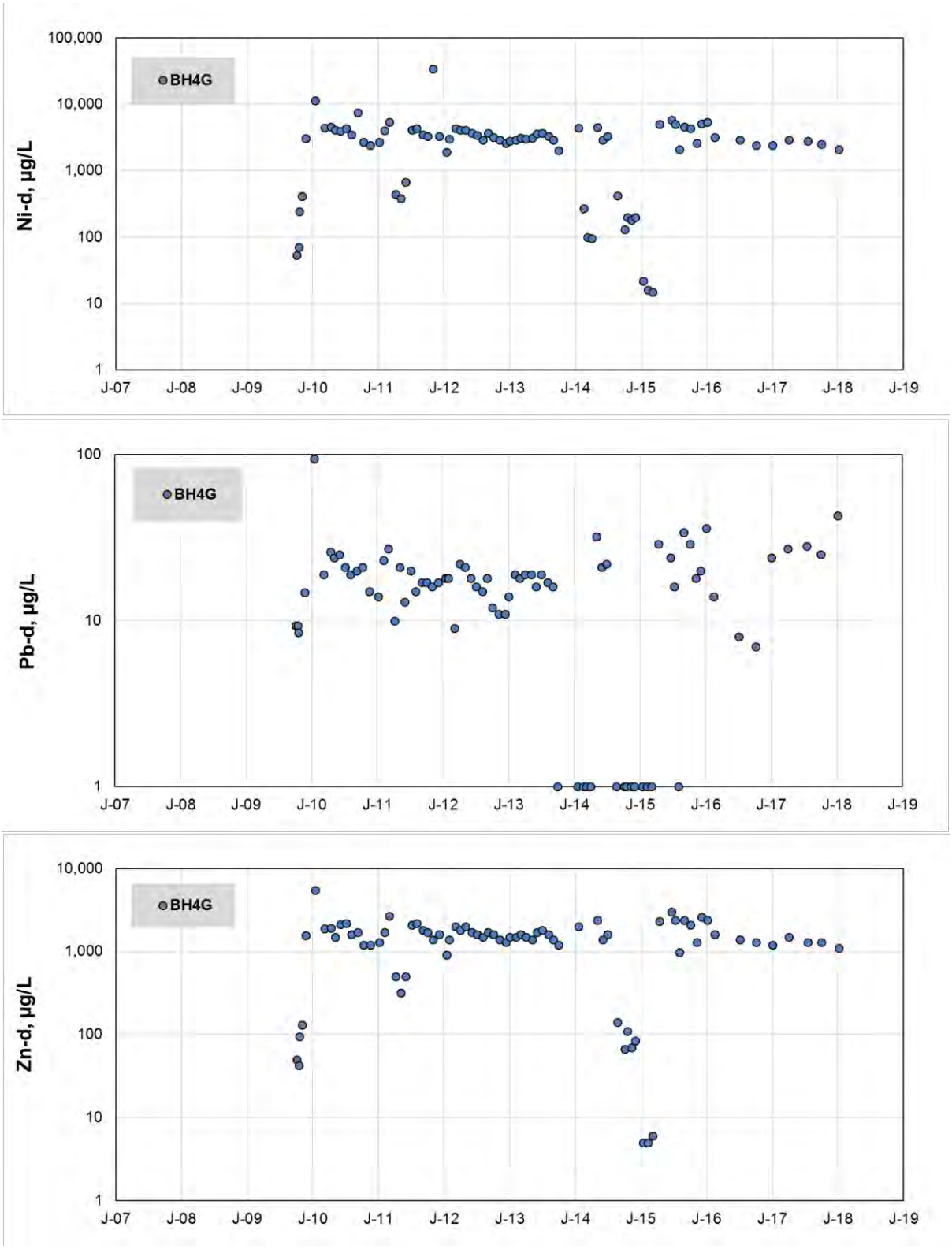


Figure D43. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH4G, 2009 to 2018

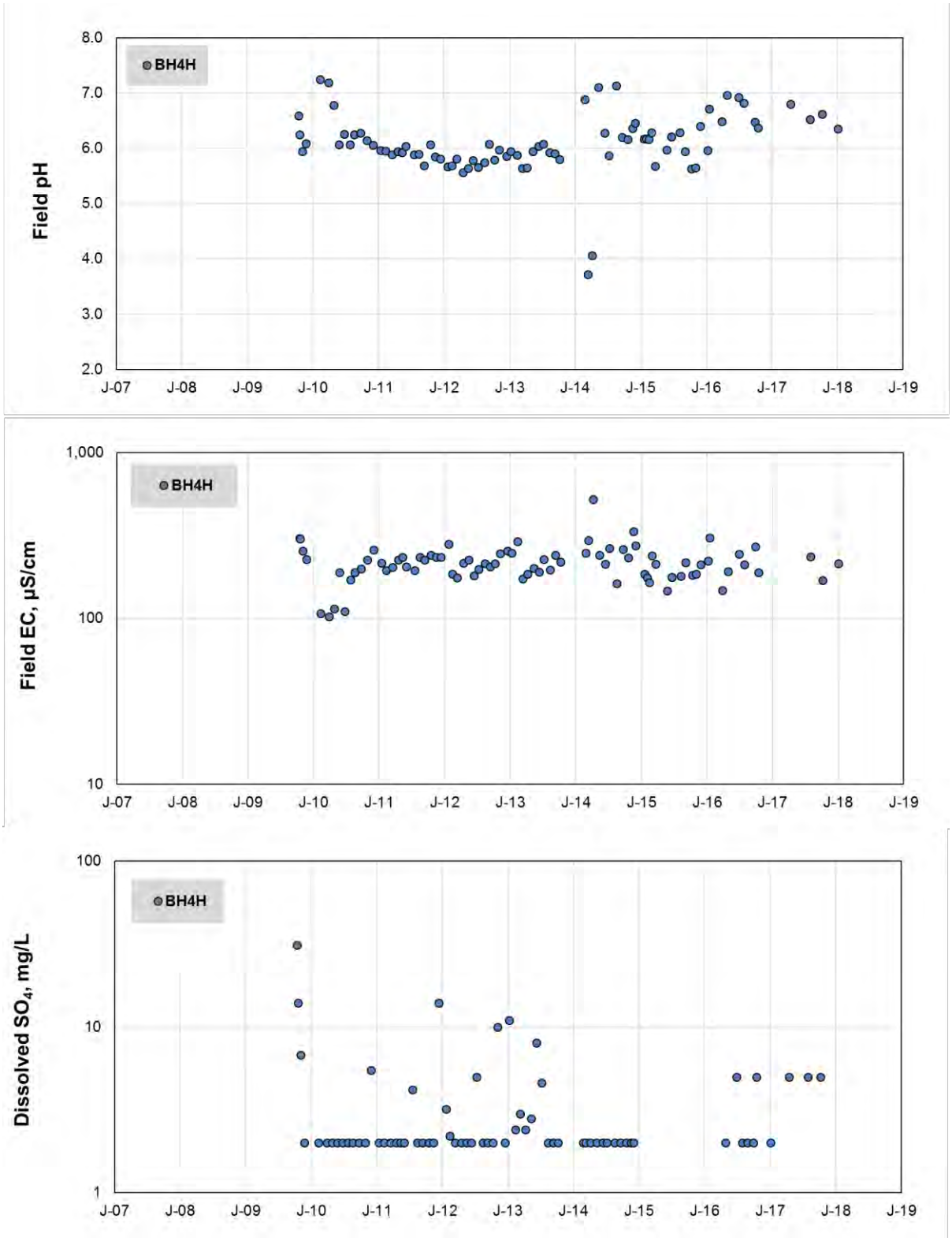


Figure D44. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH4H, 2009 to 2018

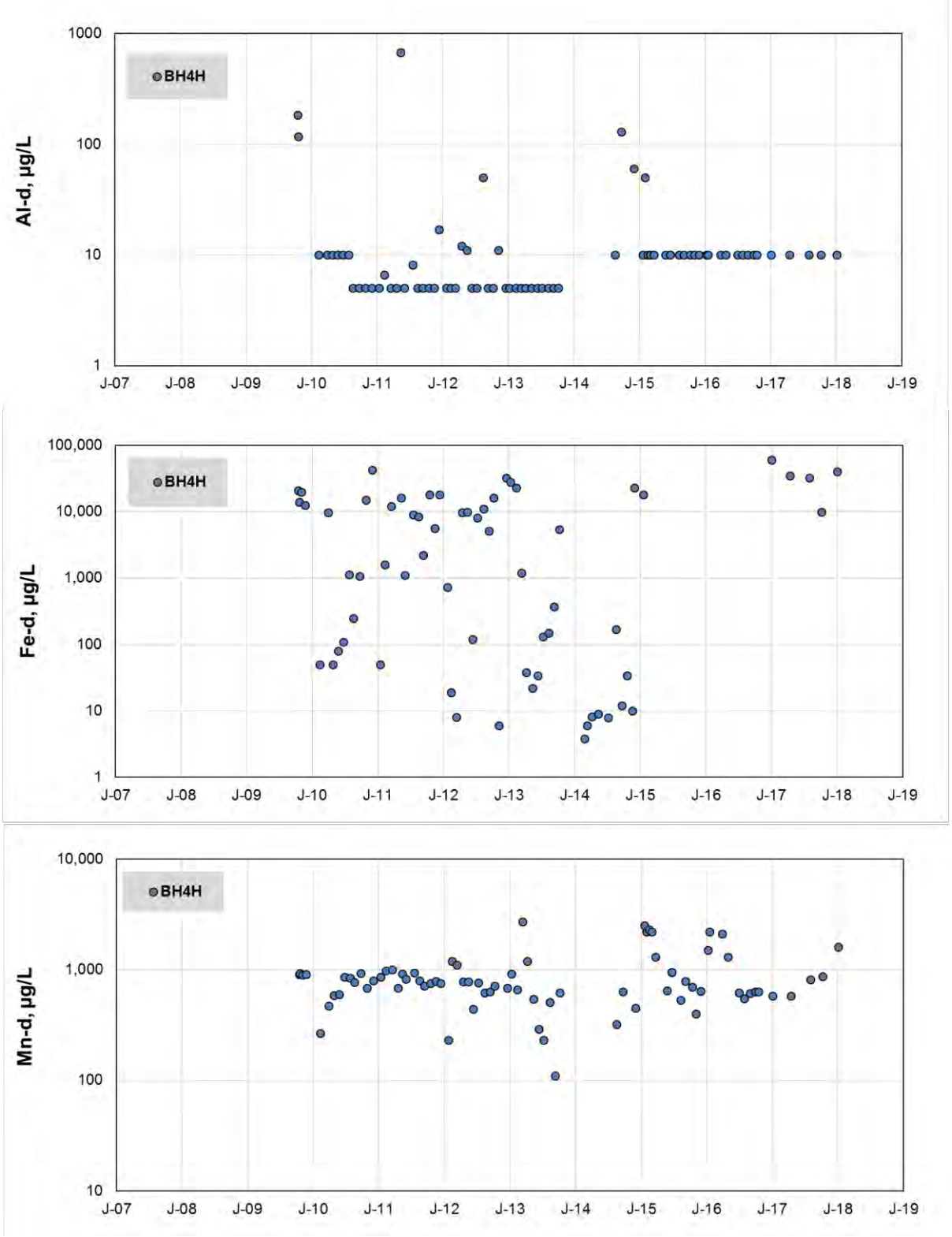
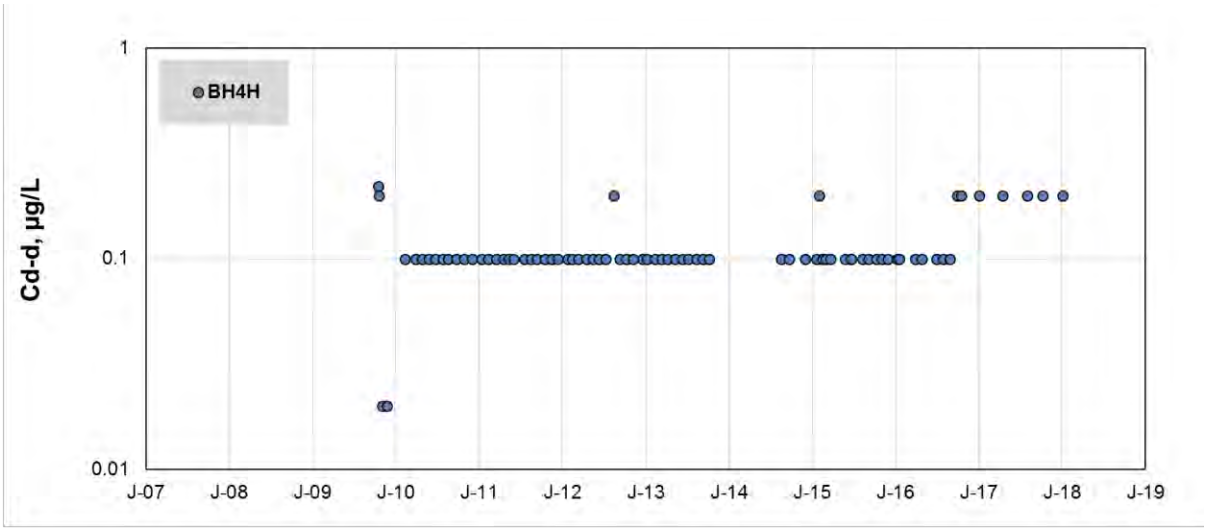
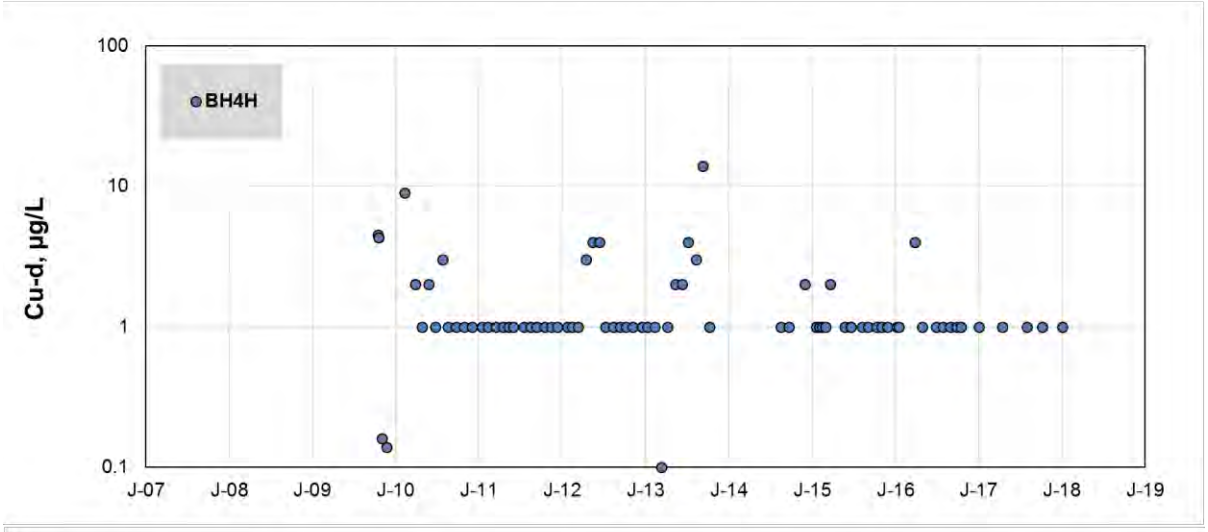


Figure D45. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH4H, 2009 to 2018





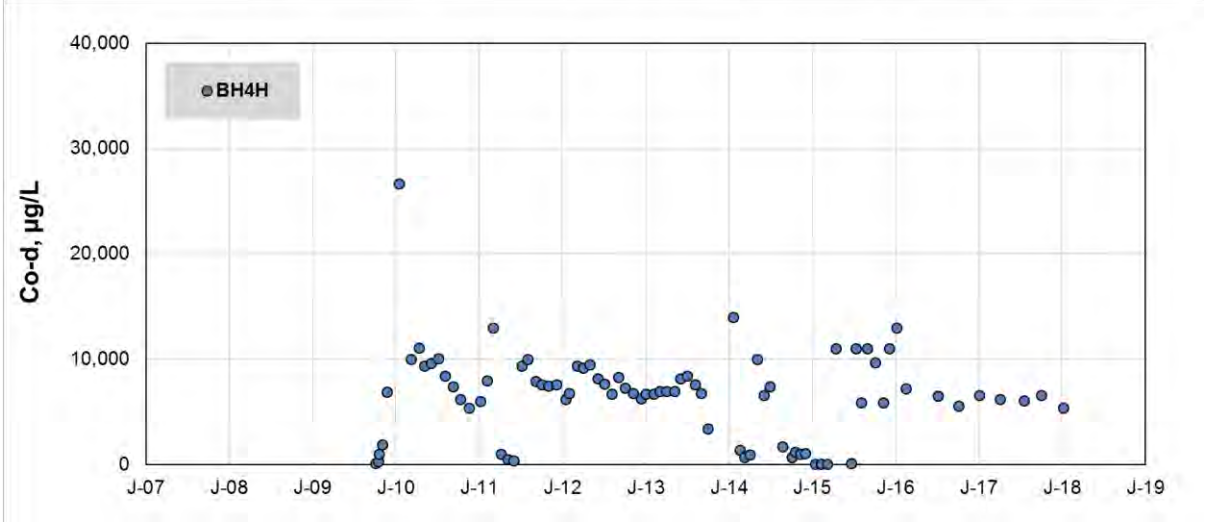


Figure D46. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH4H, 2009 to 2018

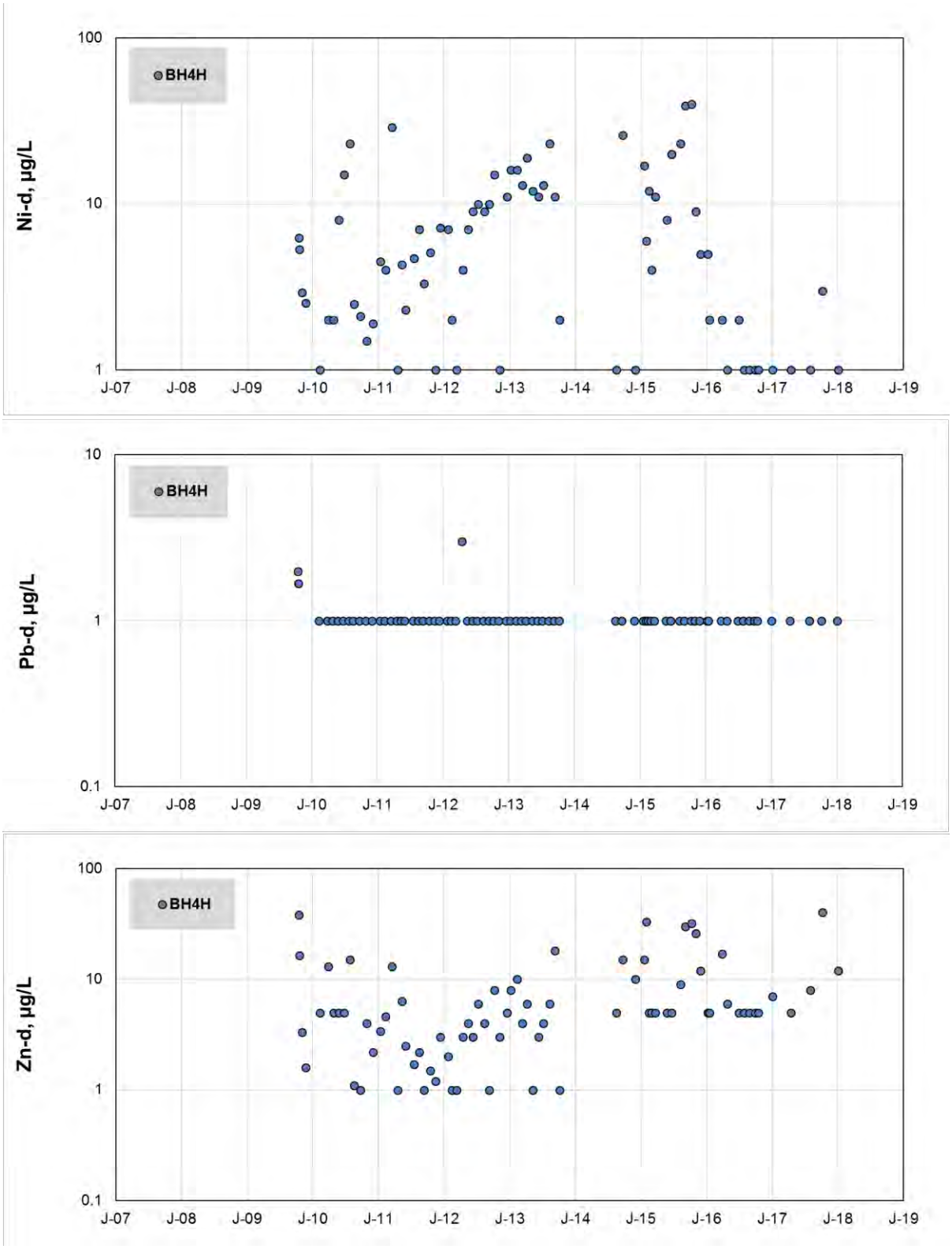


Figure D47. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH4H, 2009 to 2018

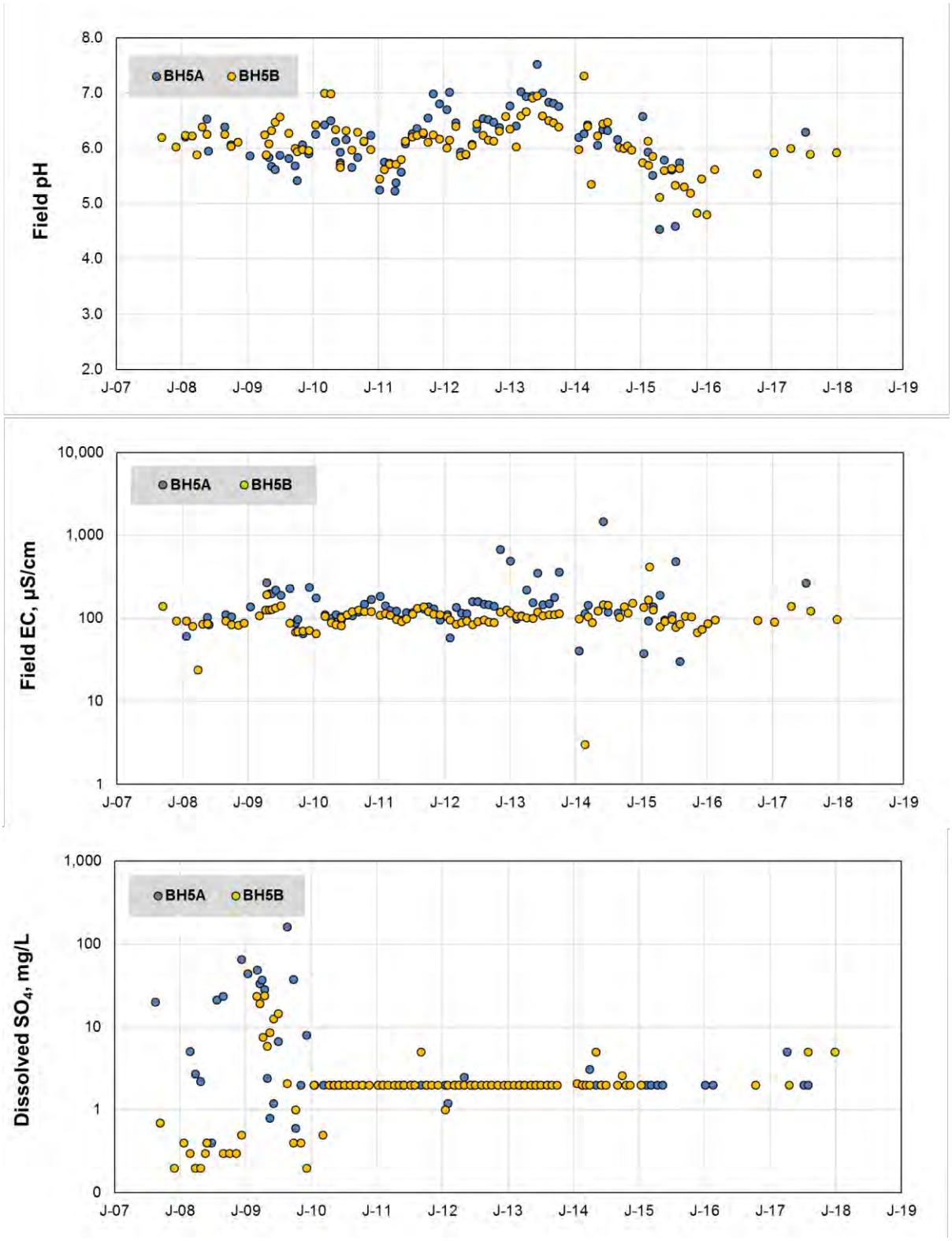


Figure D48. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH5A and BH5B, 2007 to 2018

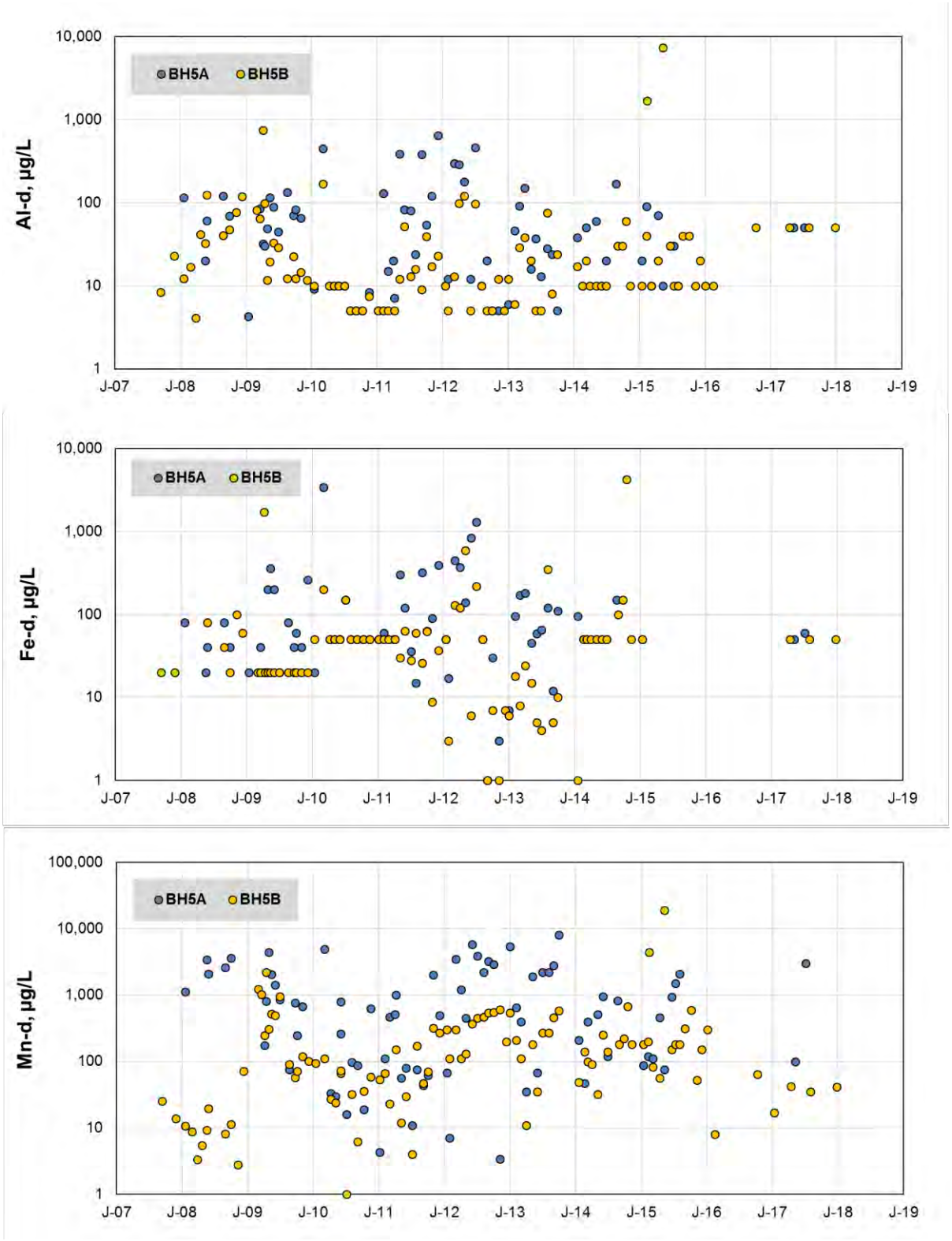


Figure D49. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH5A and BH5B, 2007 to 2018

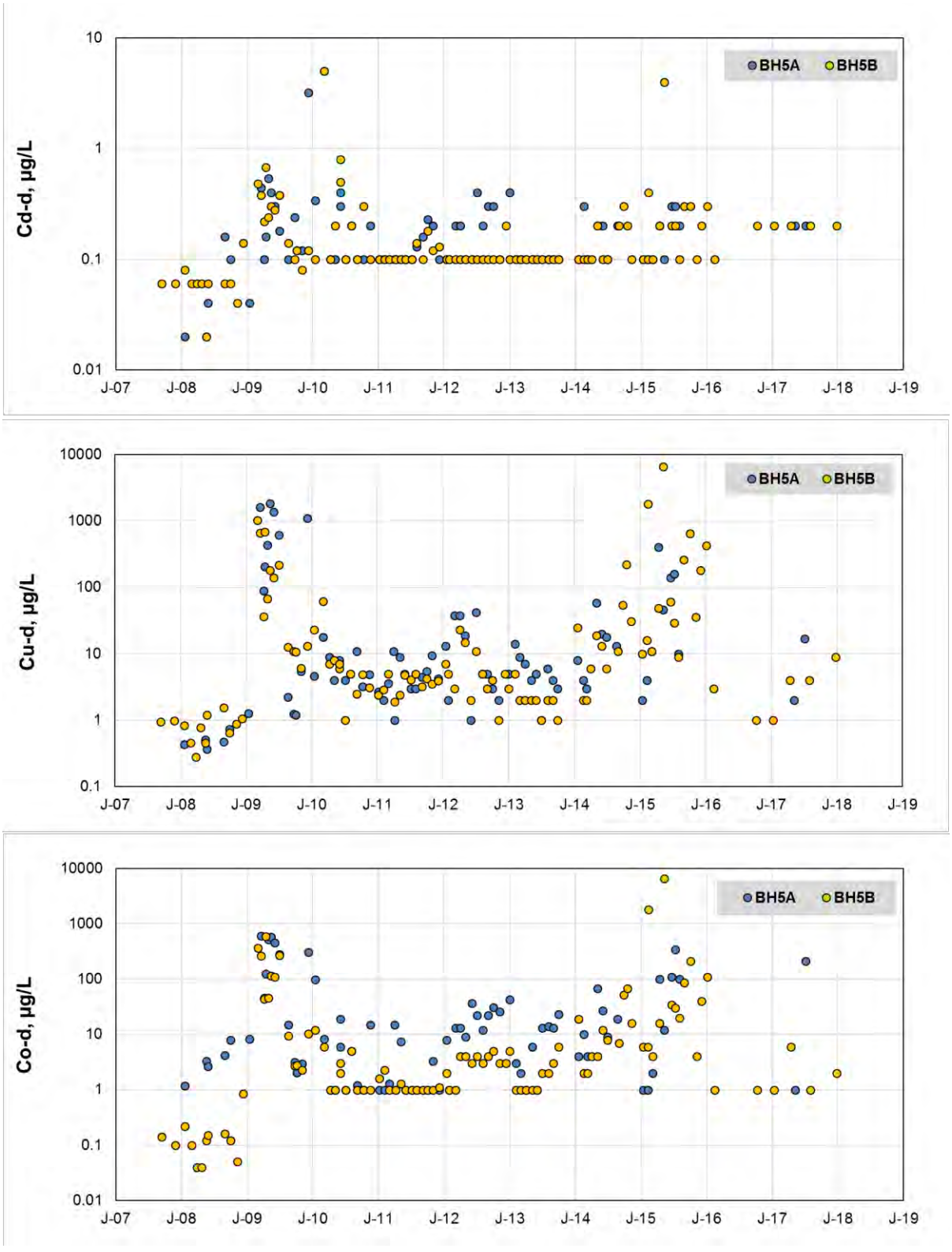


Figure D50. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH5A and BH5B, 2007 to 2018

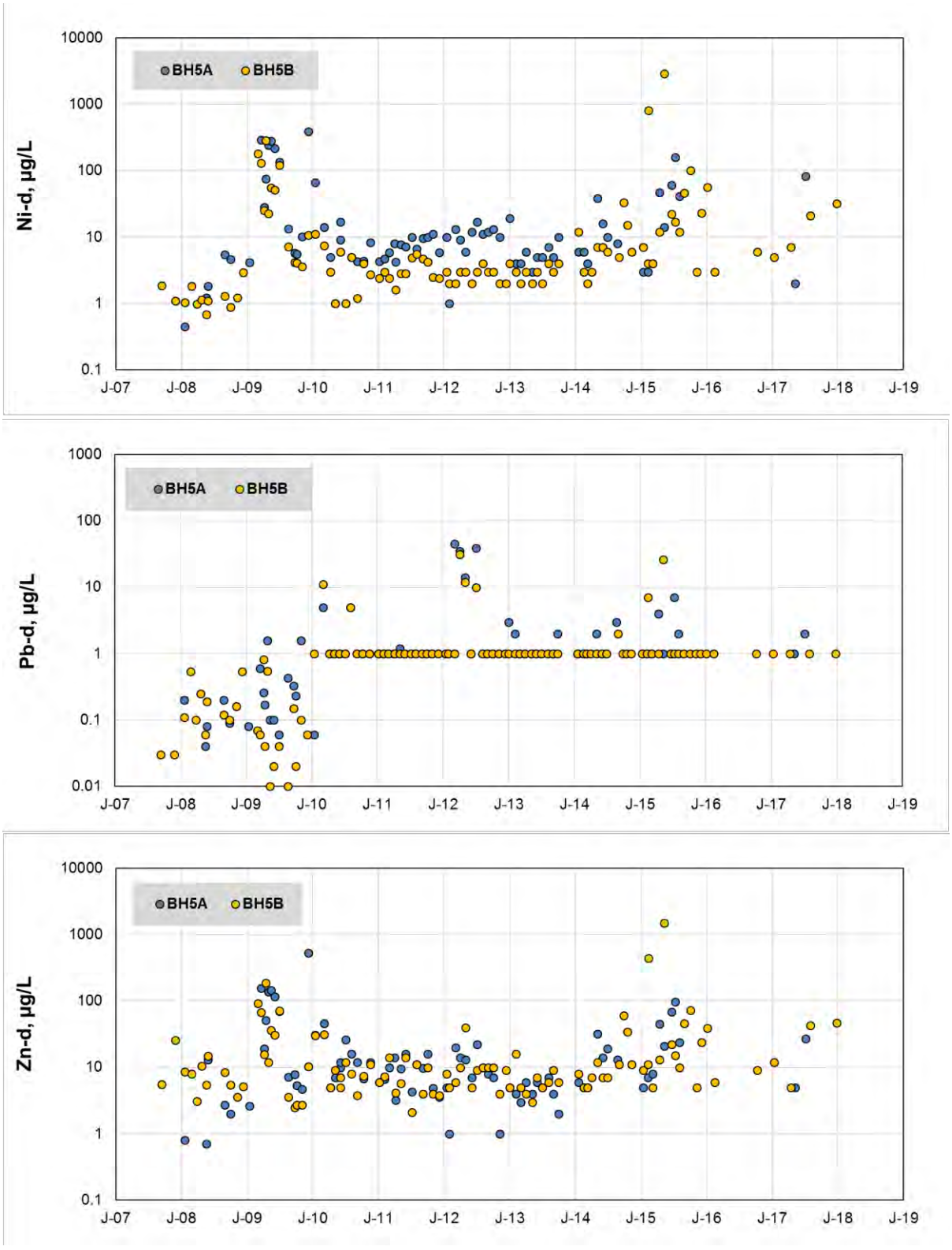


Figure D51. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH5A and BH5B, 2007 to 2018

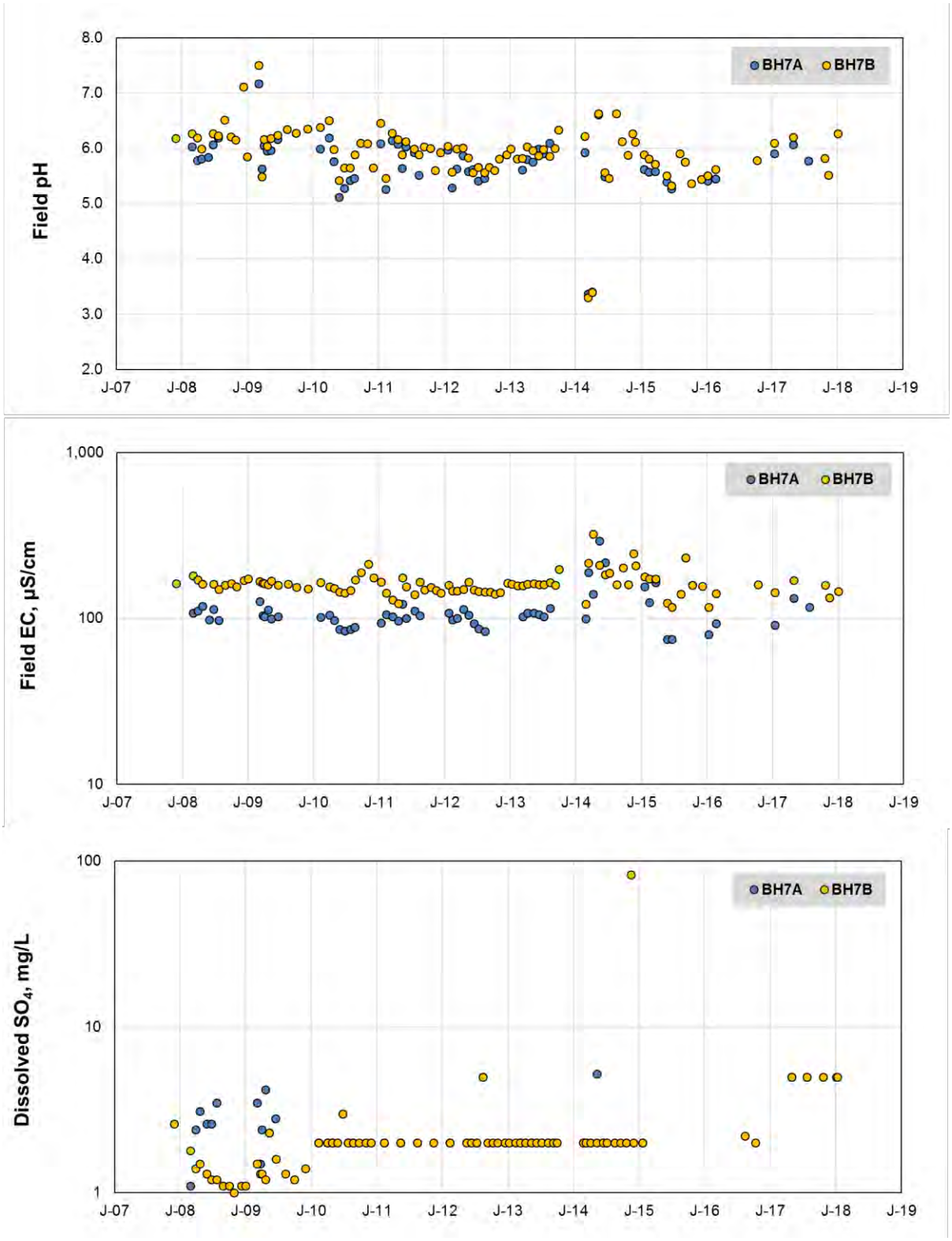


Figure D52. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH7A and BH7B, 2007 to 2018

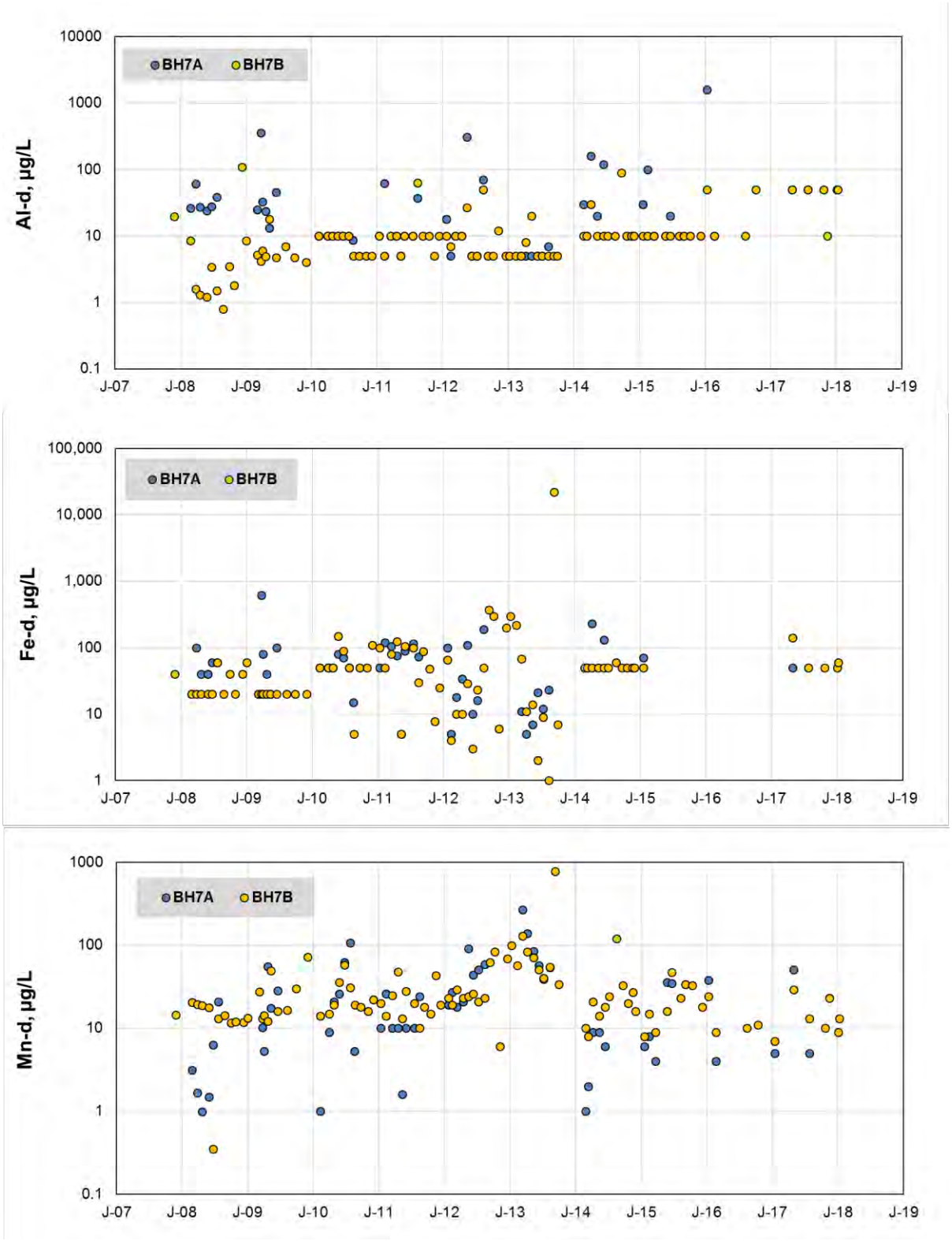


Figure D53. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH7A and BH7B, 2007 to 2018

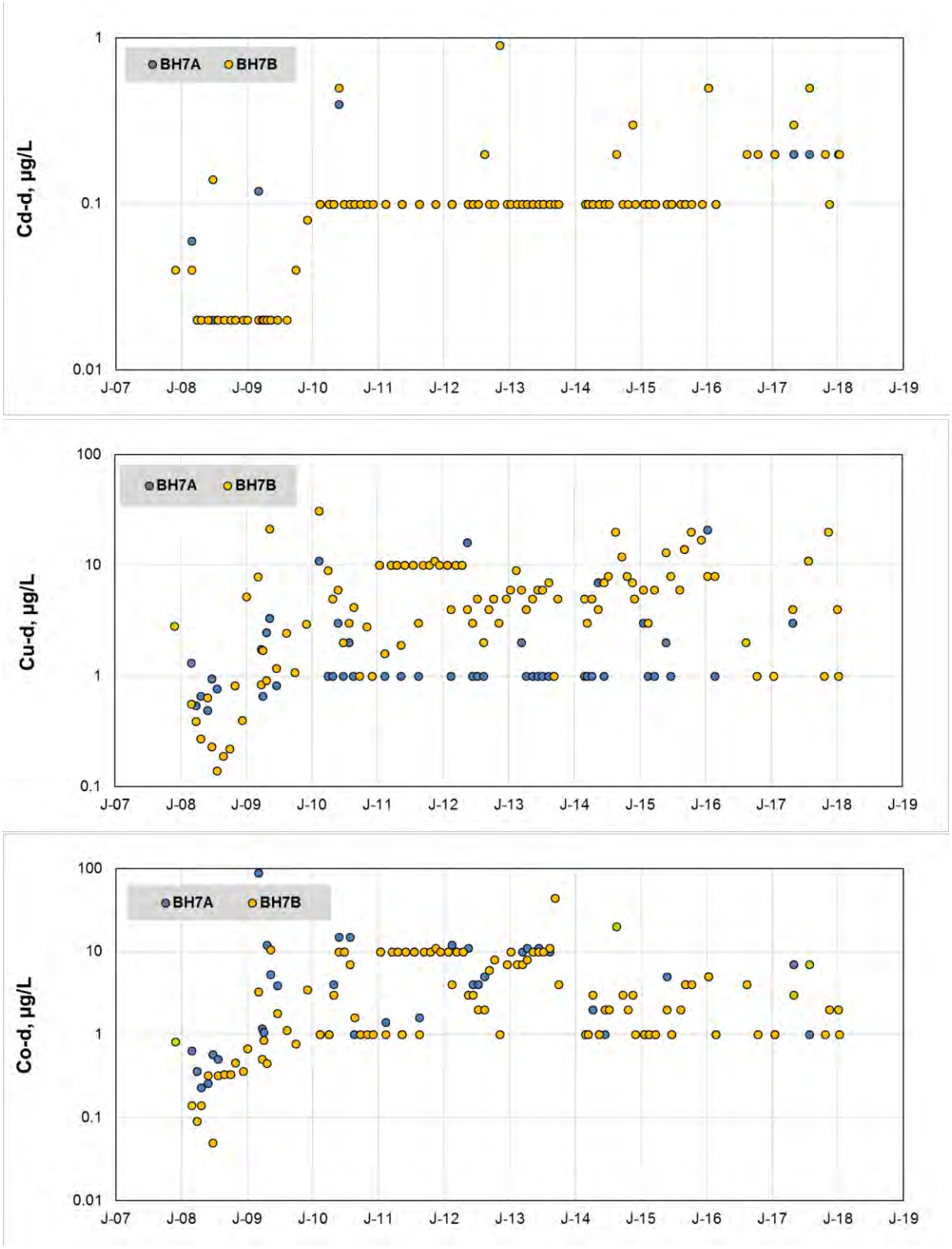


Figure D54. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH7A and BH7B, 2007 to 2018

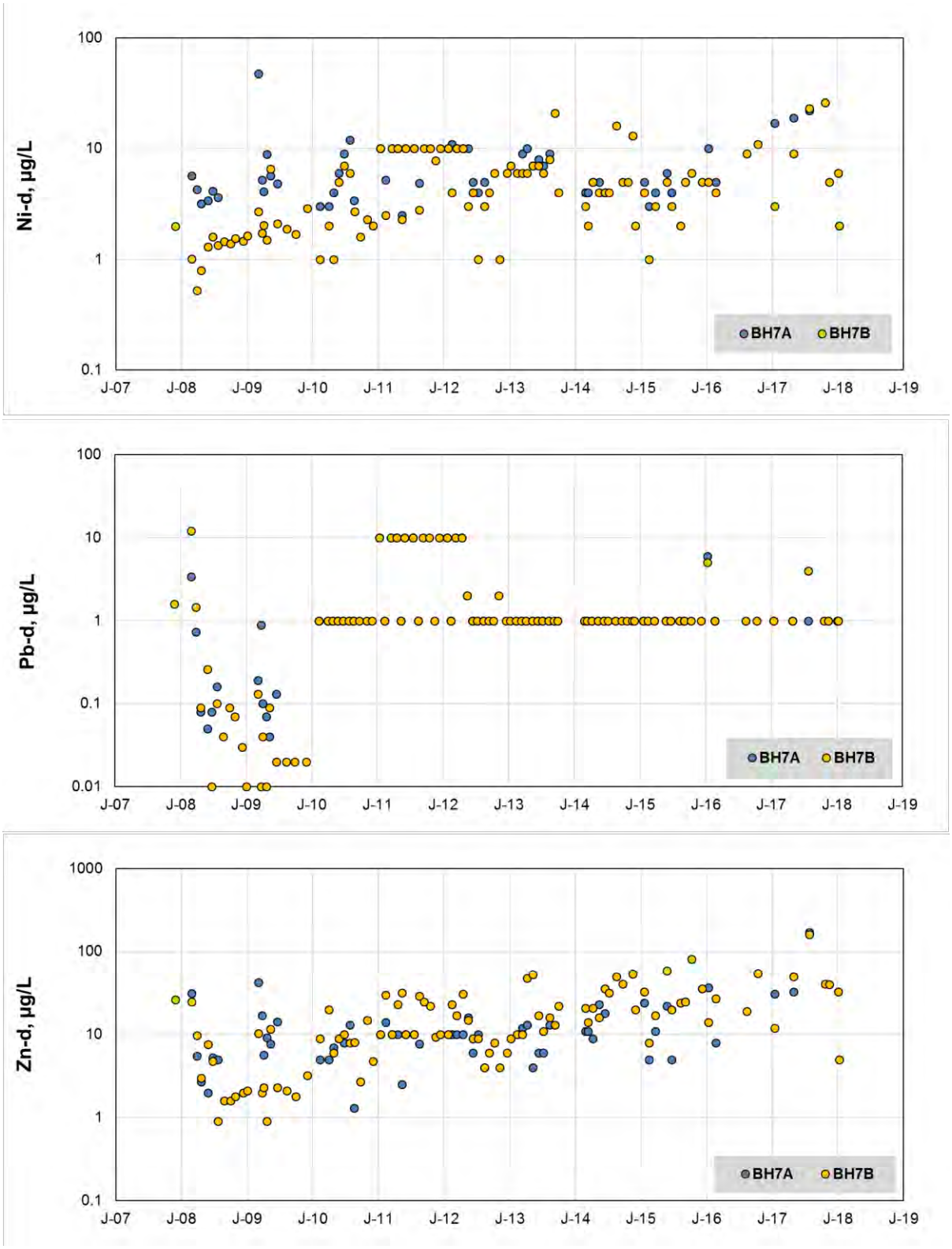


Figure D55. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH7A and BH7B, 2007 to 2018

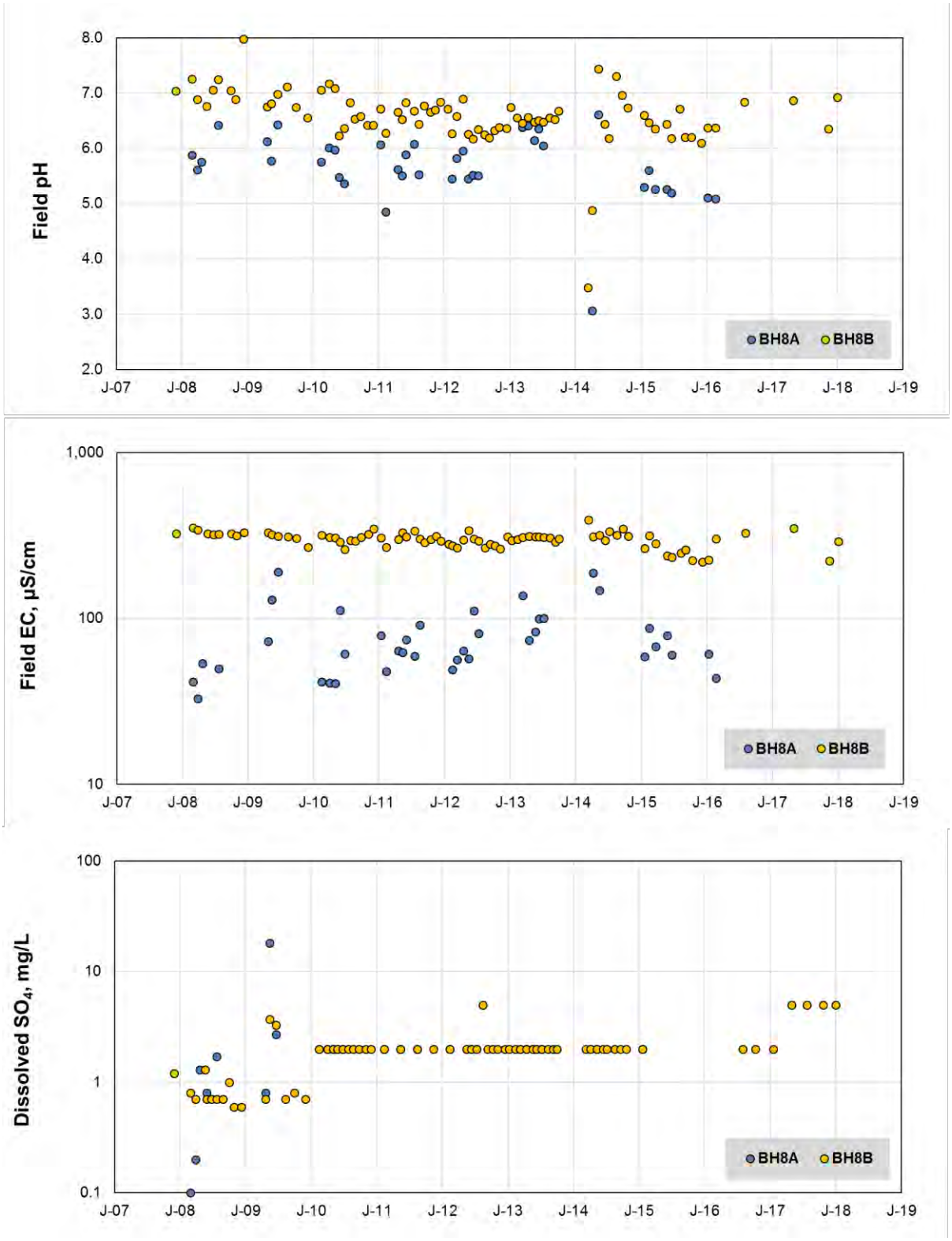


Figure D56. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH8A and BH8B, 2007 to 2018

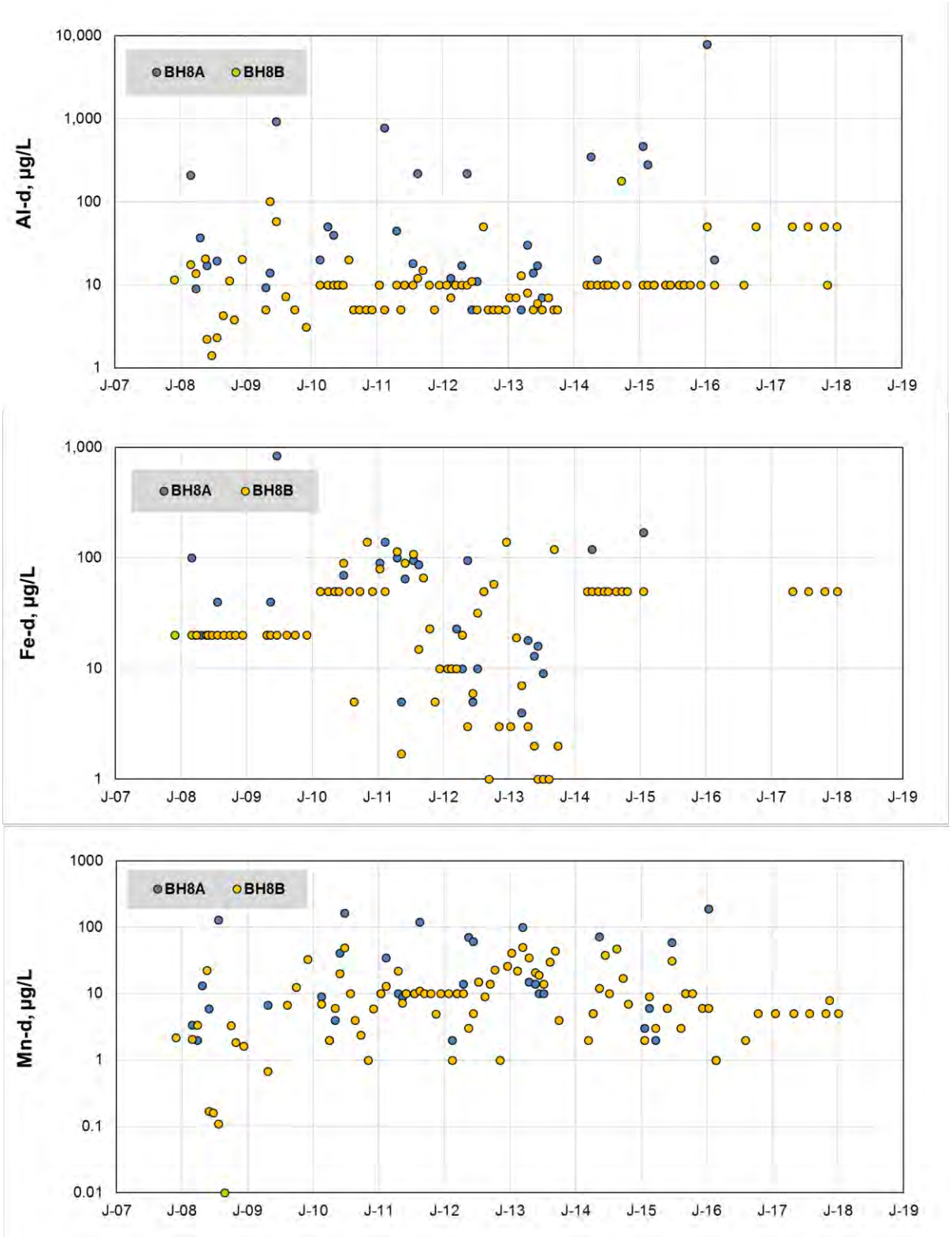


Figure D57. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH8A and BH8B, 2007 to 2018

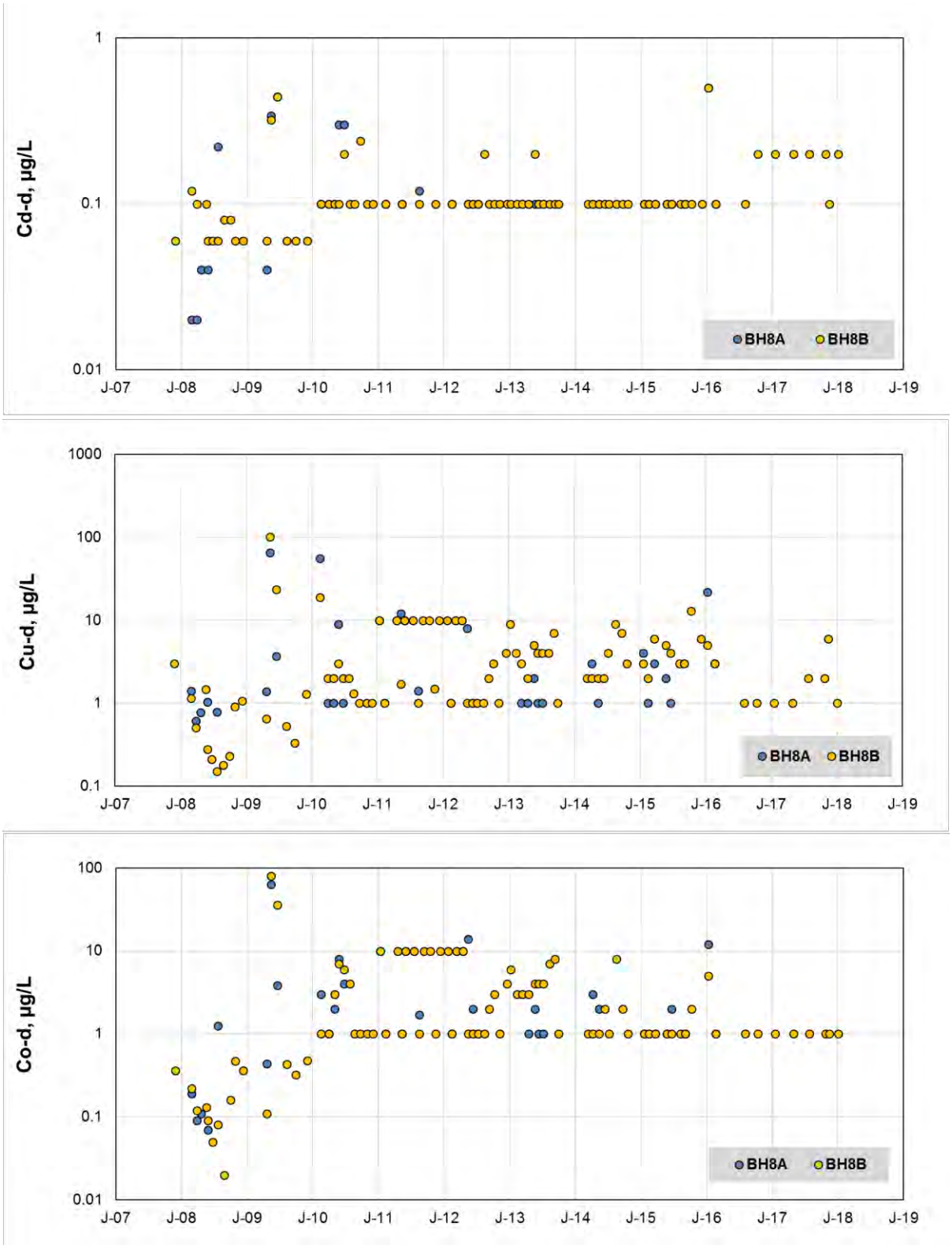


Figure D58. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH8A and BH8B, 2007 to 2018

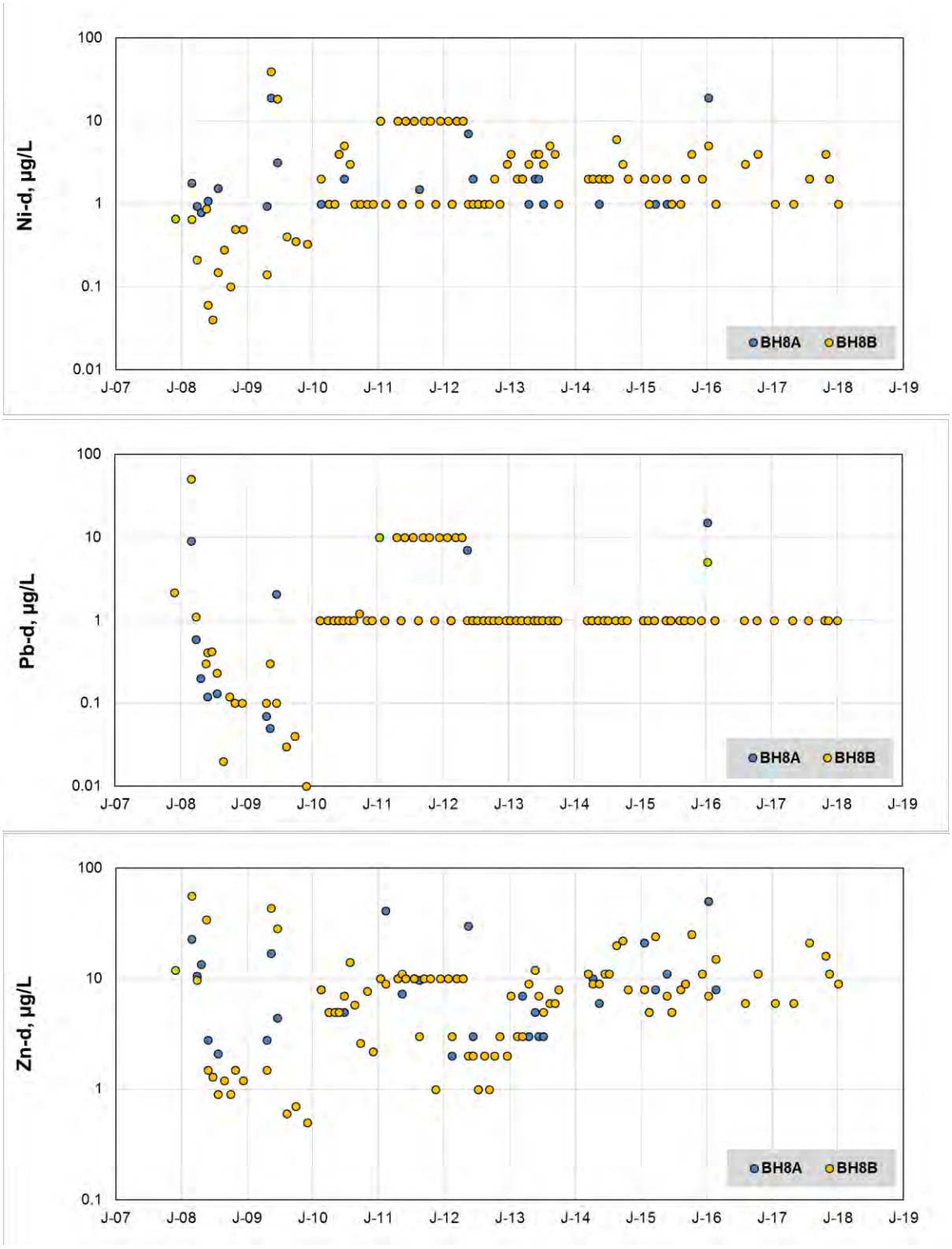


Figure D59. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH8A and BH8B, 2007 to 2018

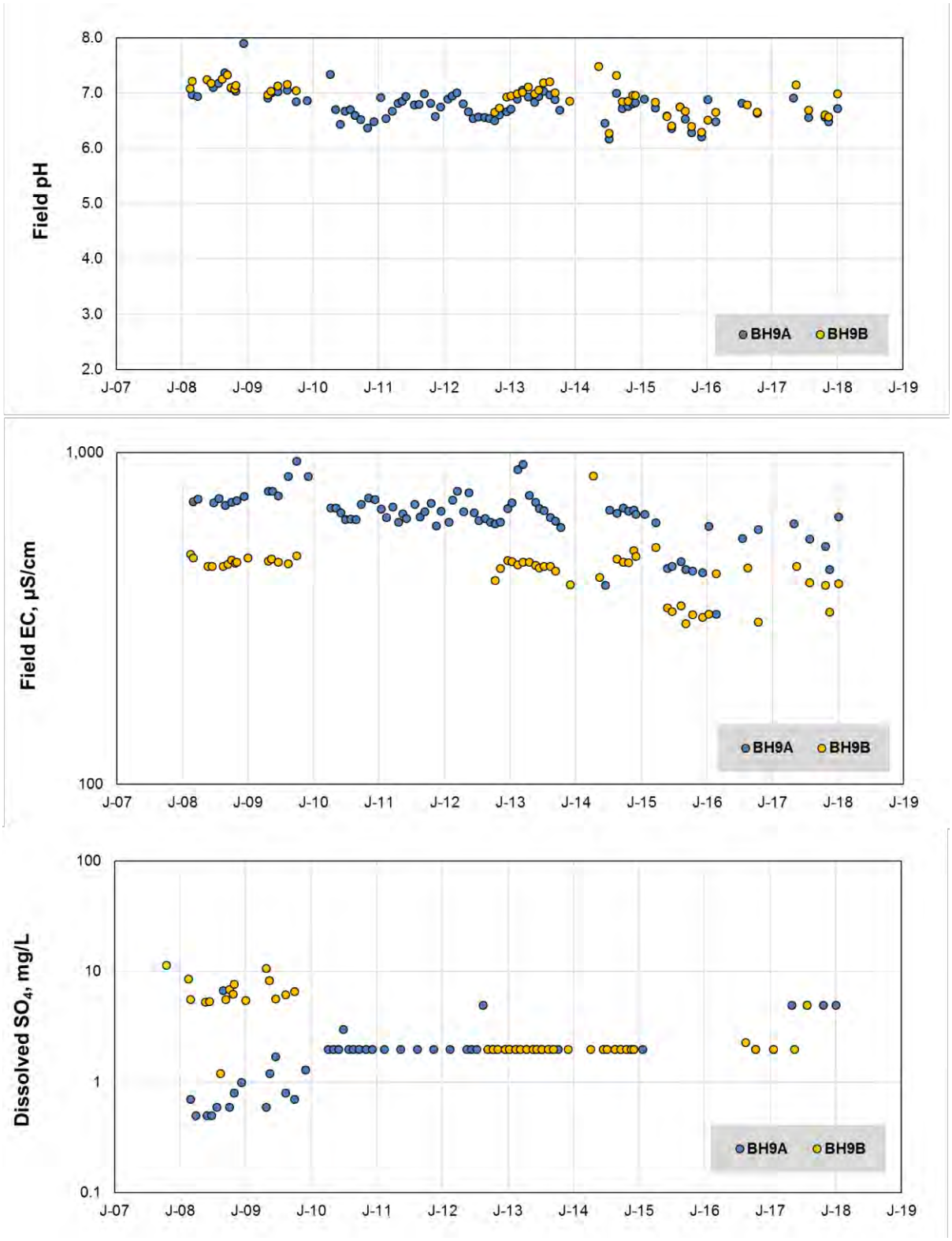


Figure D60. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH9A and BH9B, 2007 to 2018

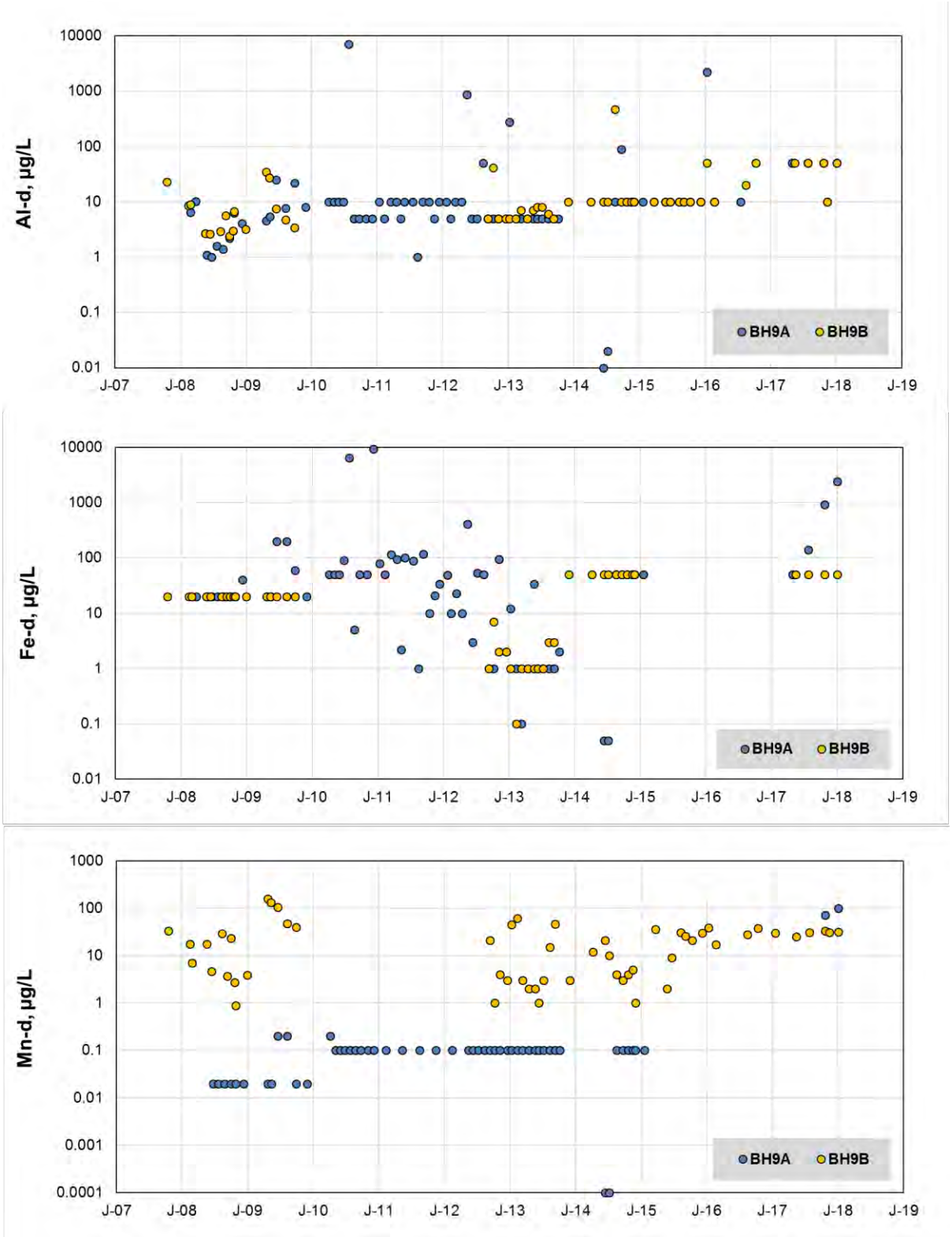


Figure D61. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH9A and BH9B, 2007 to 2018

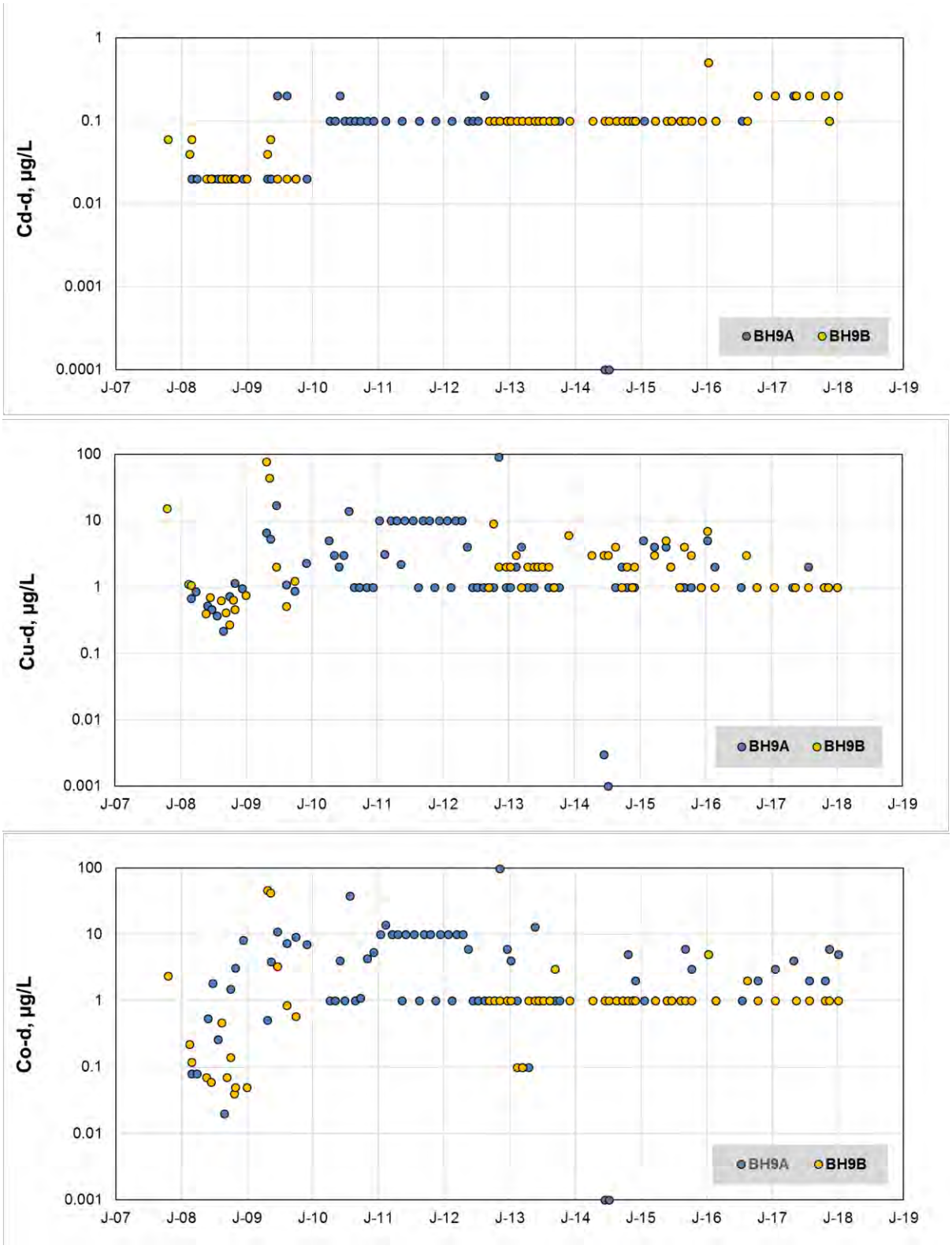


Figure D62. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH9A and BH9B, 2007 to 2018

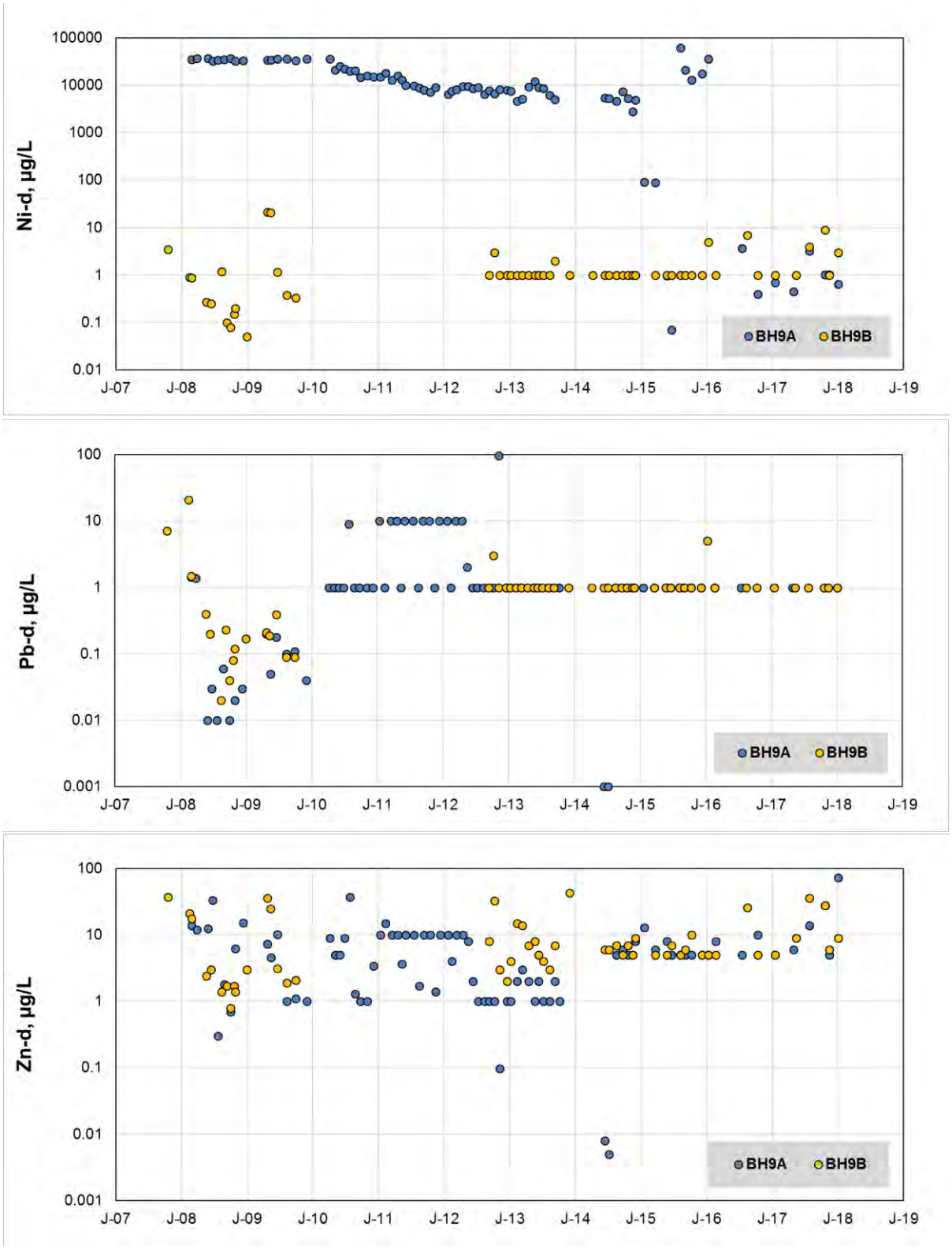


Figure D63. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH9A and BH9B, 2007 to 2018

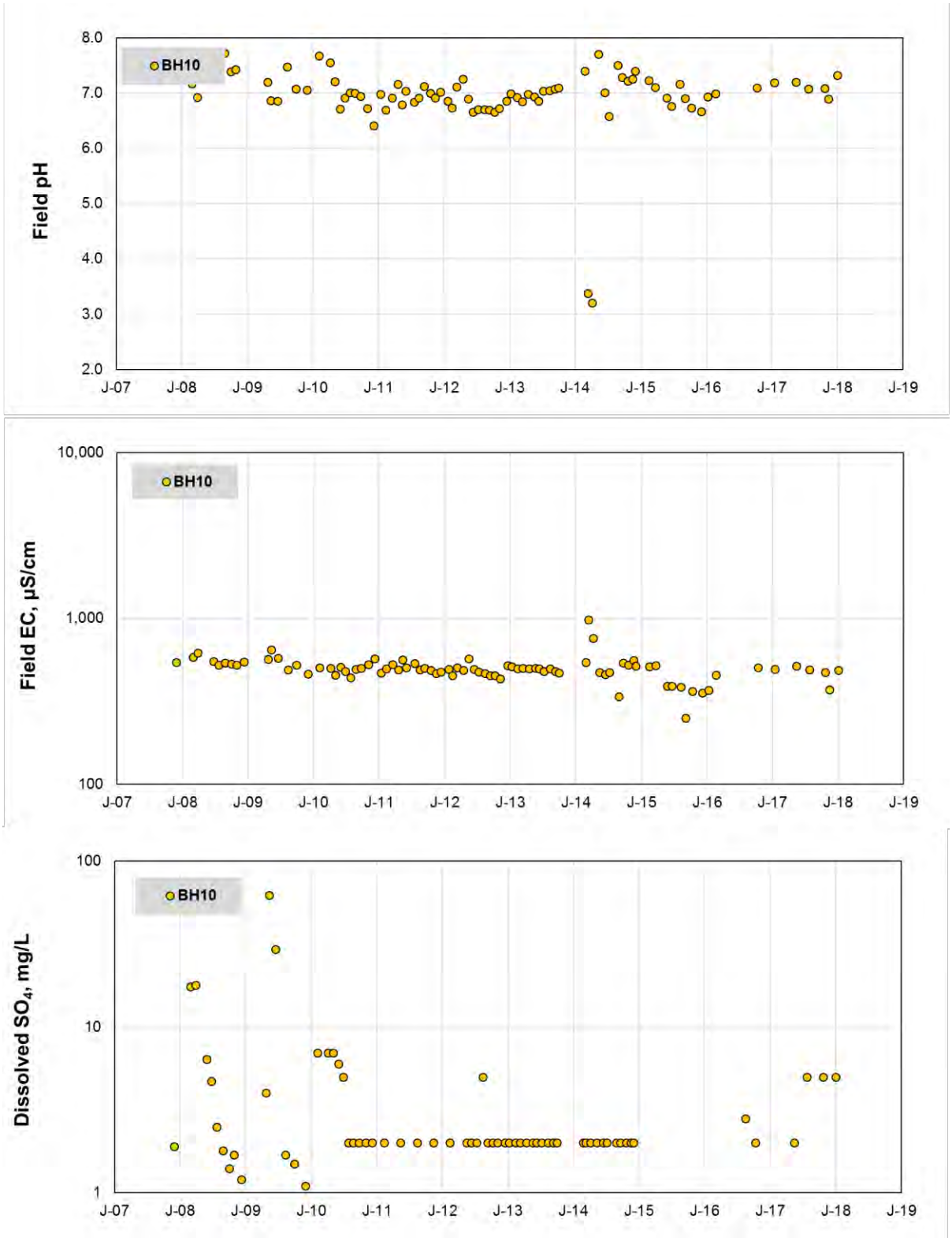


Figure D64. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH10, 2007 to 2018

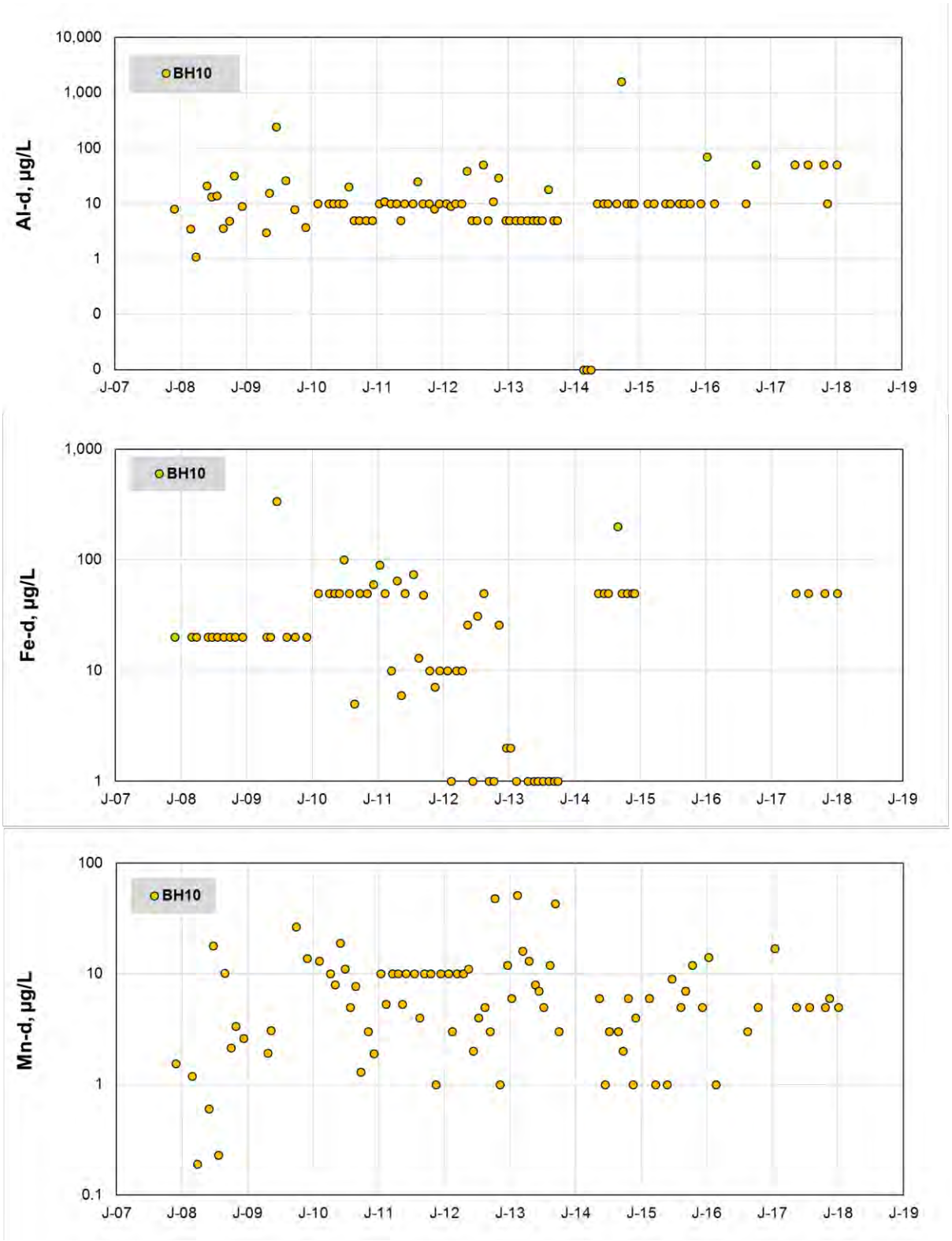


Figure D65. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH10, 2007 to 2018

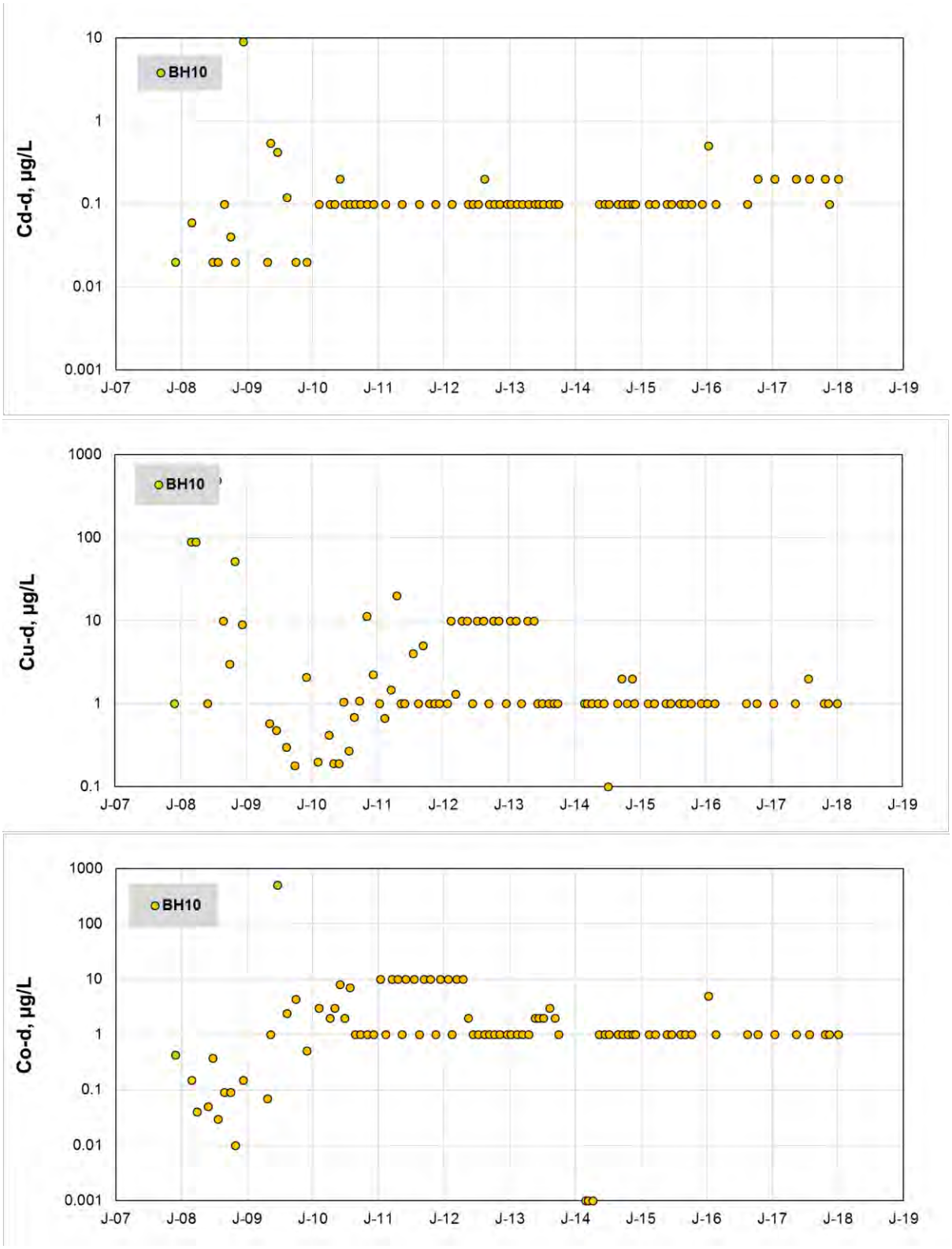


Figure D66. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH10, 2007 to 2018

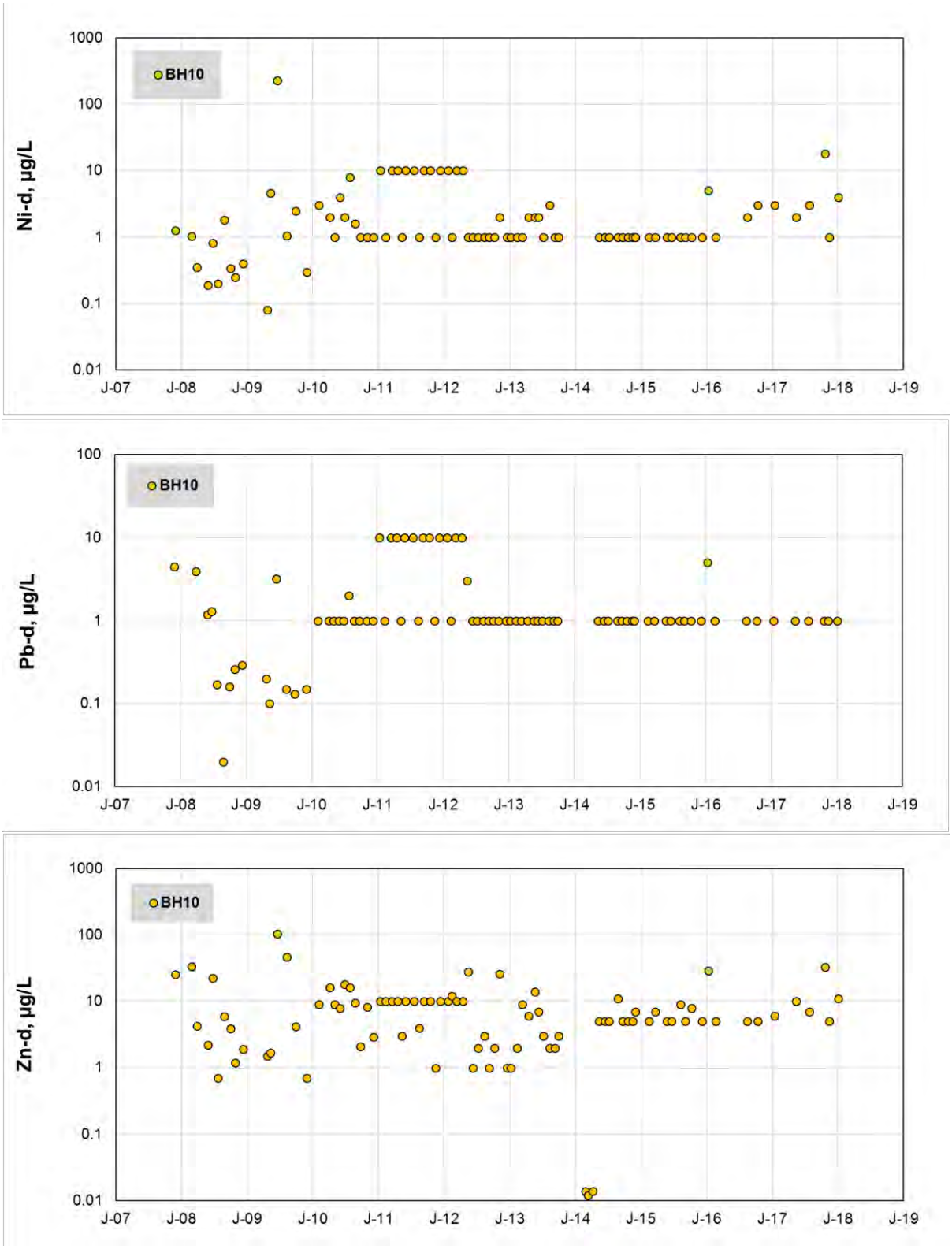


Figure D67. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH10, 2007 to 2018

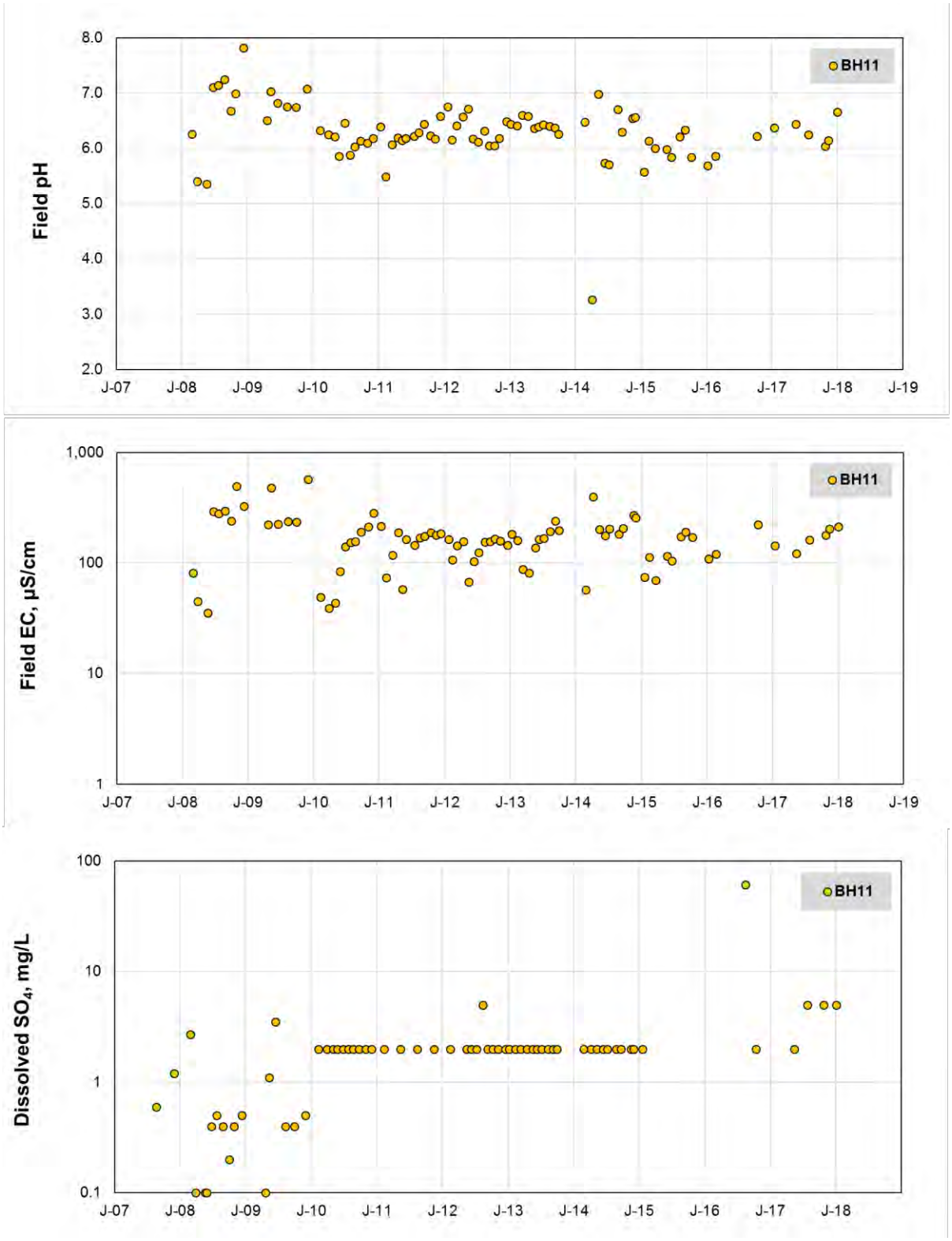


Figure D68. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH11, 2007 to 2018

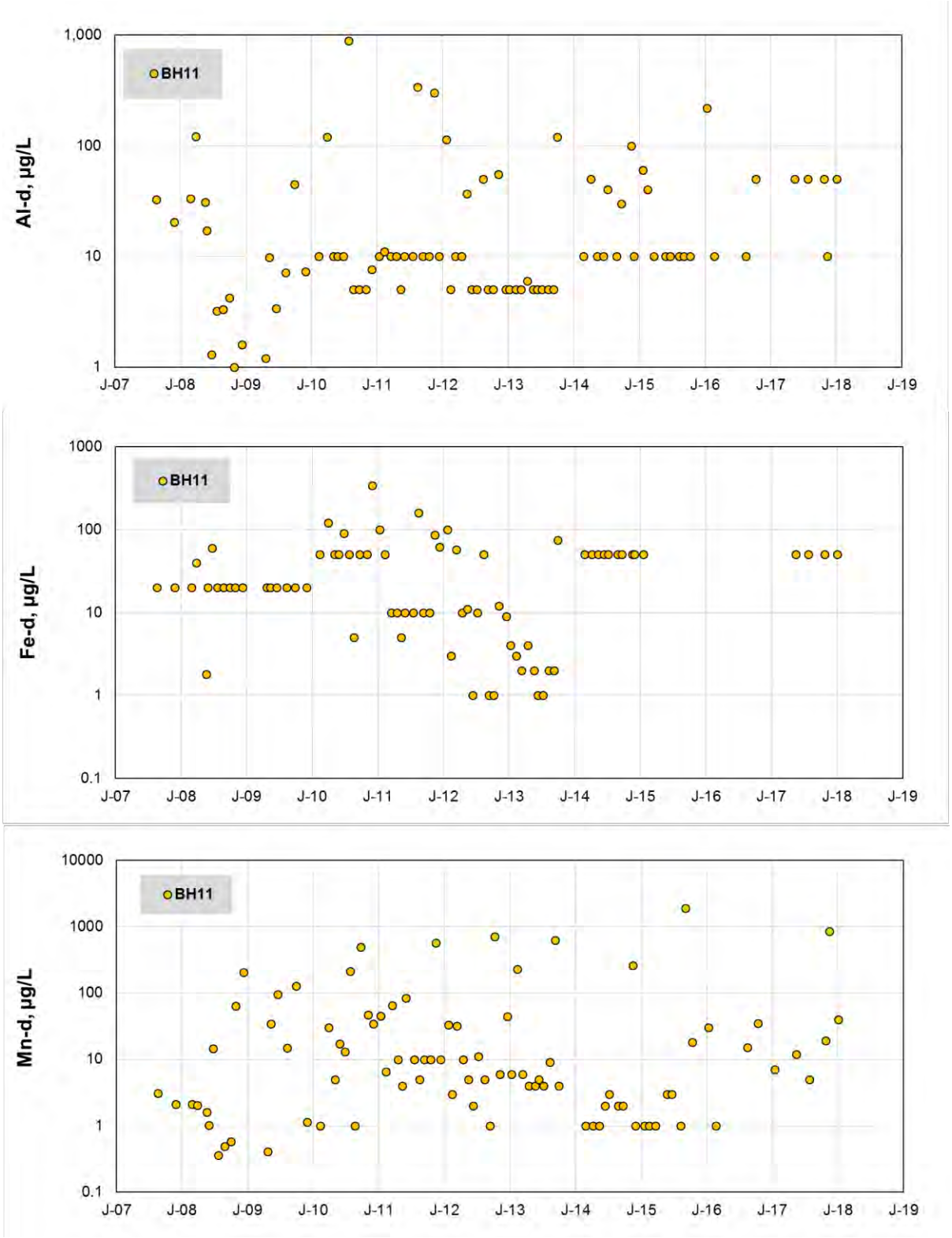
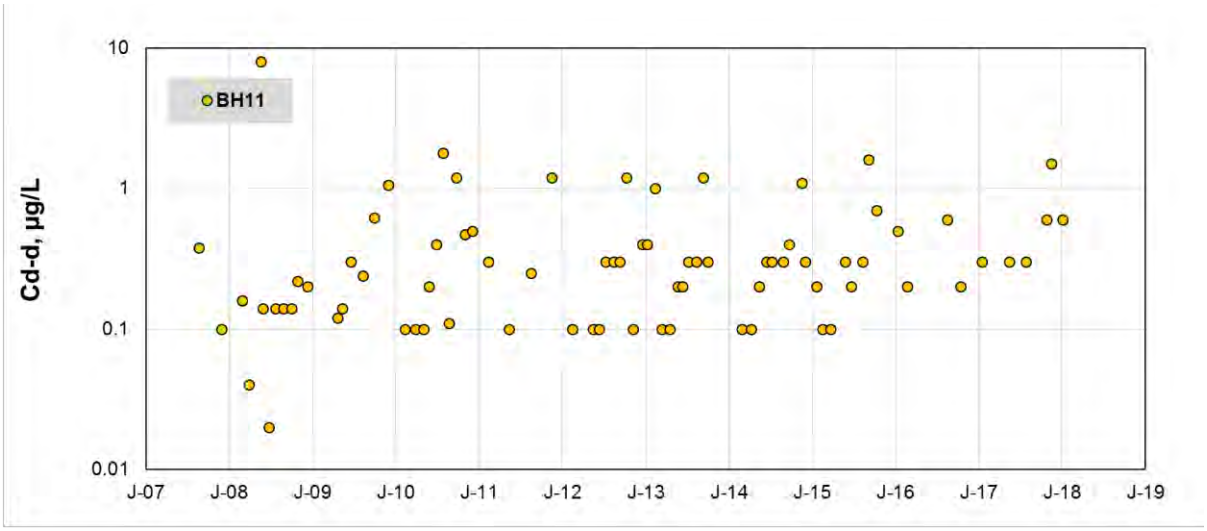
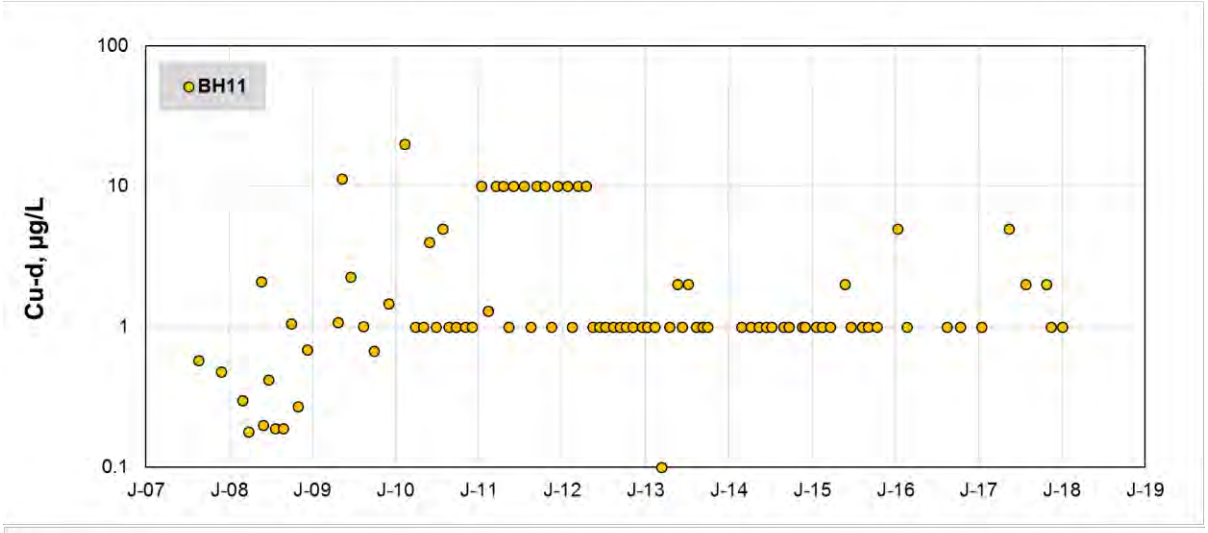


Figure D69. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH11, 2007 to 2018





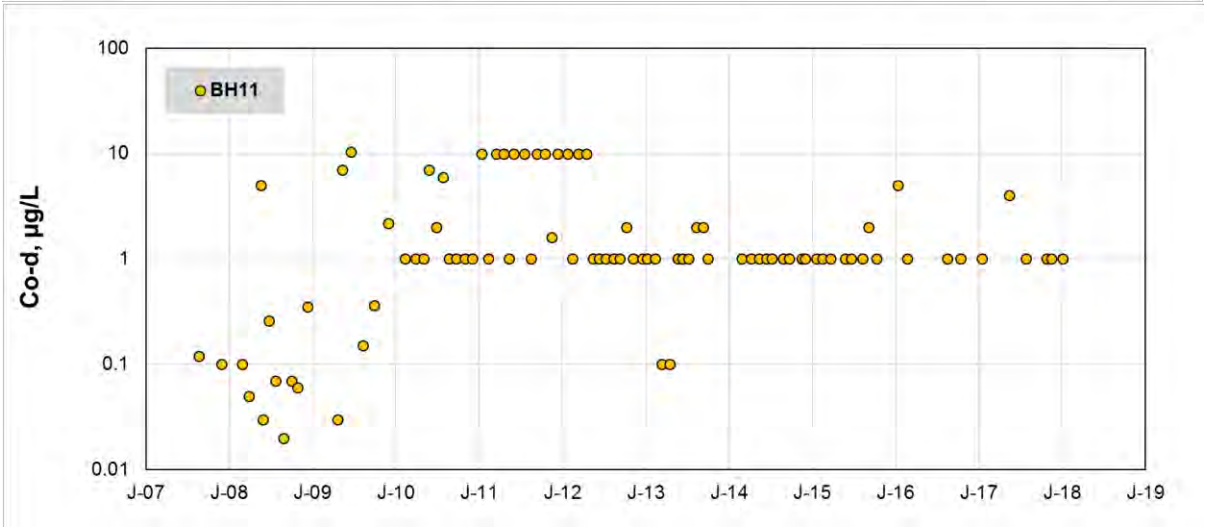


Figure D70. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH11, 2007 to 2018

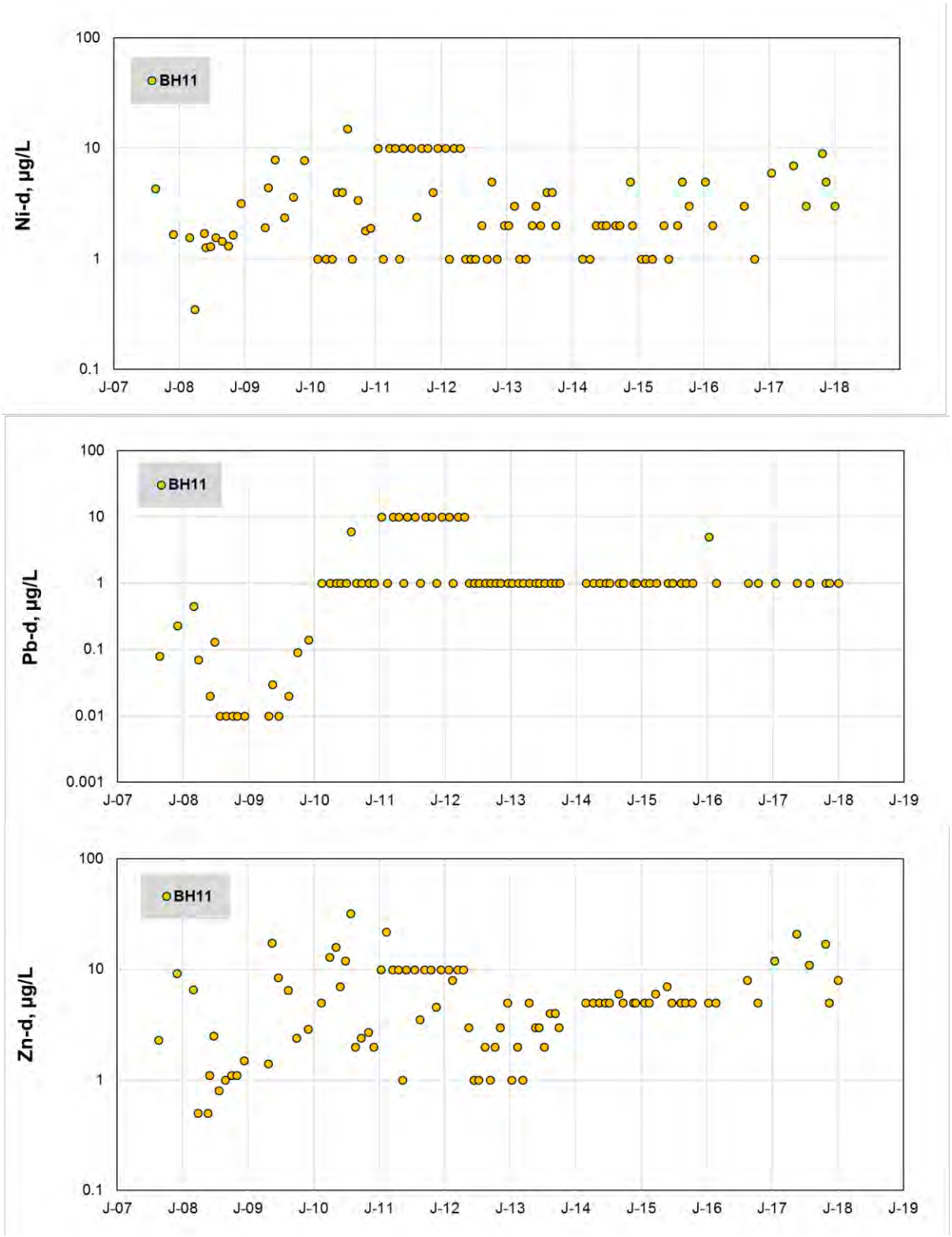


Figure D71. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH11, 2007 to 2018

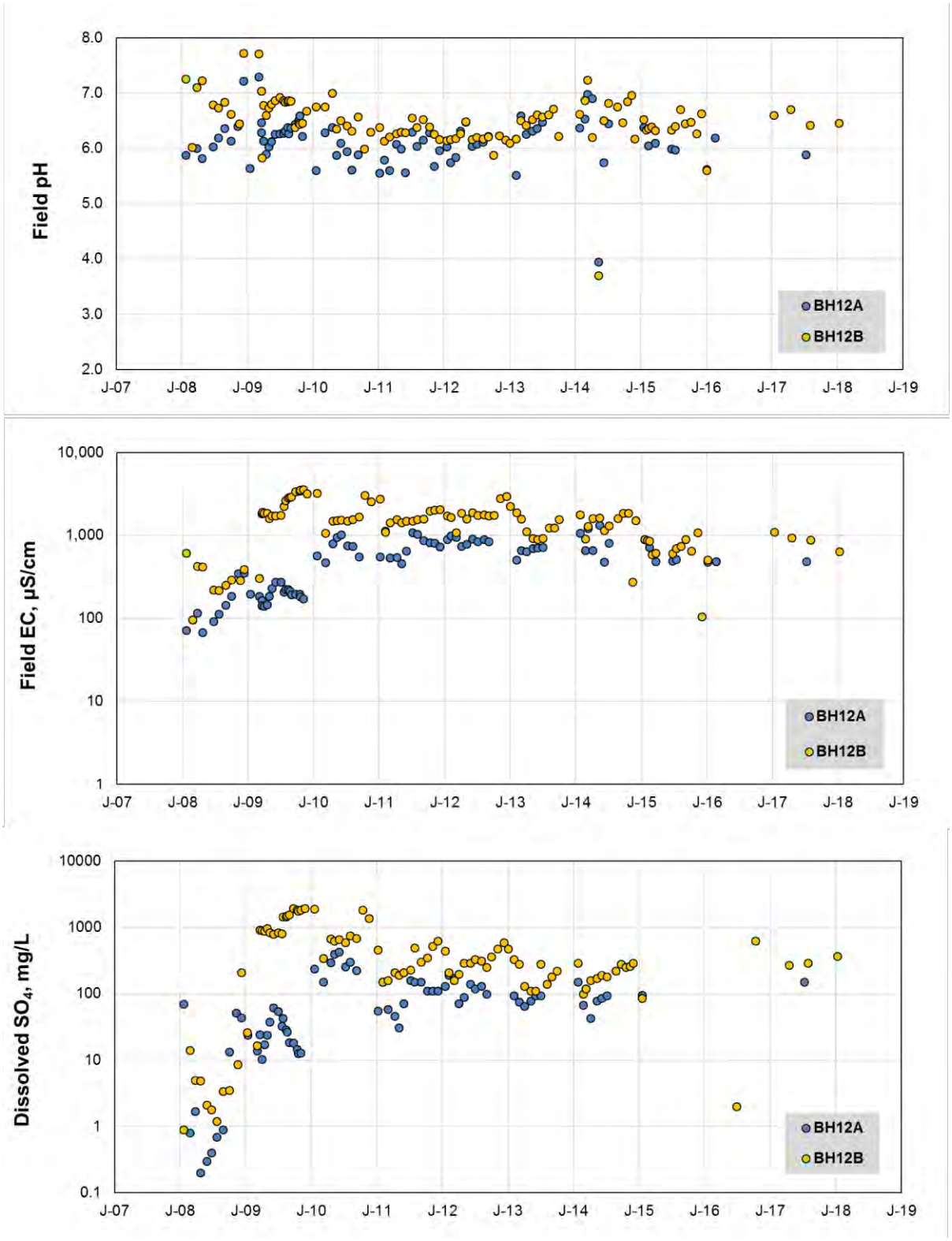


Figure D72. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH12A and BH12B, 2008 to 2018

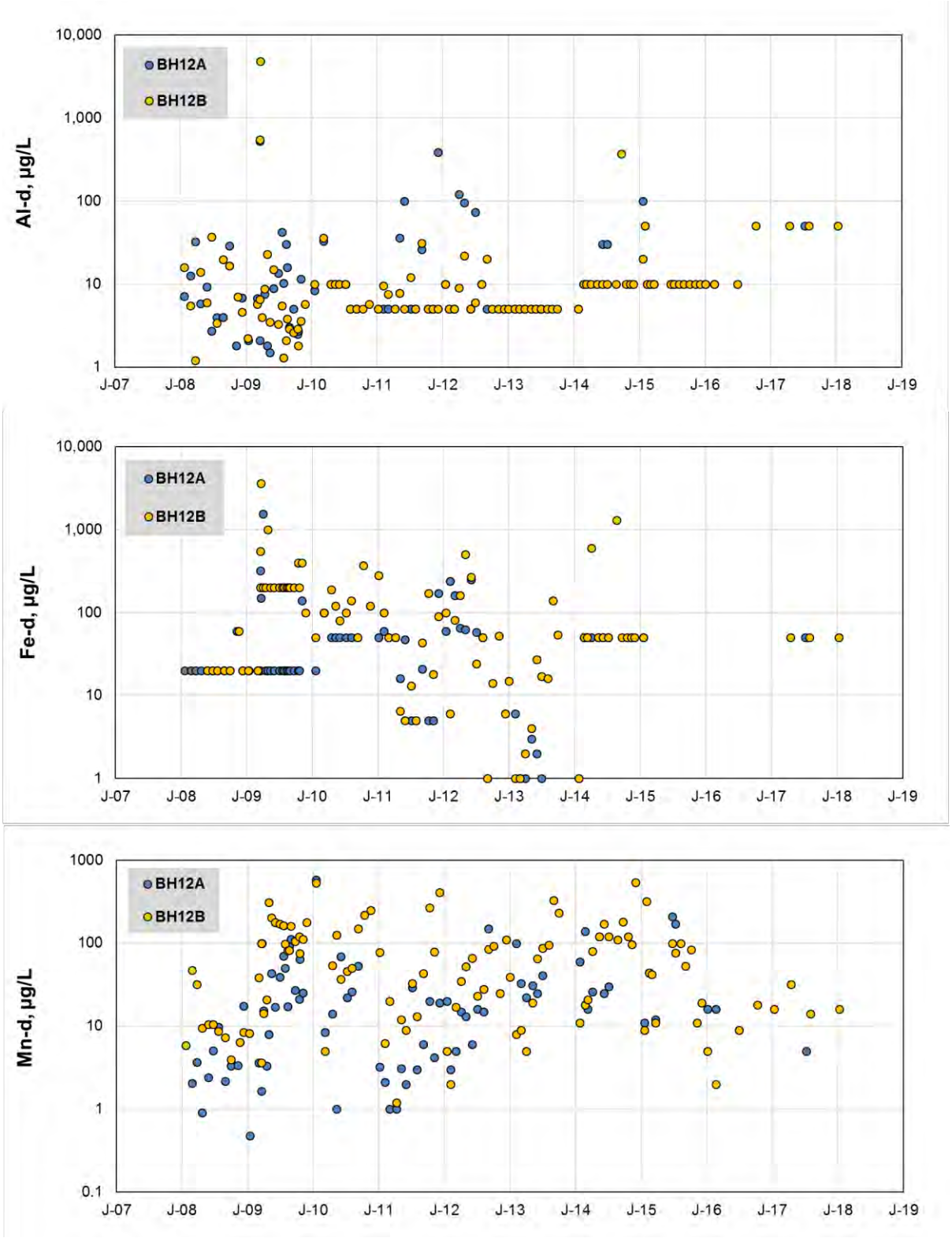
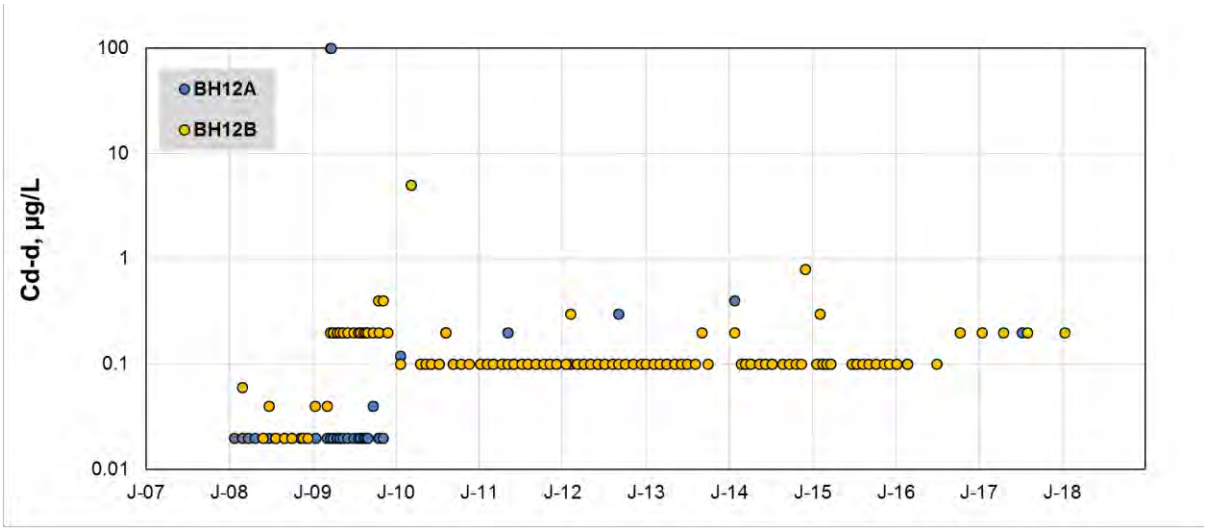
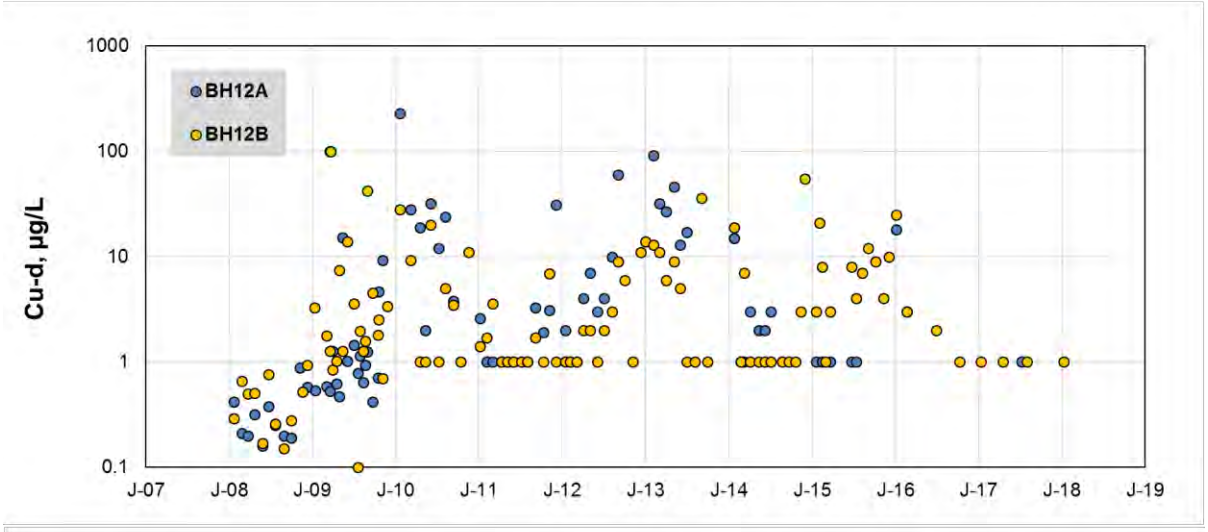


Figure D73. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH12A and BH12B, 2008 to 2018





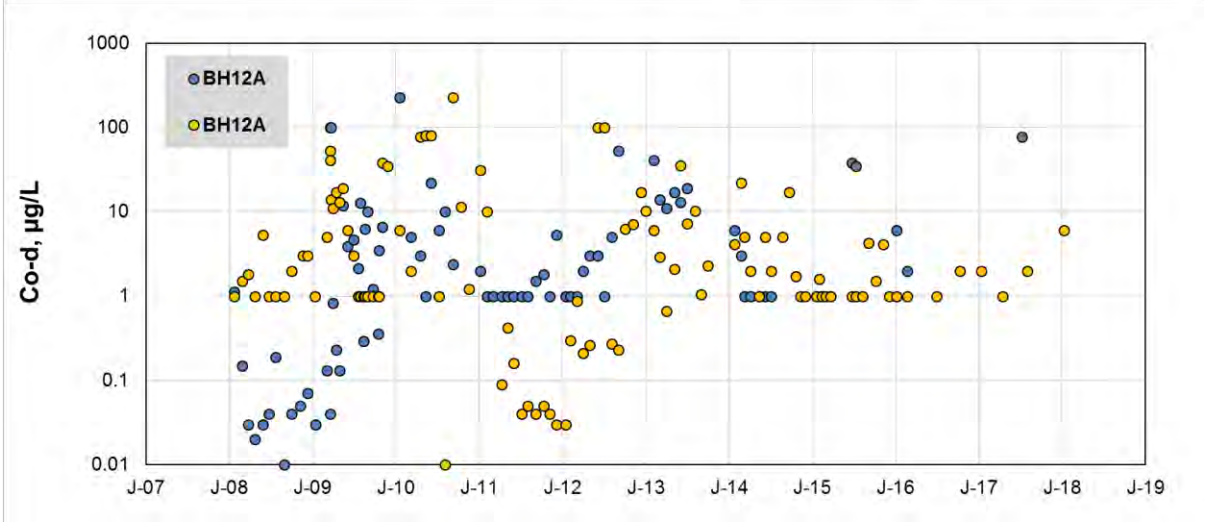


Figure D74. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH12A and BH12B, 2008 to 2018

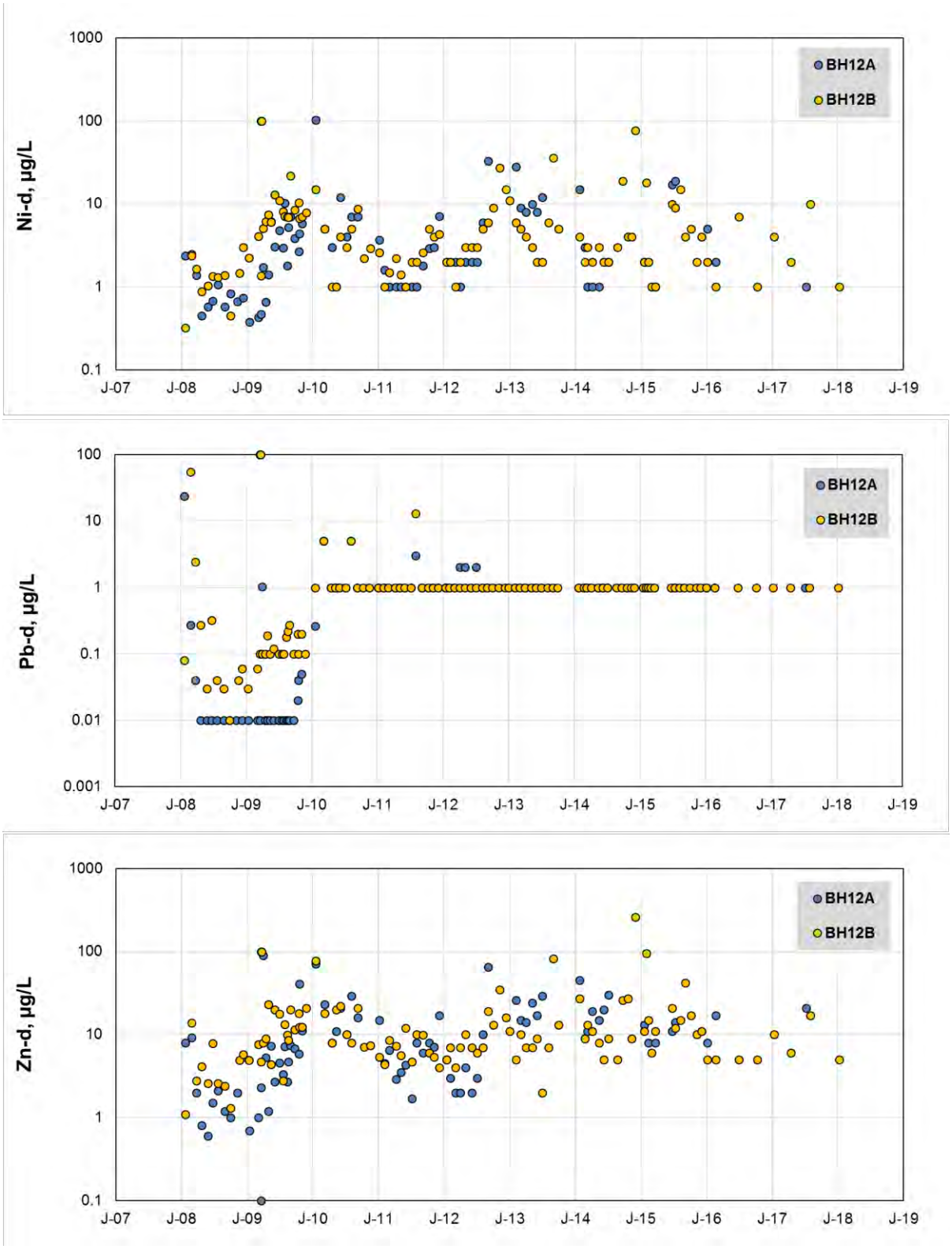


Figure D75. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH12A and BH12B, 2008 to 2018

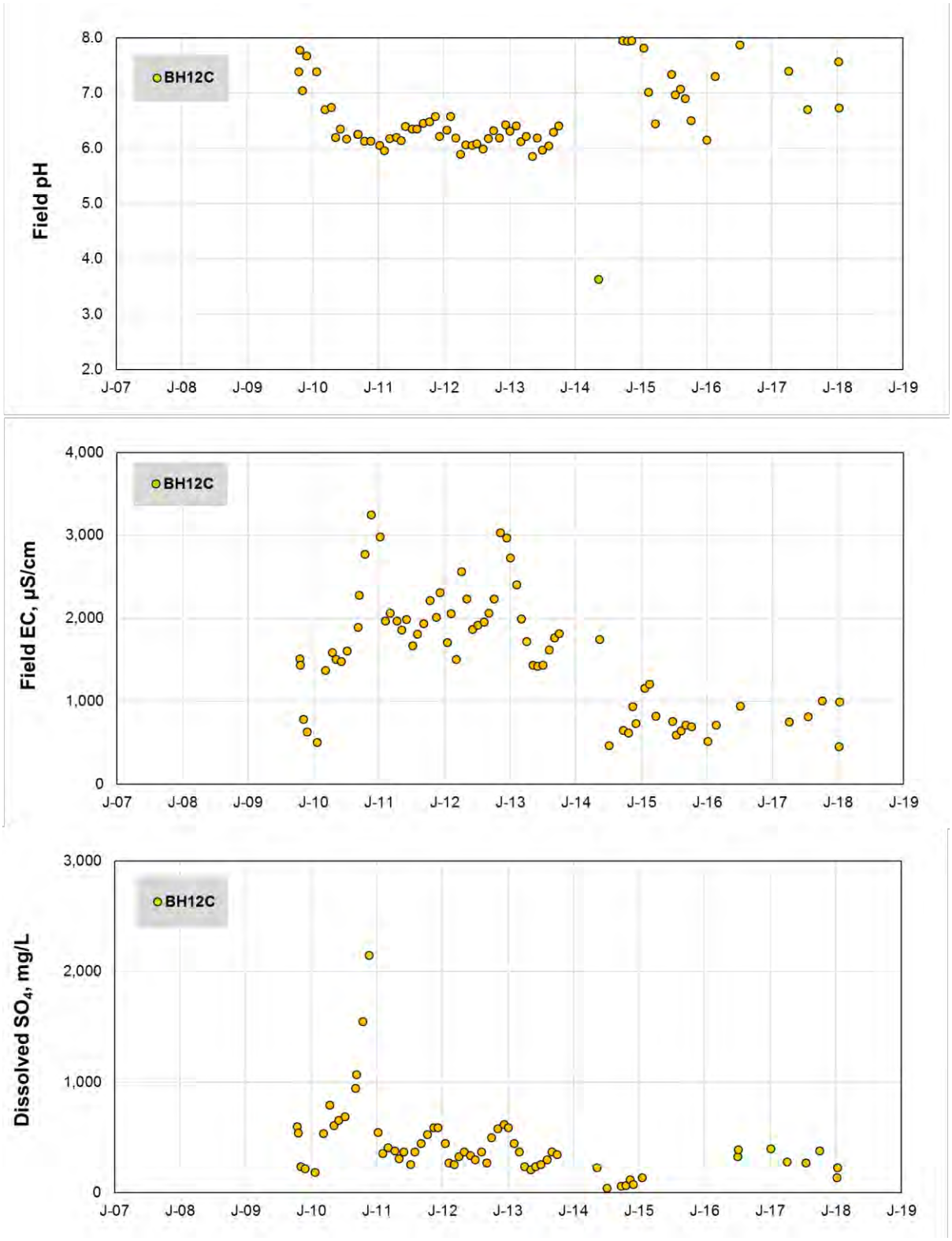


Figure D76. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH12C, 2009 to 2018

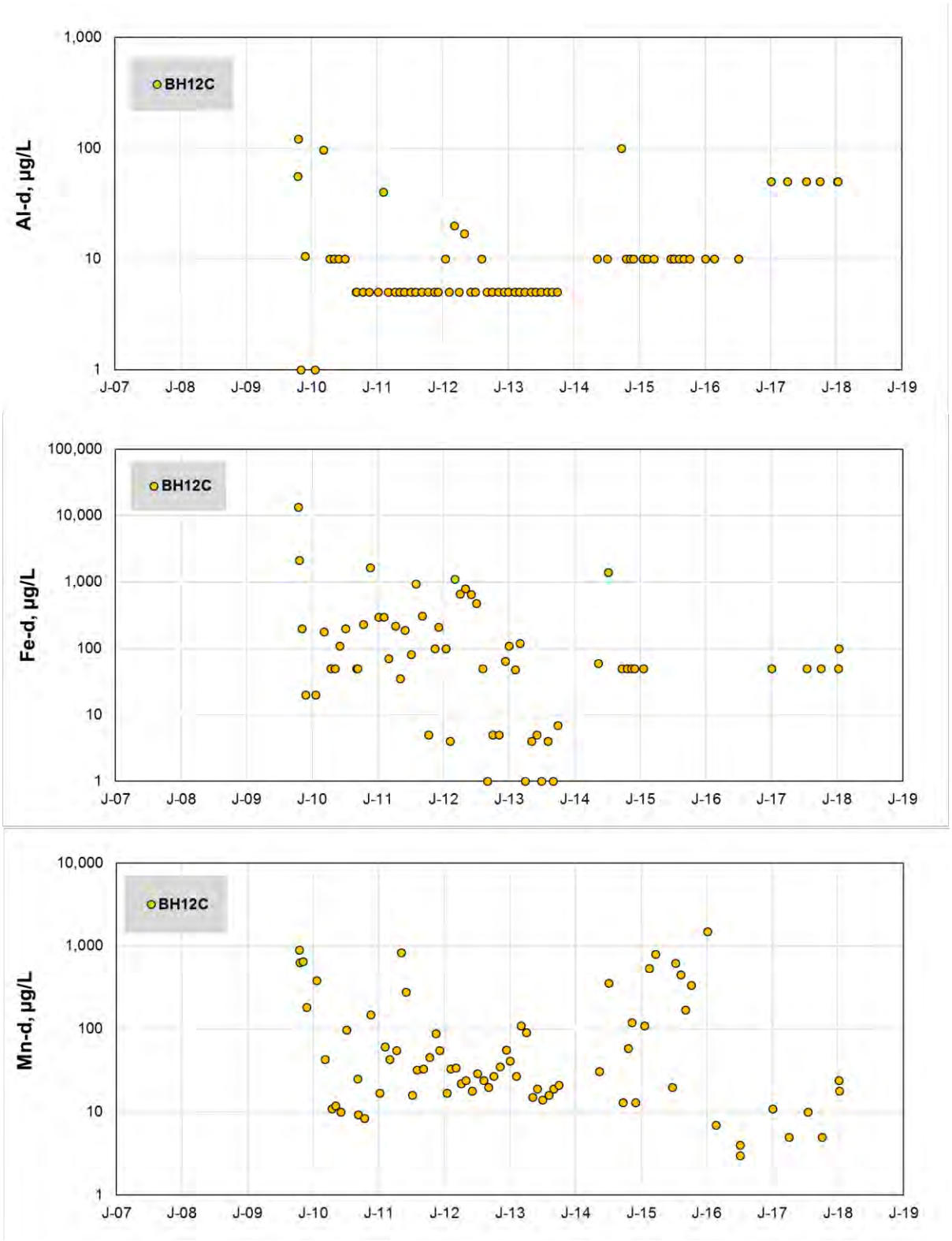


Figure D77. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH12C, 2009 to 2018

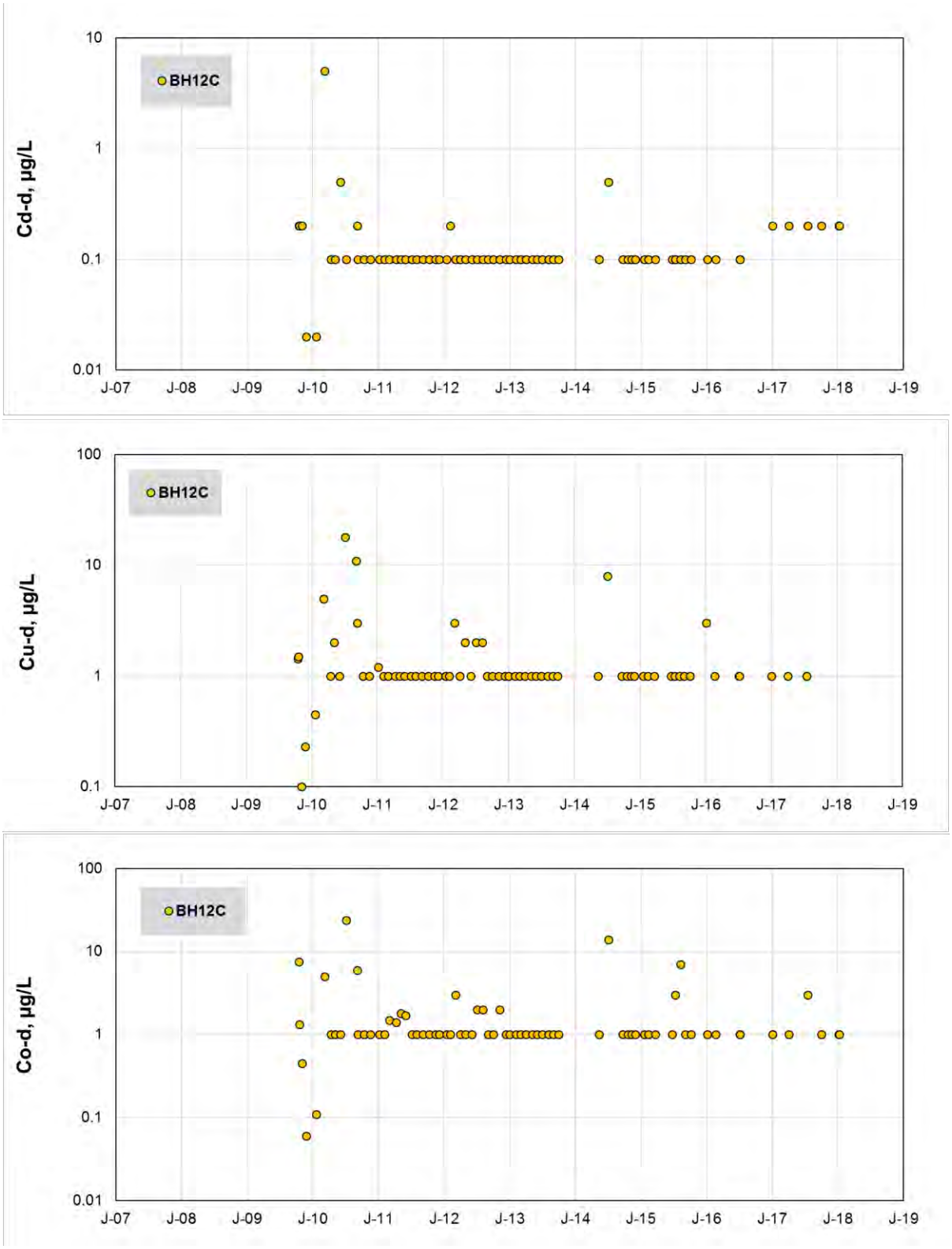


Figure D78. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH12C, 2009 to 2018

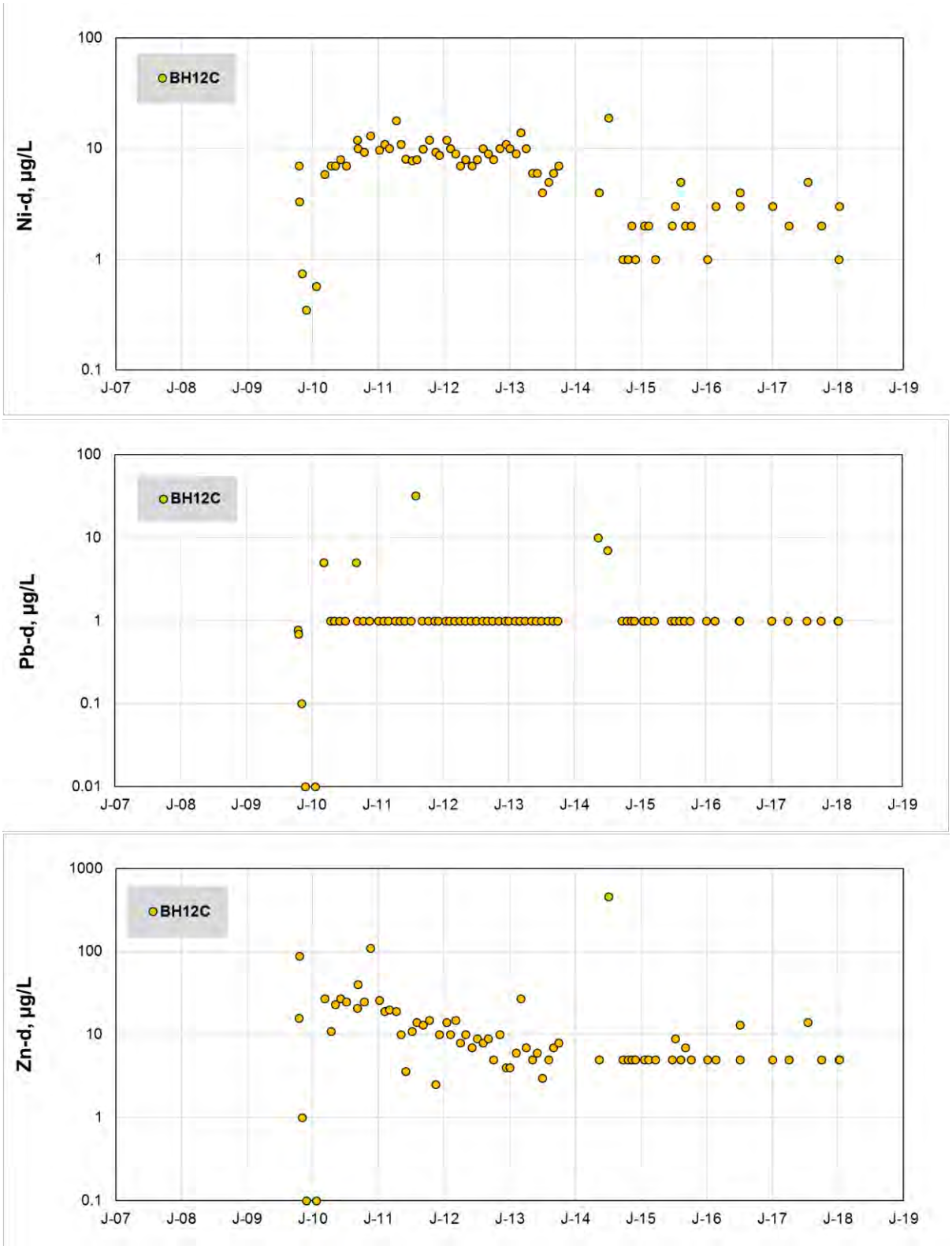


Figure D79. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH12C, 2009 to 2018

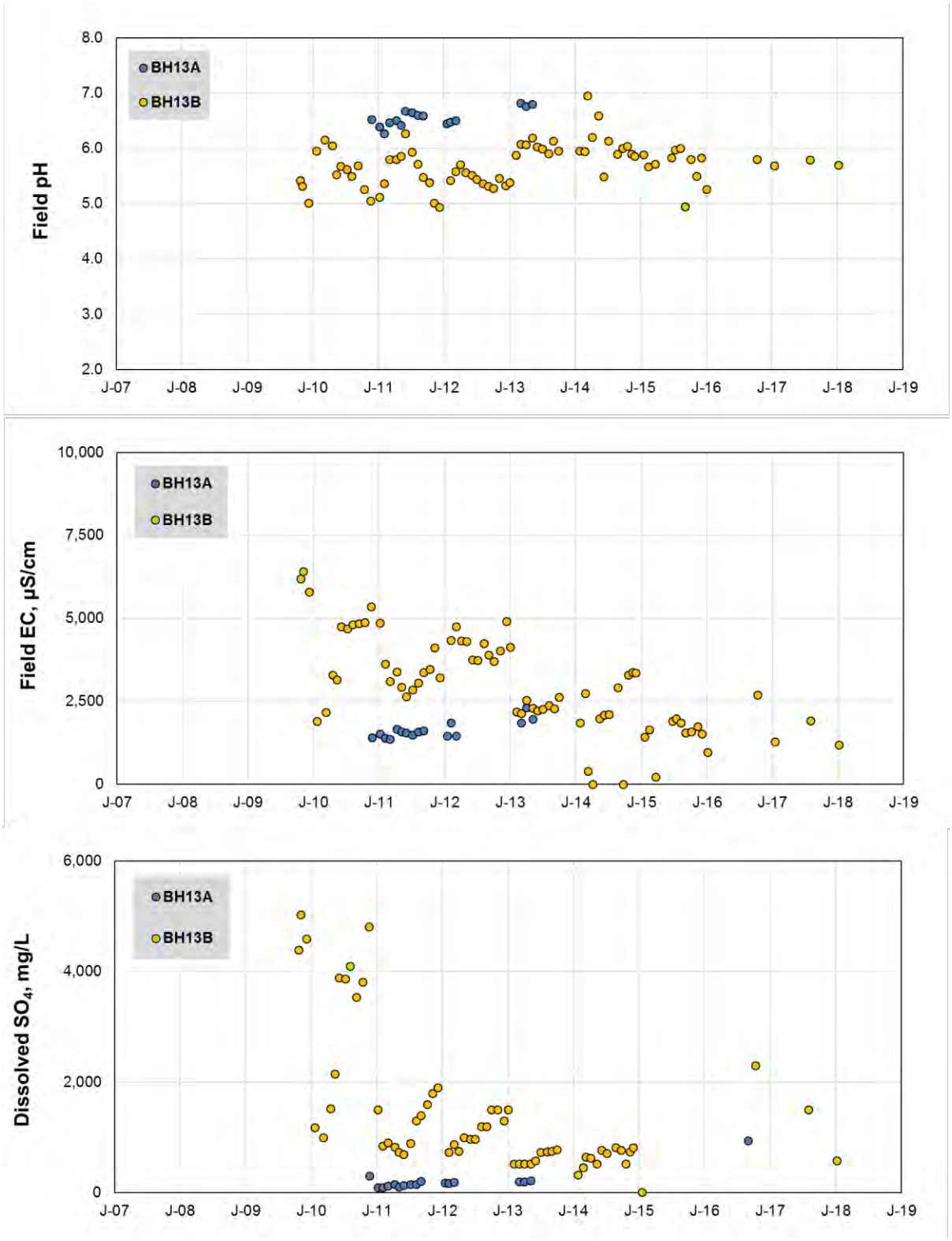


Figure D80. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH13A and BH13B, 2009 to 2018

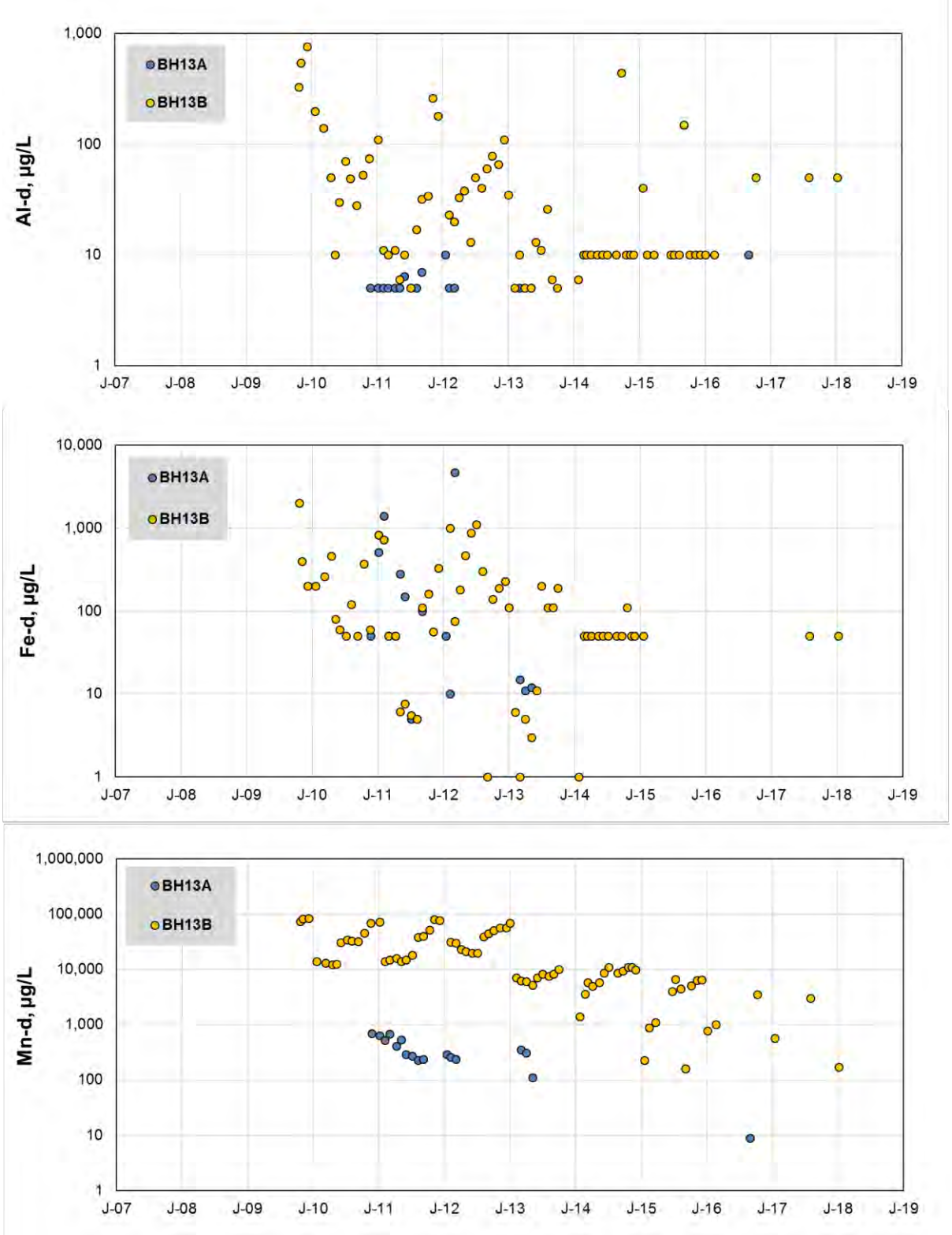
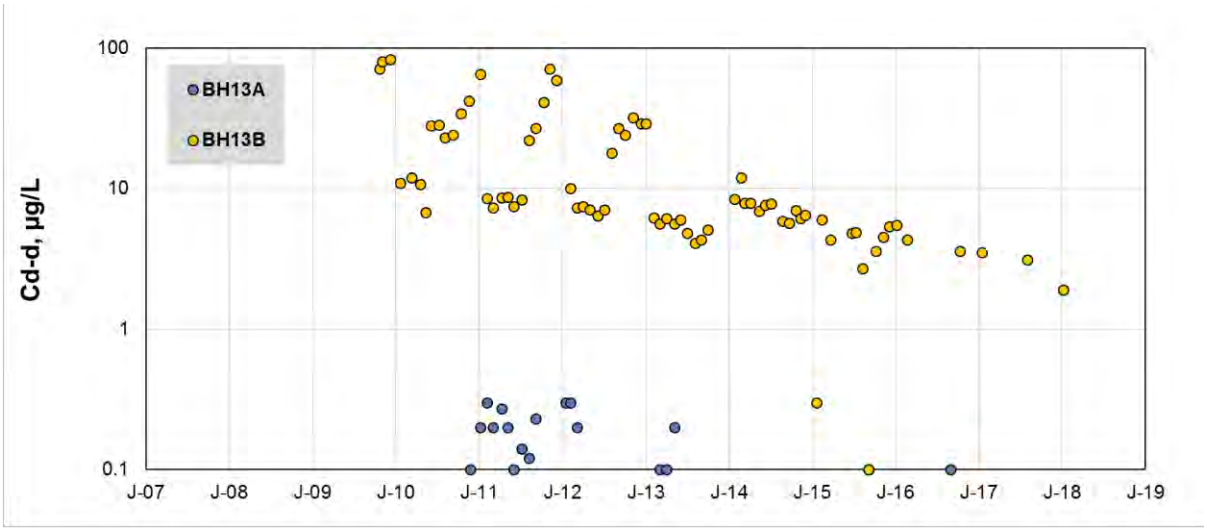
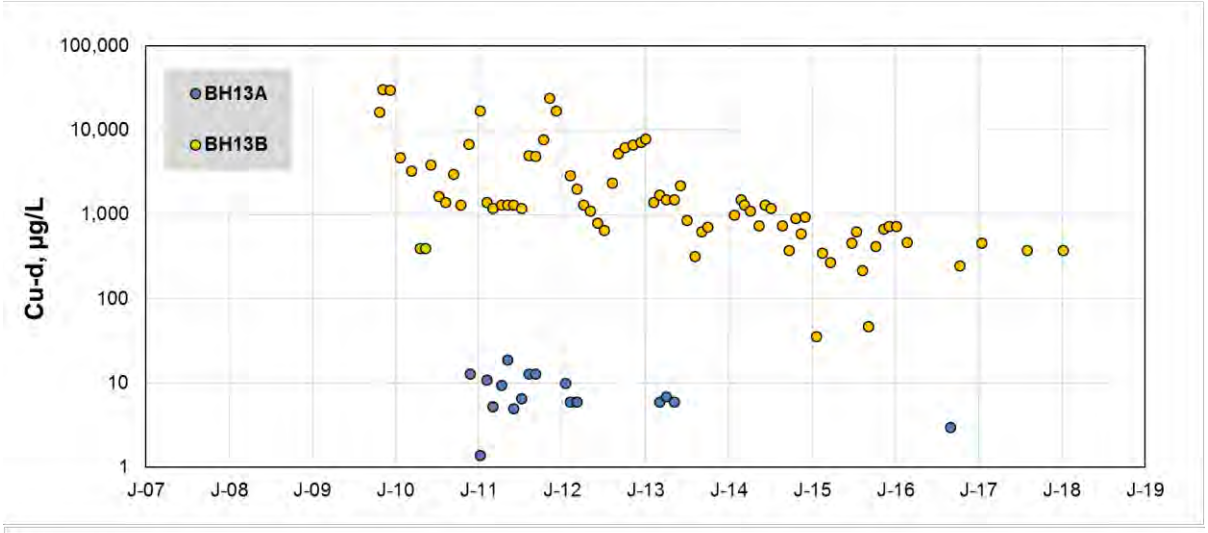


Figure D81. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH13A and BH13B, 2009 to 2018





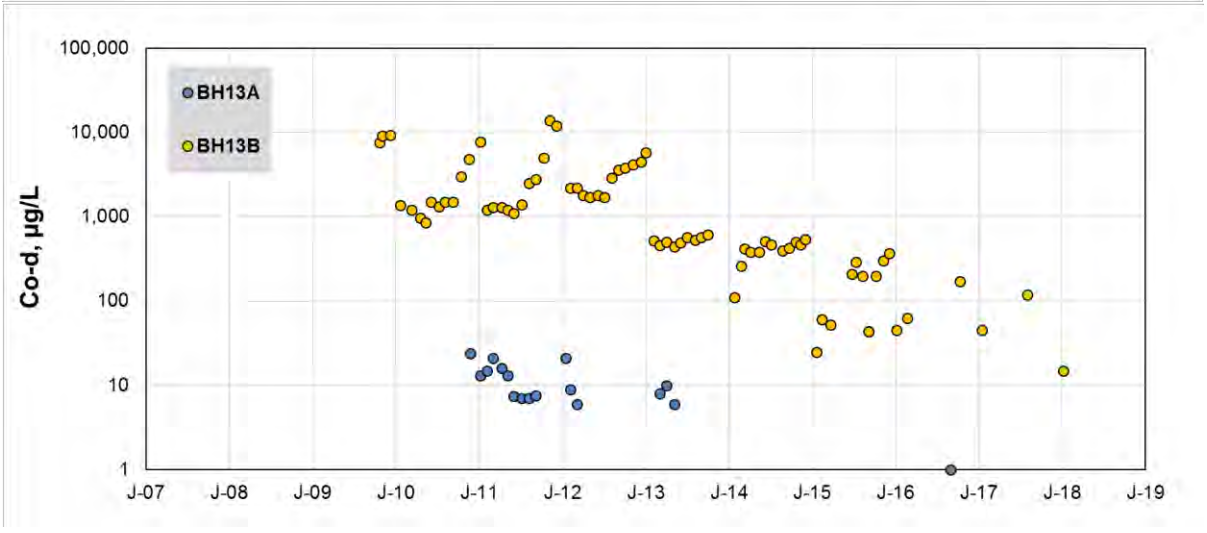
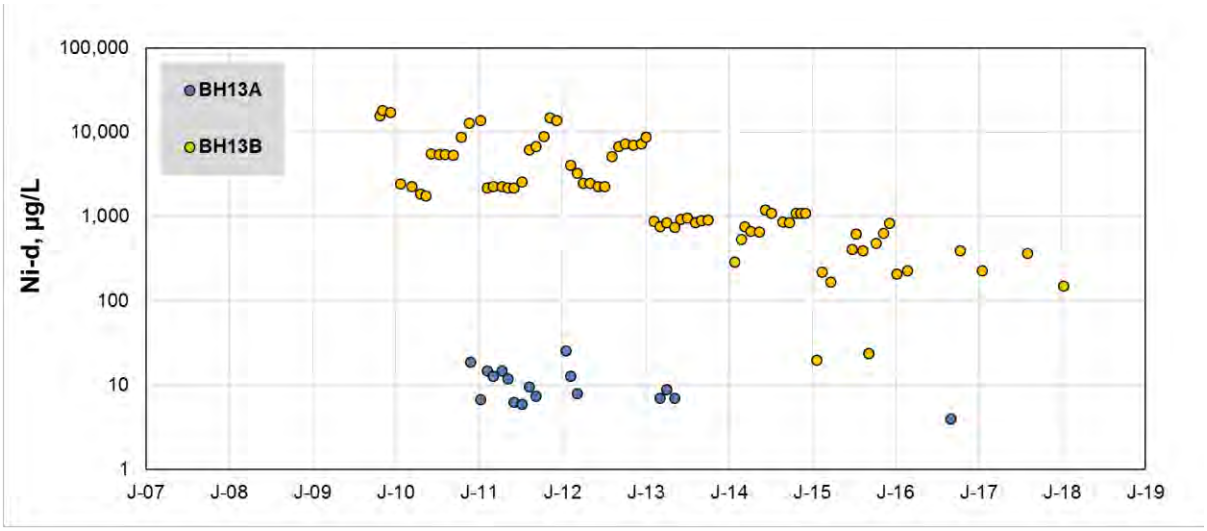
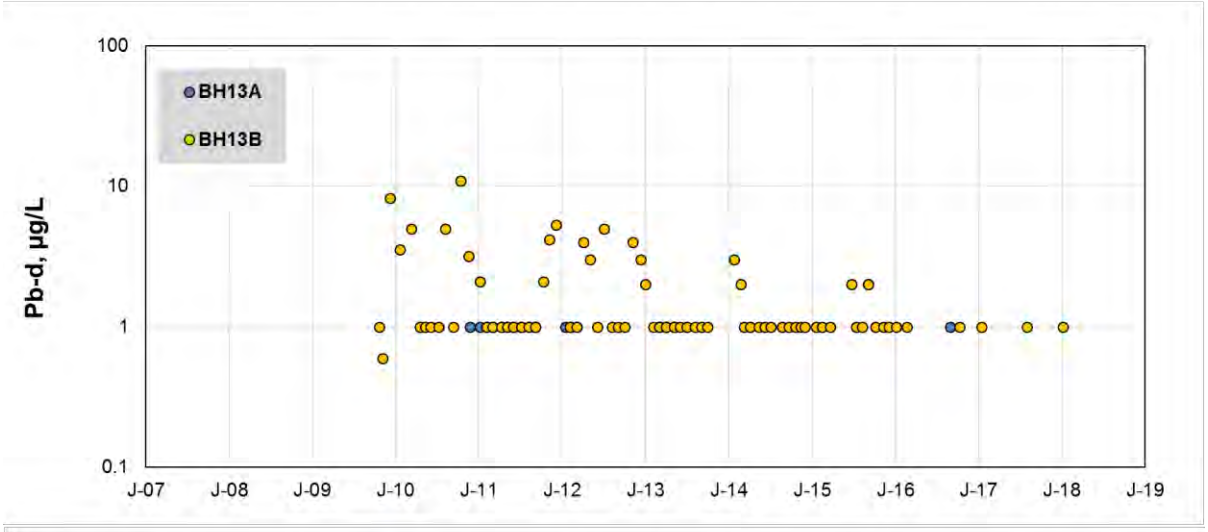


Figure D82. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH13A and BH13B, 2009 to 2018





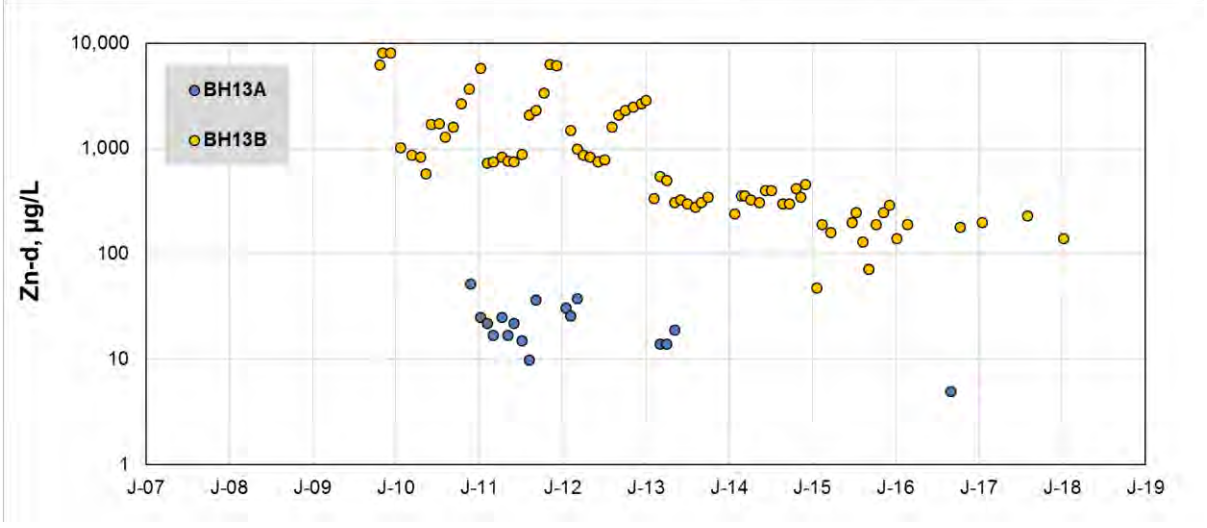


Figure D83. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH13A and BH13B, 2009 to 2018

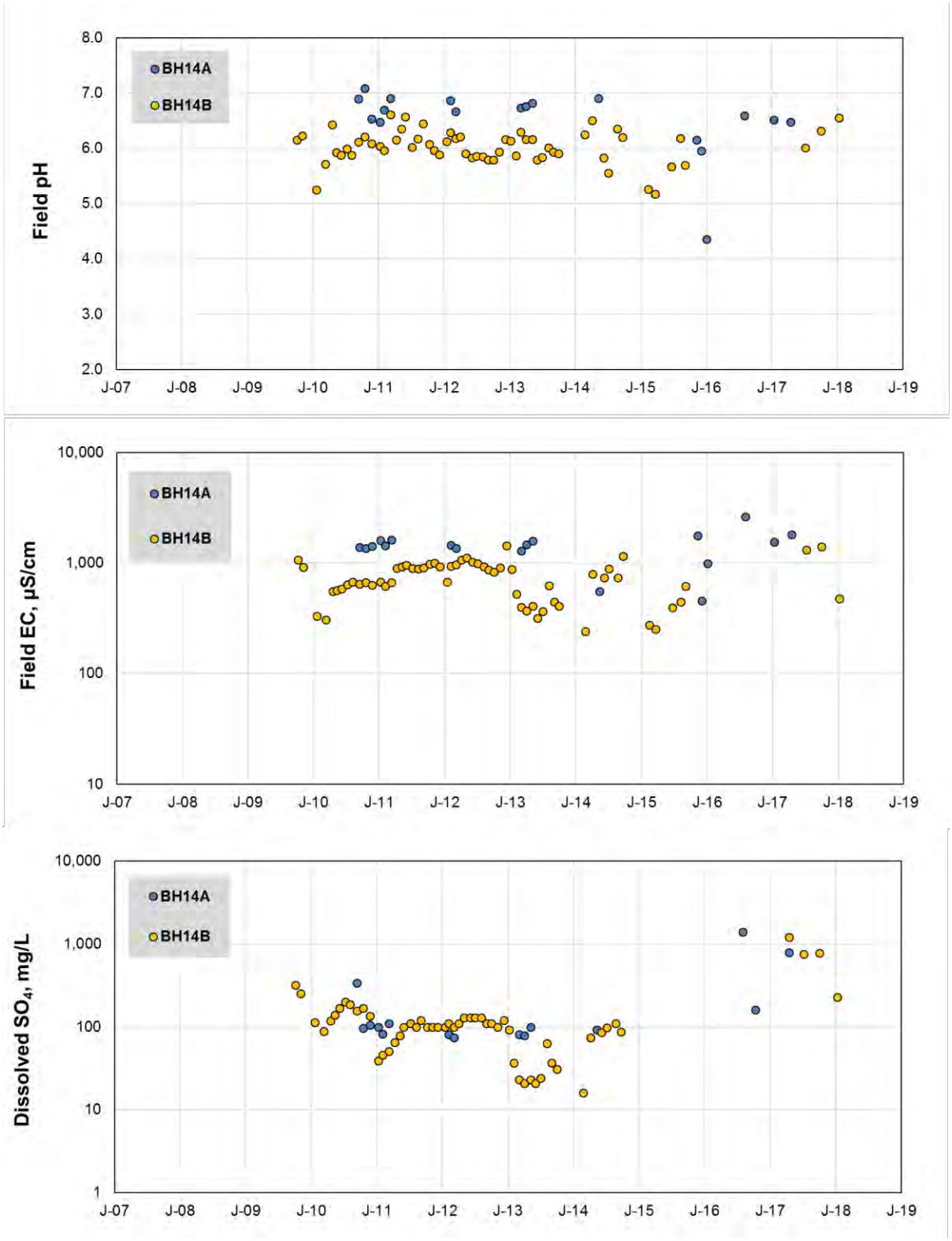


Figure D84. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH14A and BH14B, 2009 to 2018

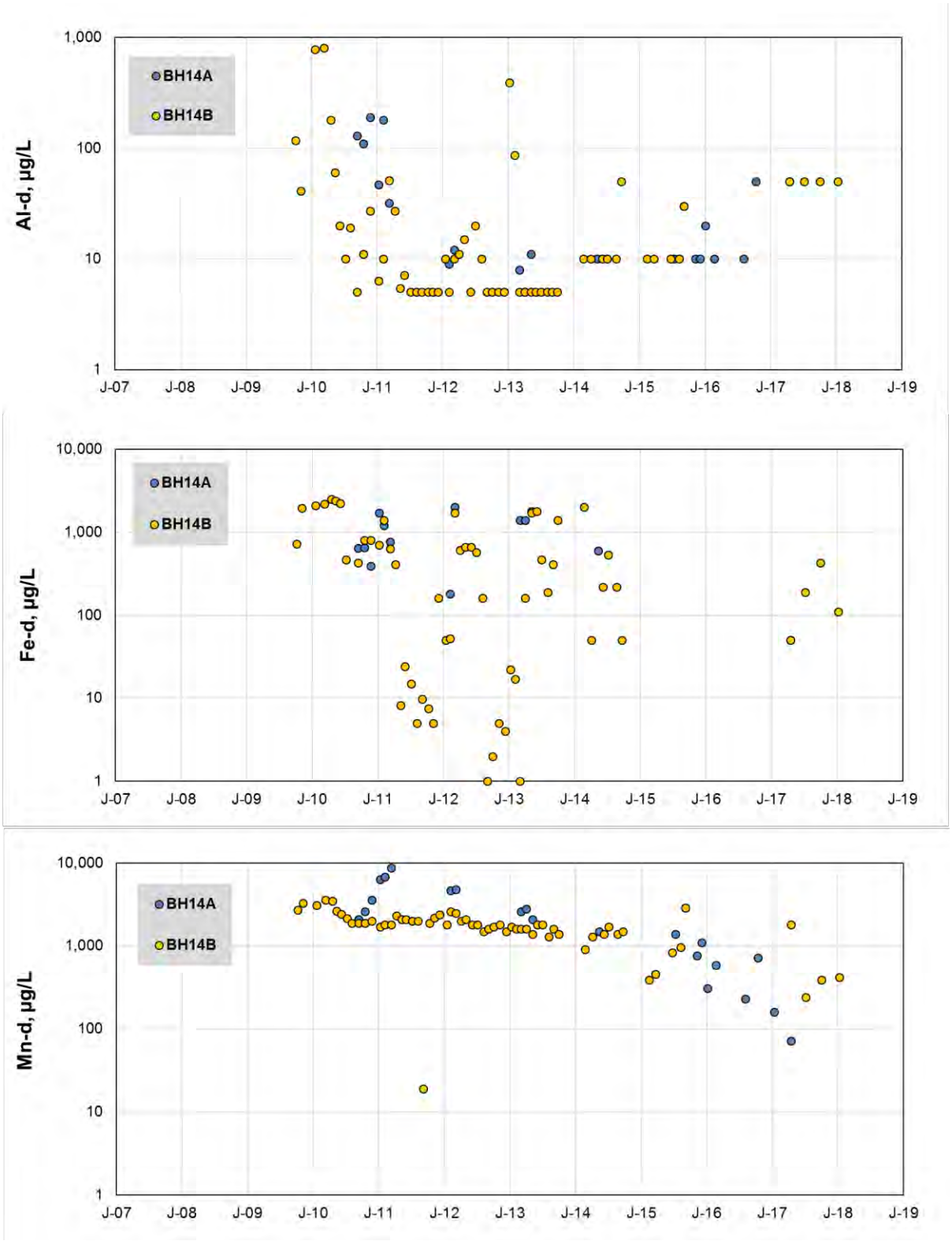
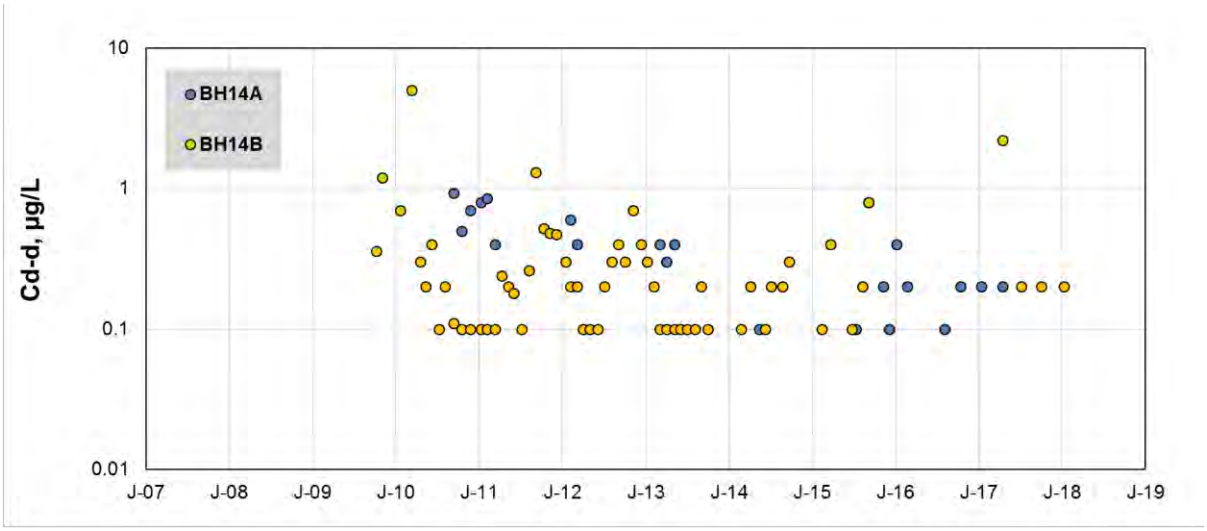
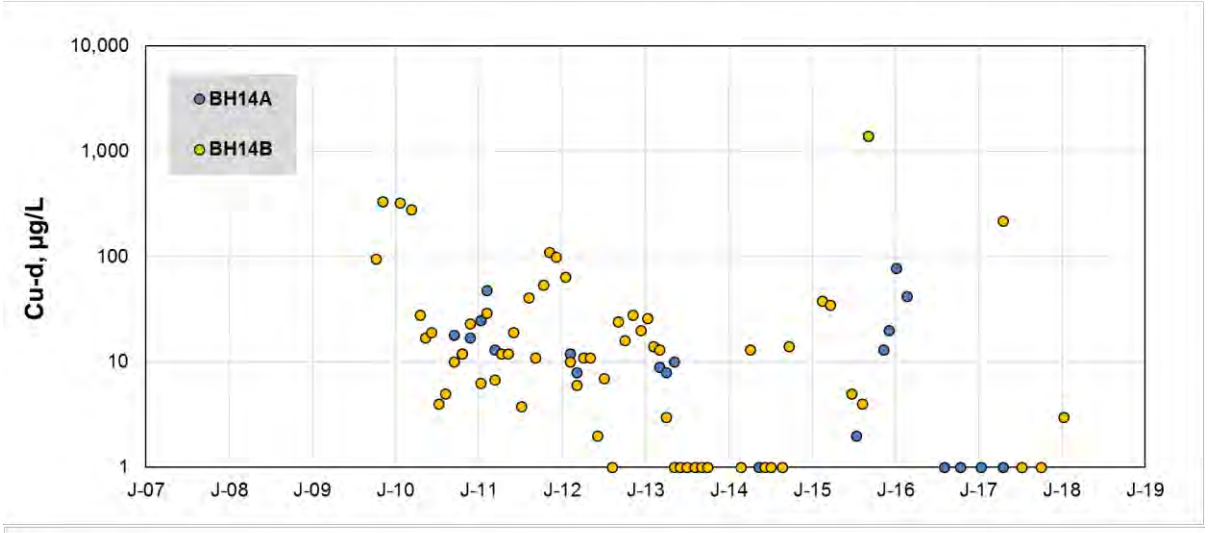


Figure D85. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH14A and BH14B, 2009 to 2018





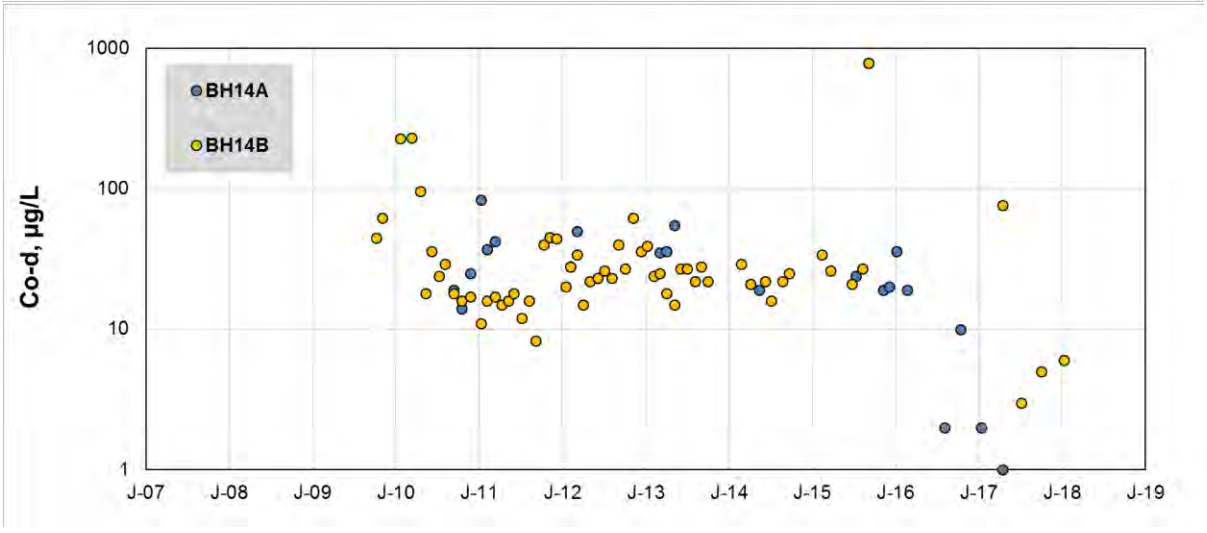
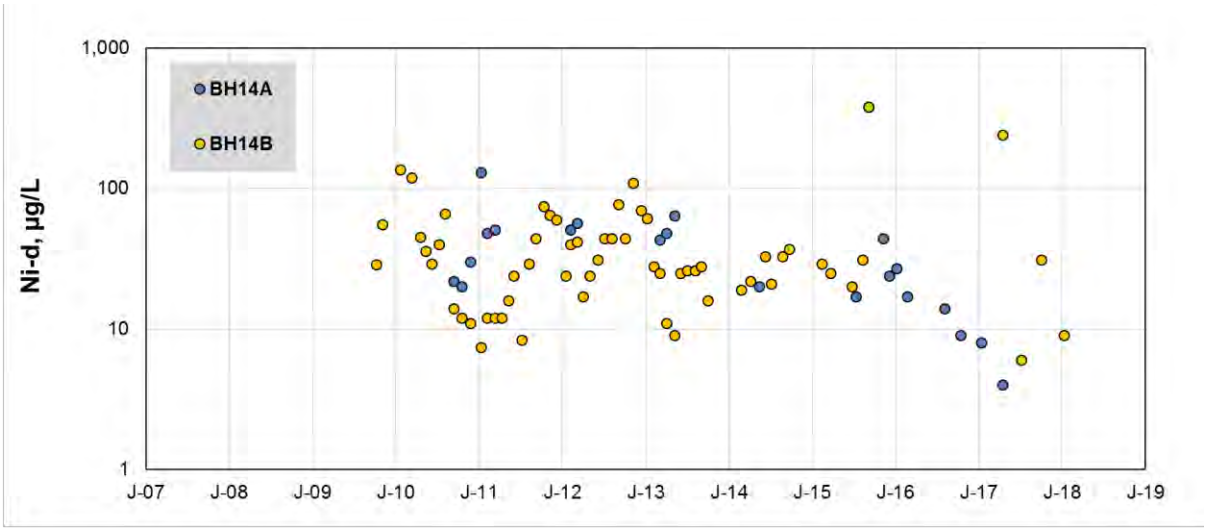
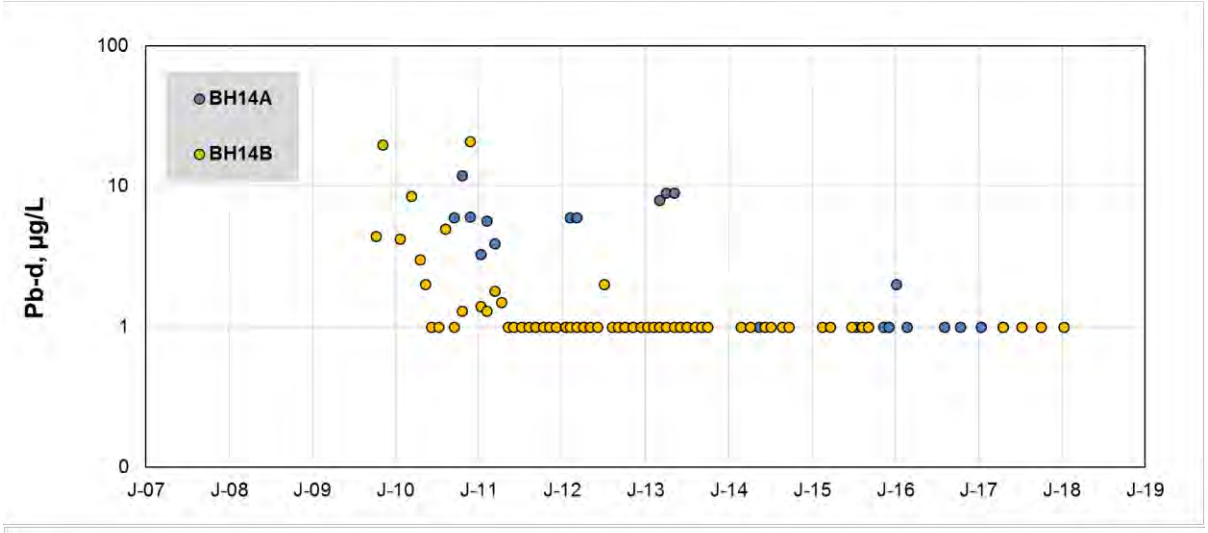


Figure D86. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH14A and BH14B, 2009 to 2018





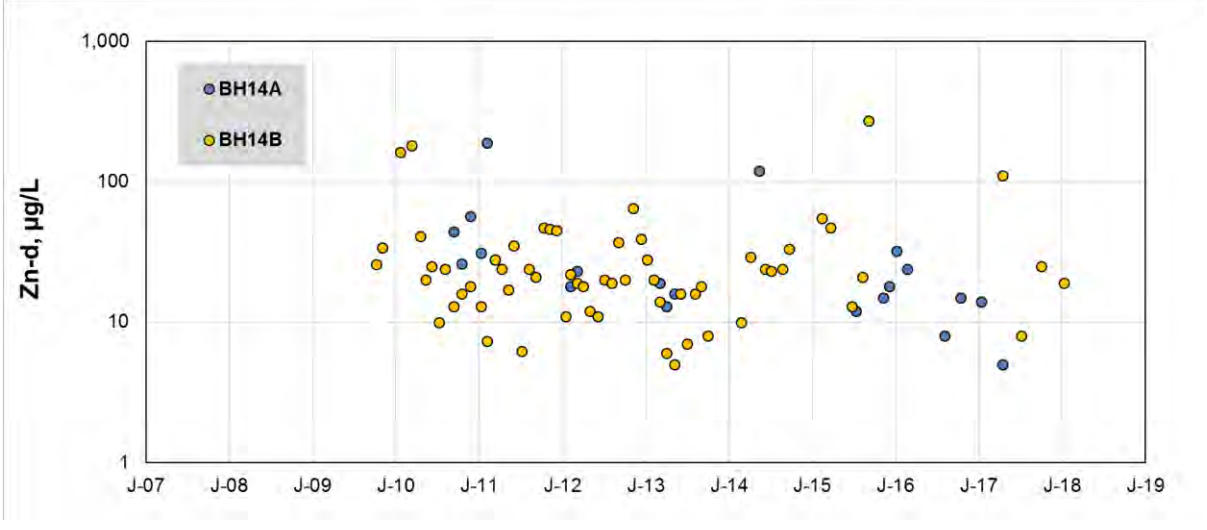


Figure D87. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH14A and BH14B, 2009 to 2018

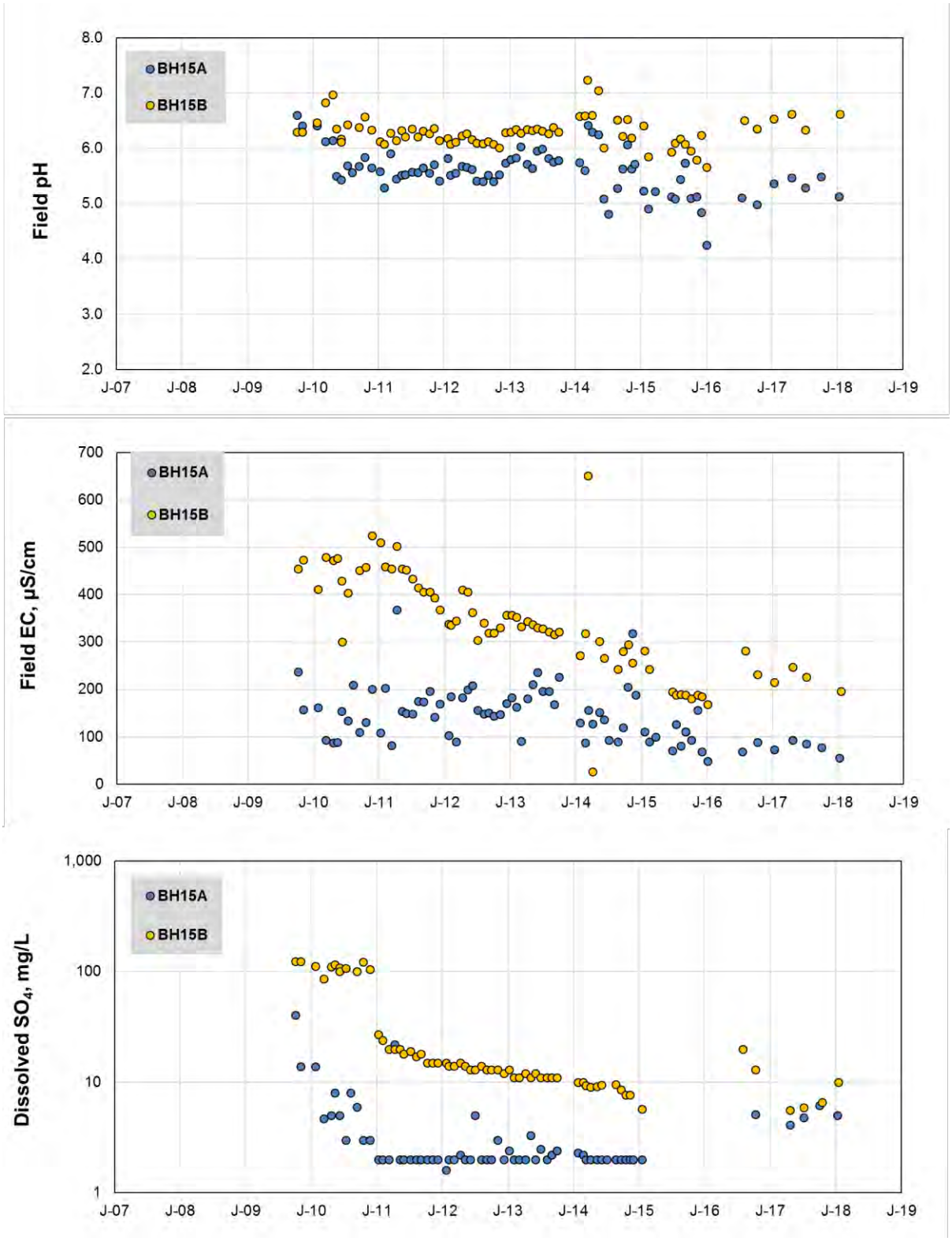


Figure D88. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH15A and BH15B, 2009 to 2018

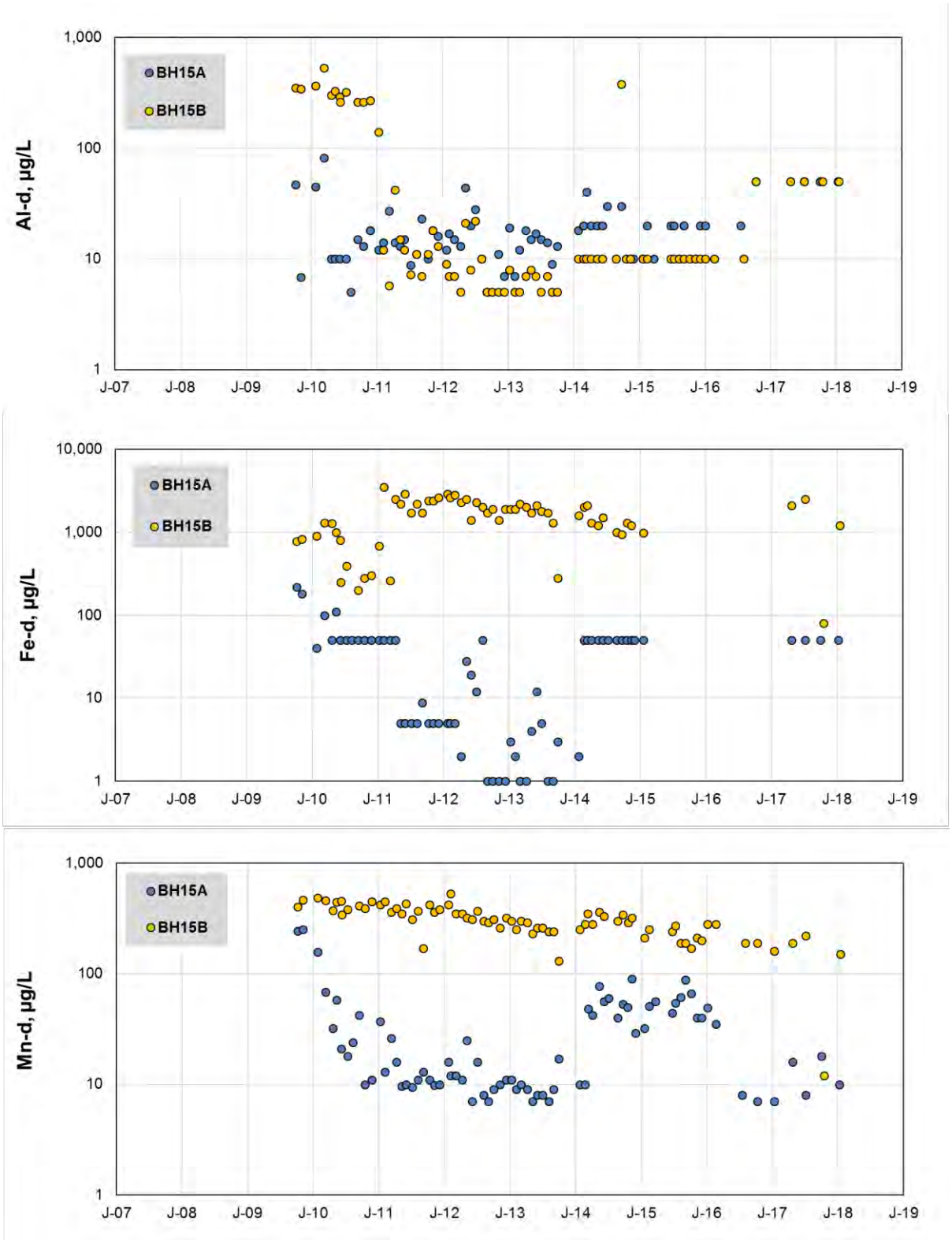


Figure D89. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH15A and BH15B, 2009 to 2018

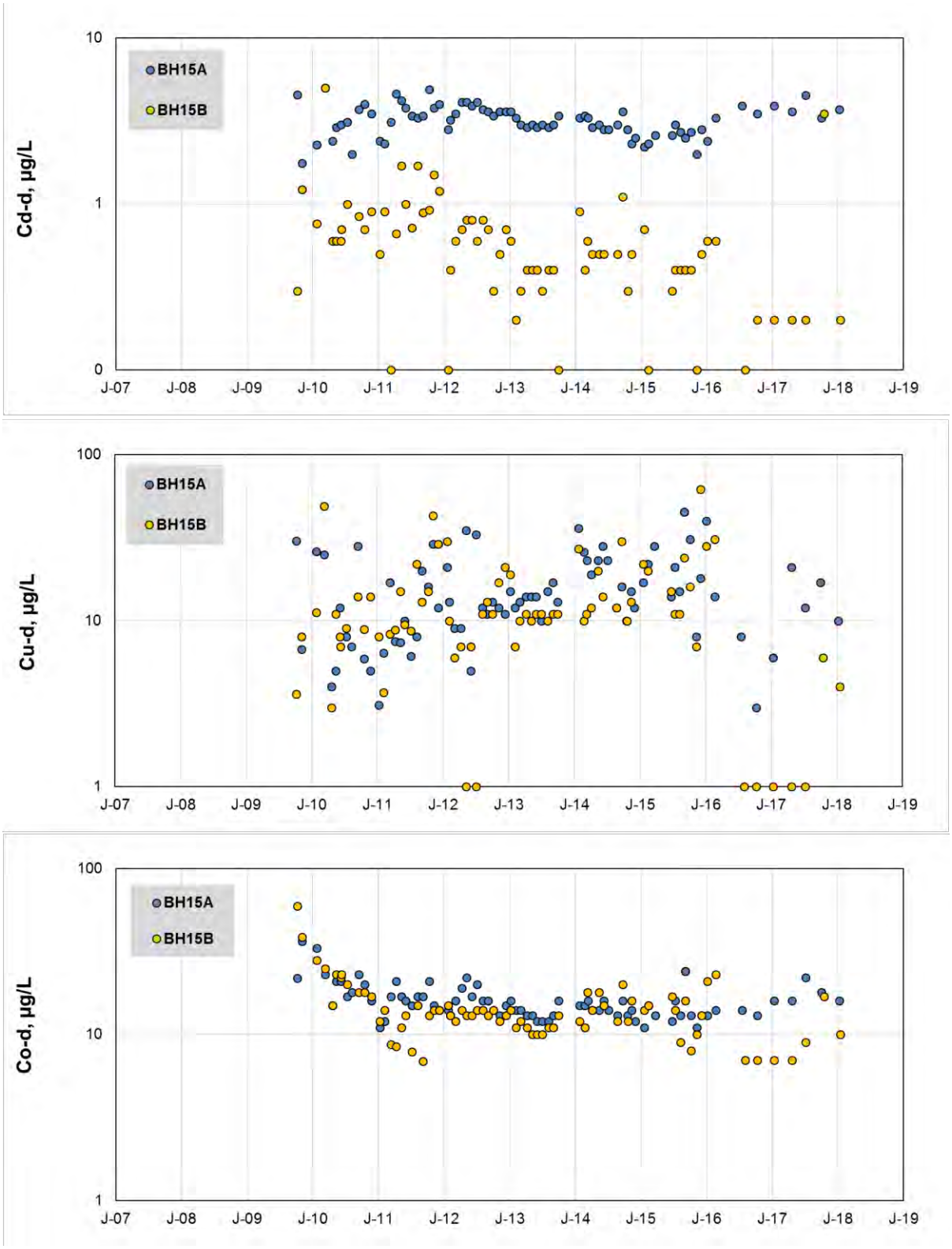


Figure D90. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH15A and BH15B, 2009 to 2018

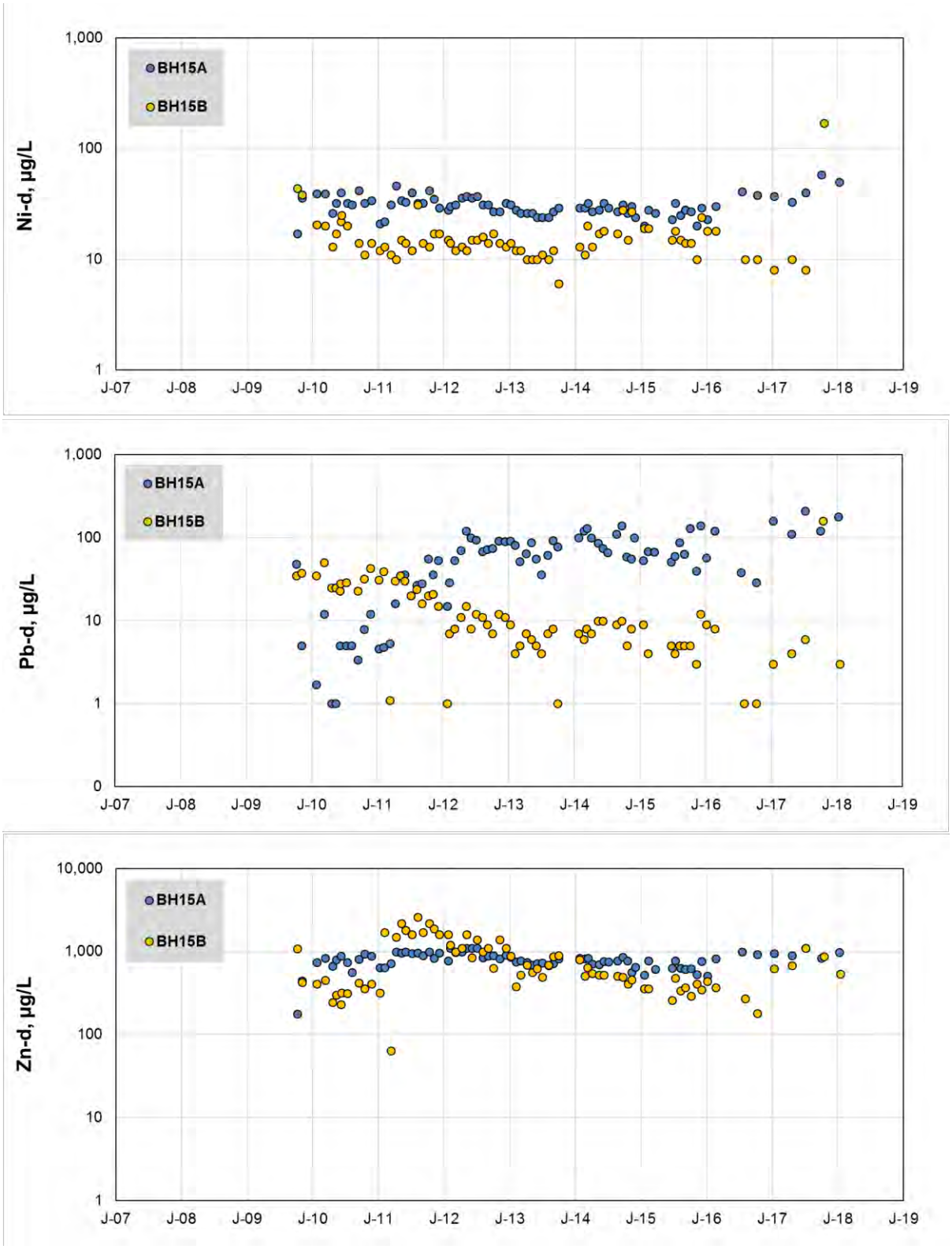


Figure D91. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH15A and BH15B, 2009 to 2018

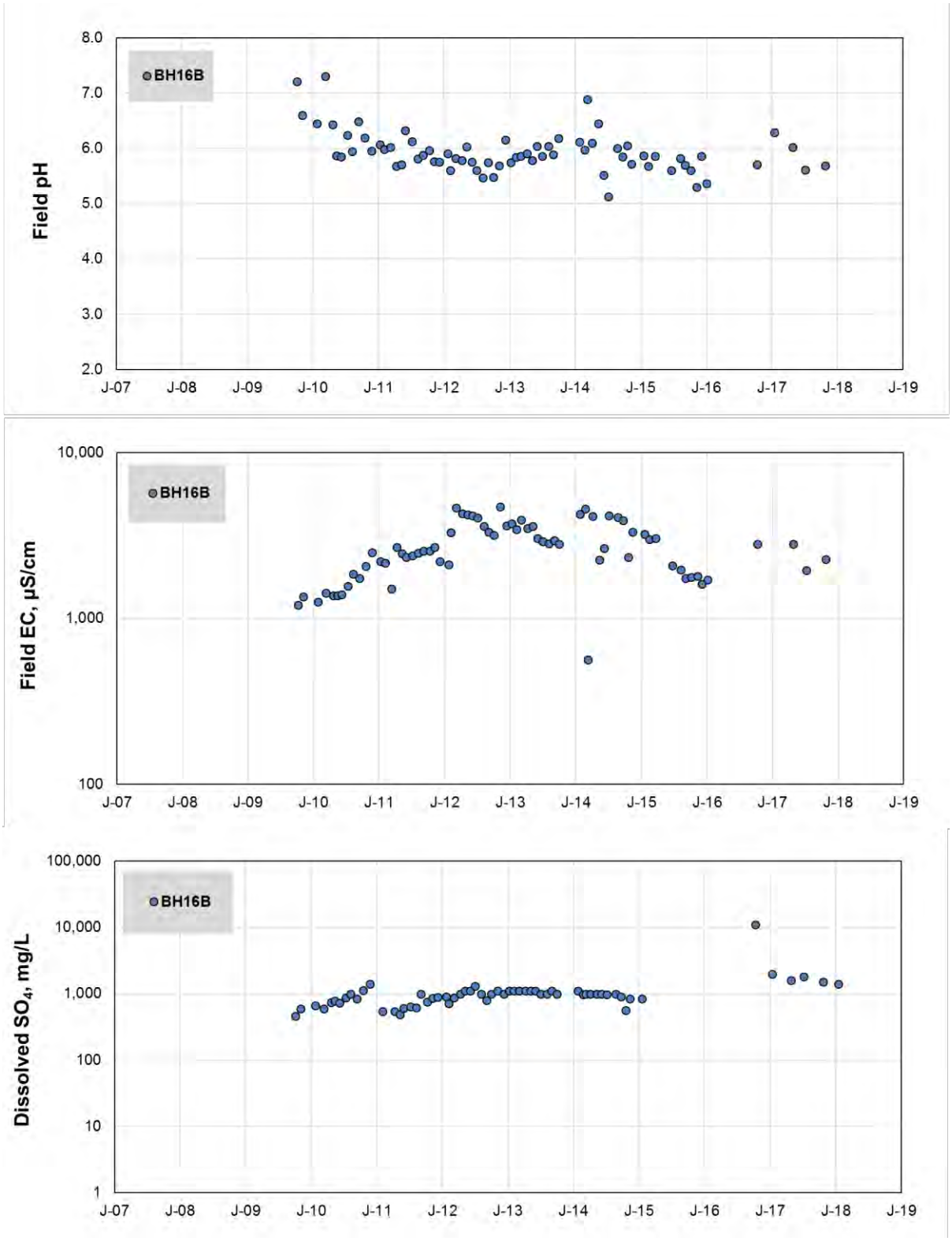


Figure D92. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH16B, 2009 to 2018

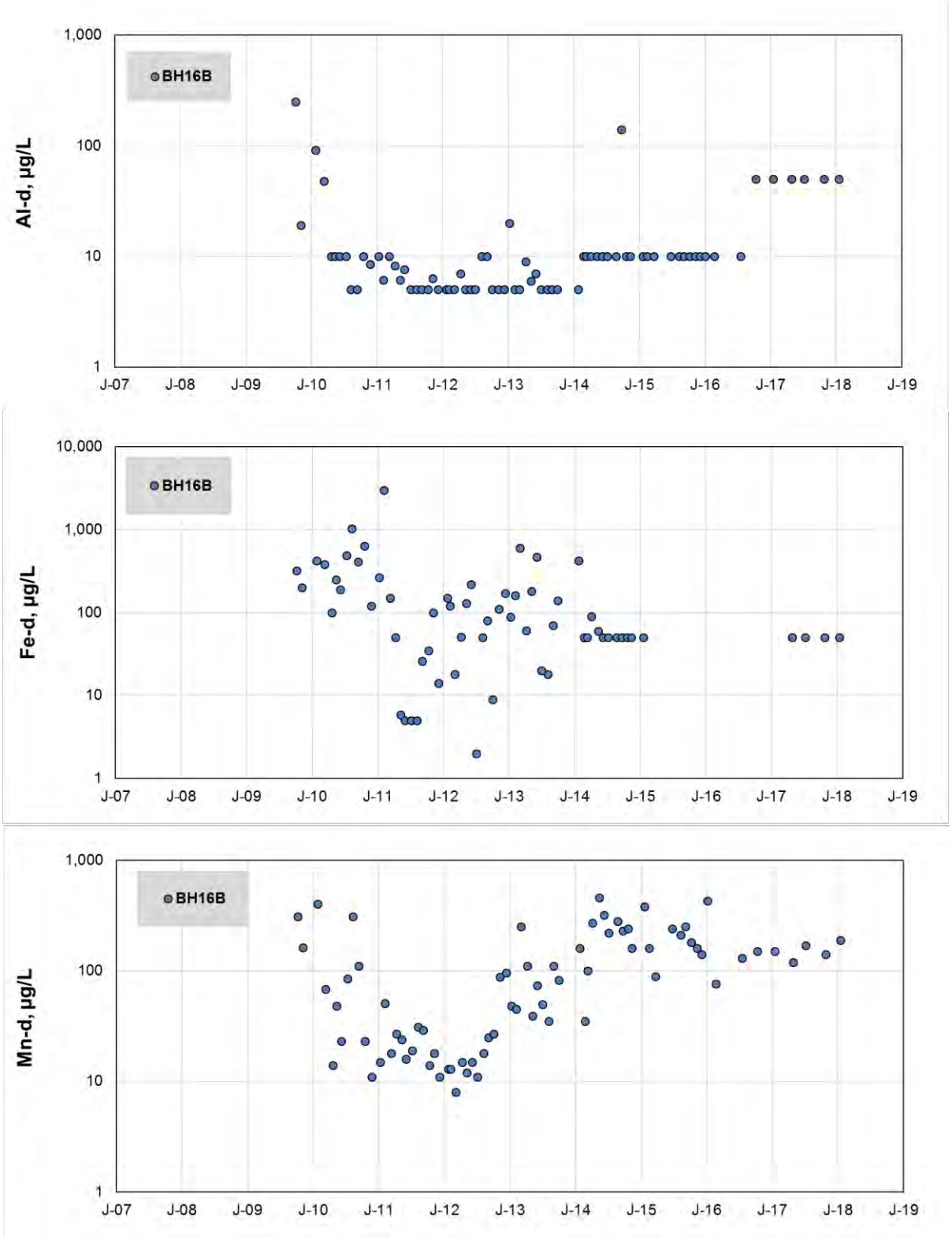
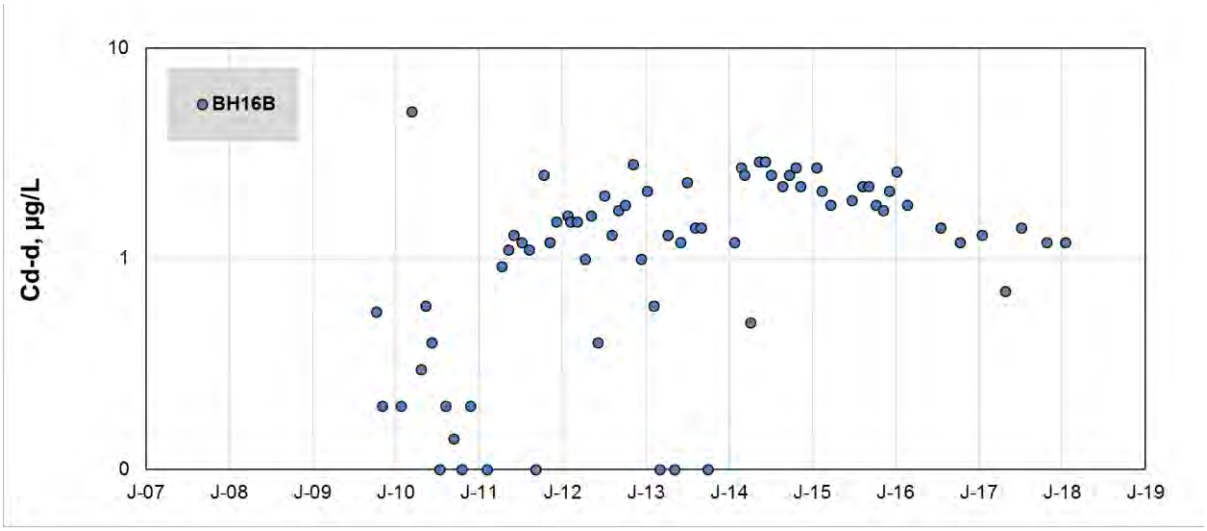
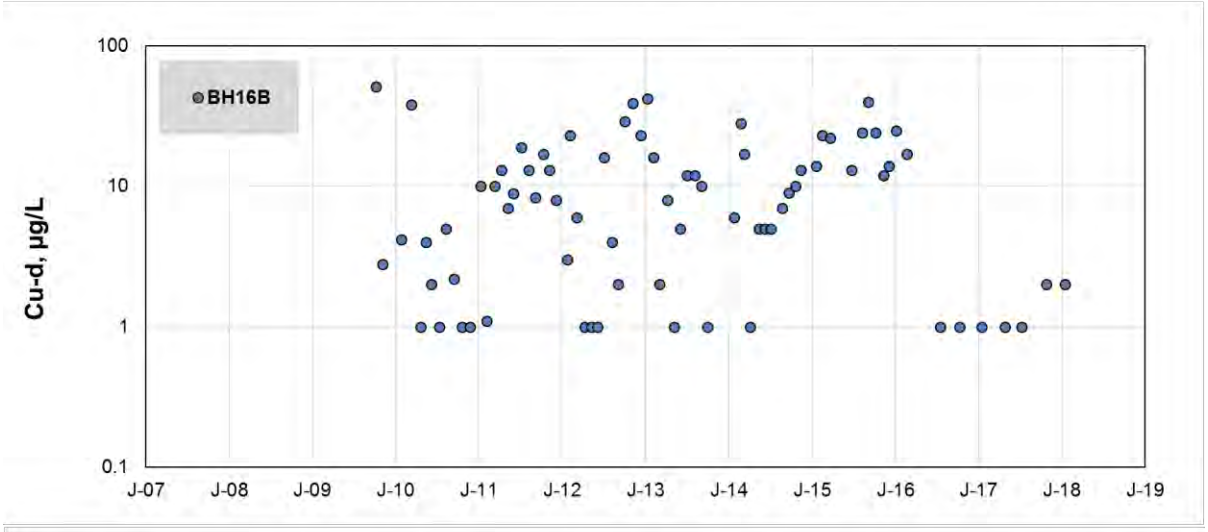


Figure D93. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH16B, 2009 to 2018





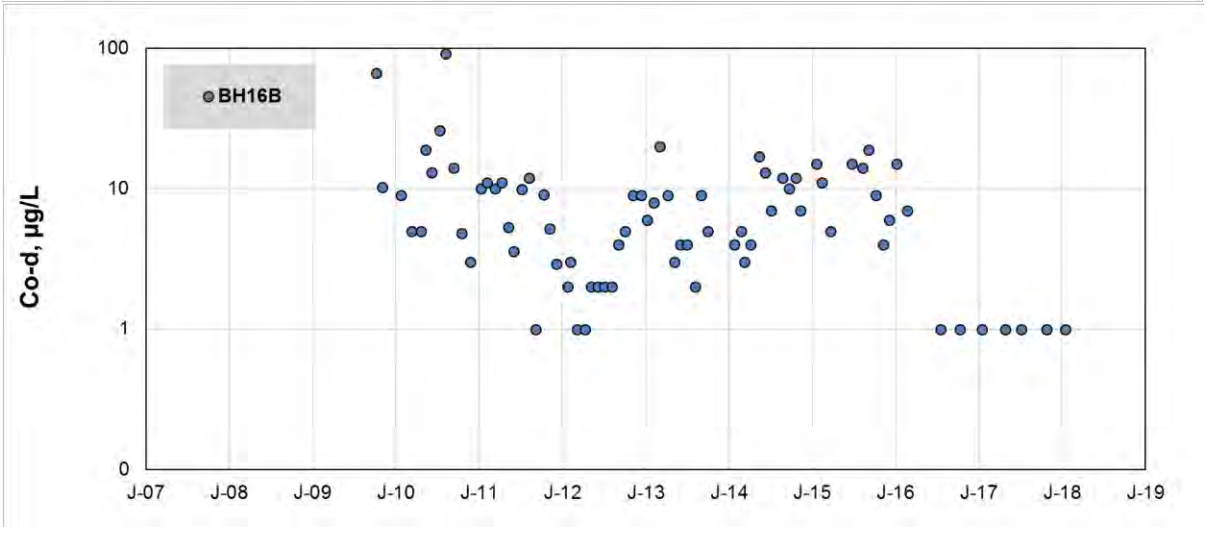
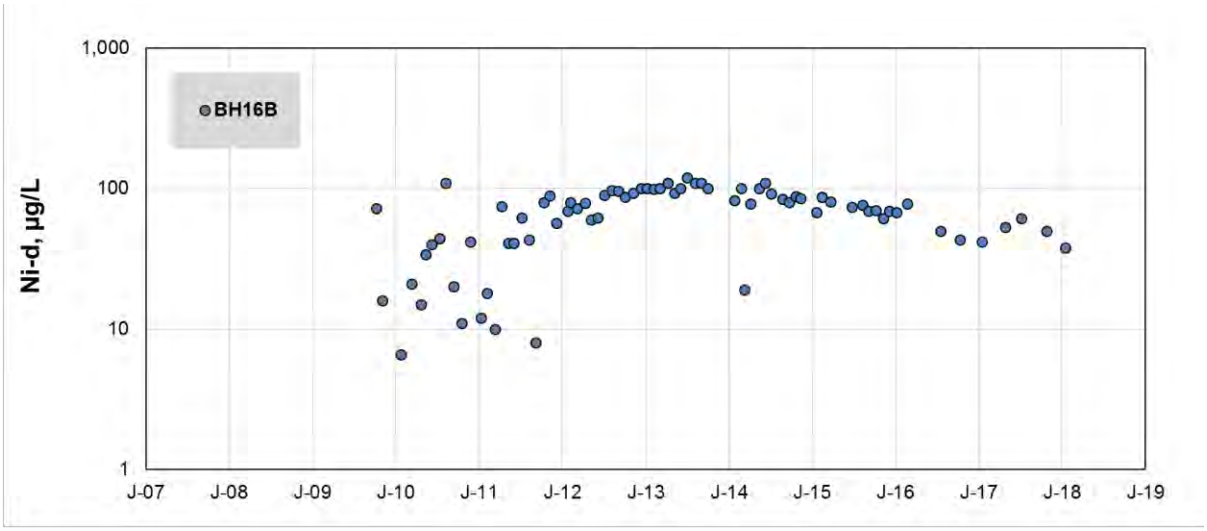
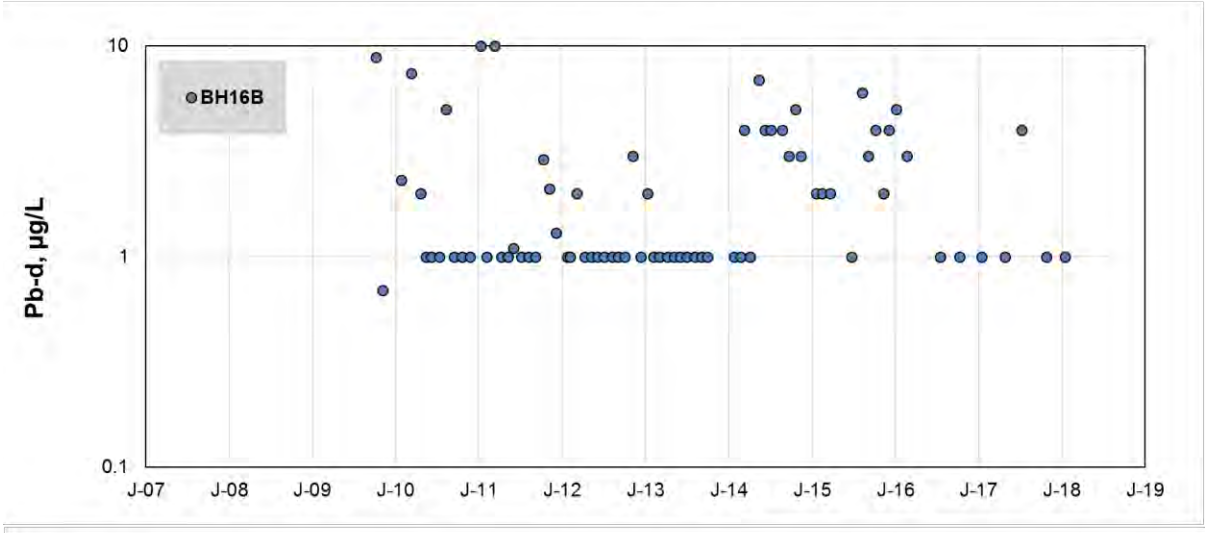


Figure D94. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH16B, 2009 to 2018





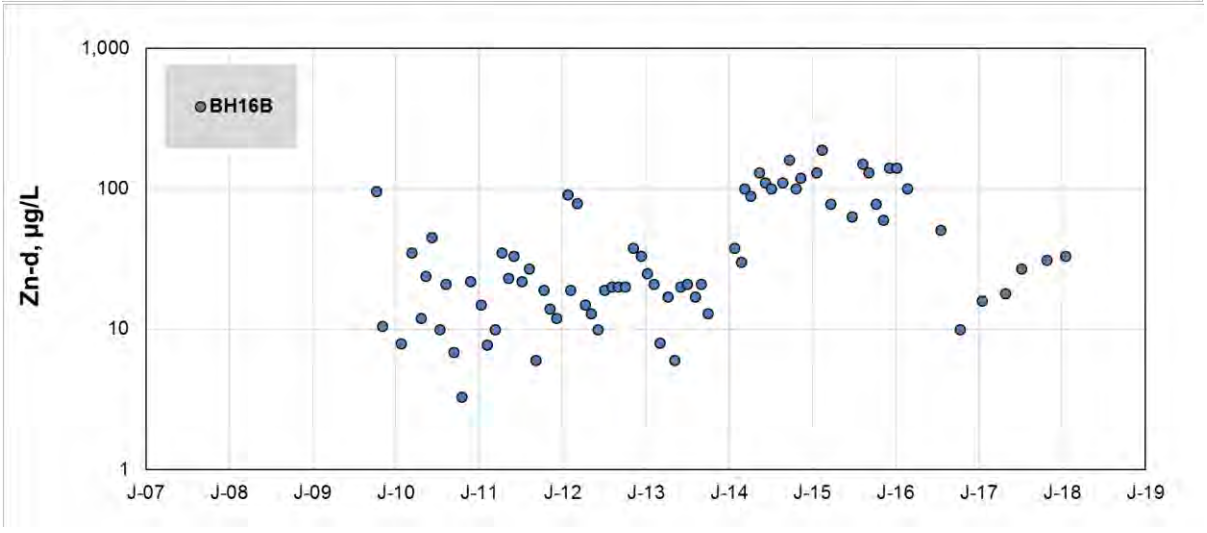


Figure D95. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH16B, 2009 to 2018

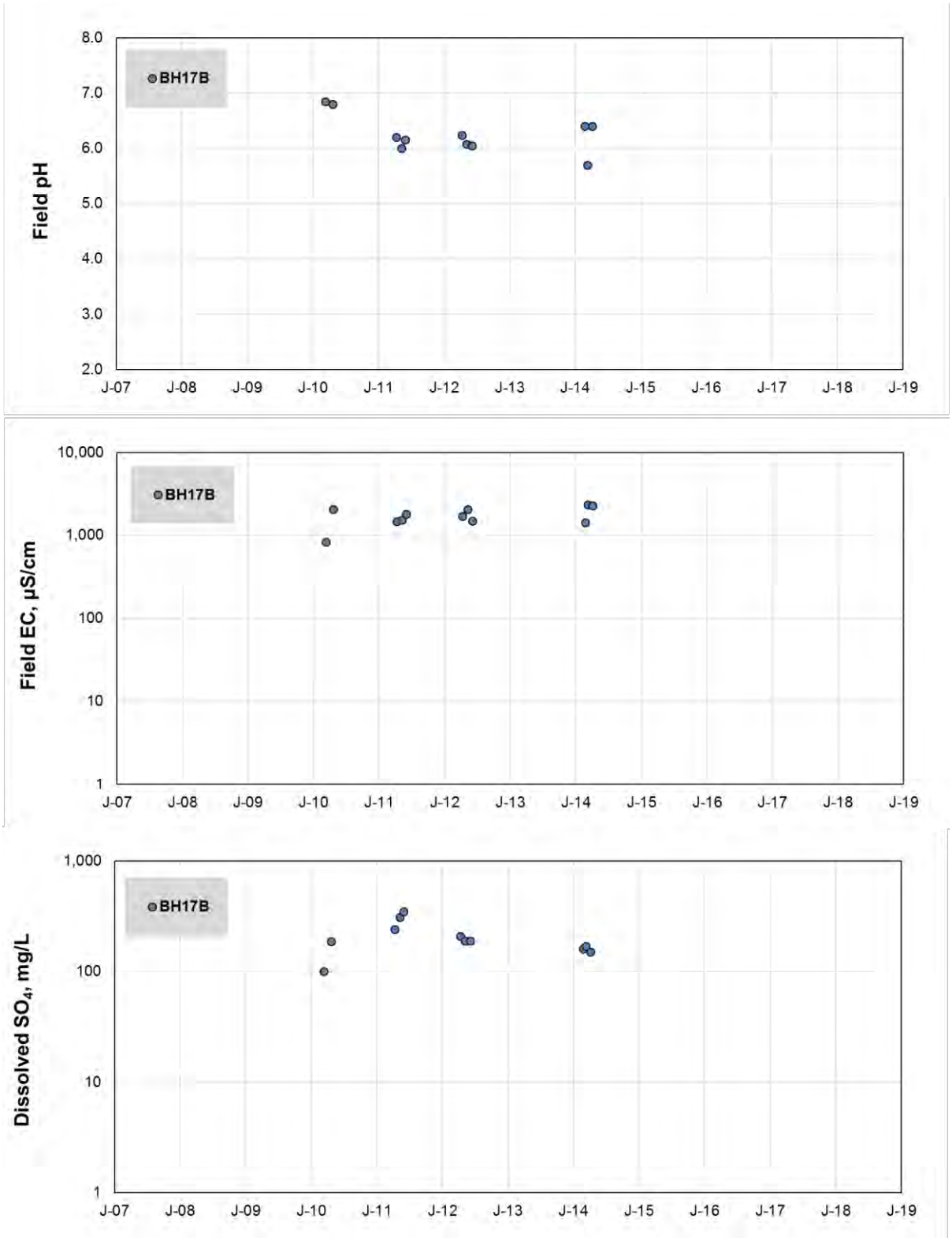


Figure D96. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore BH17B, 2010 to 2018

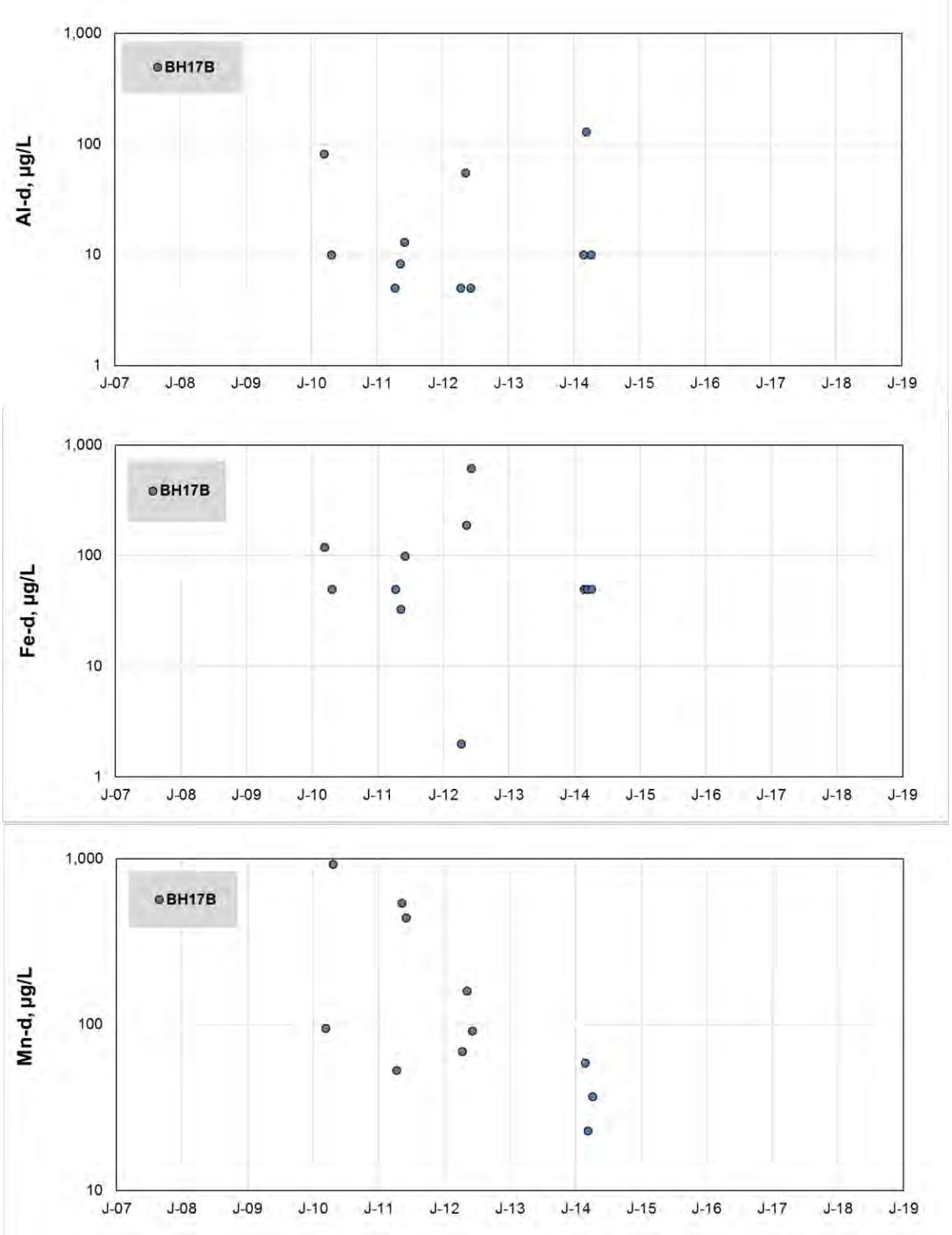
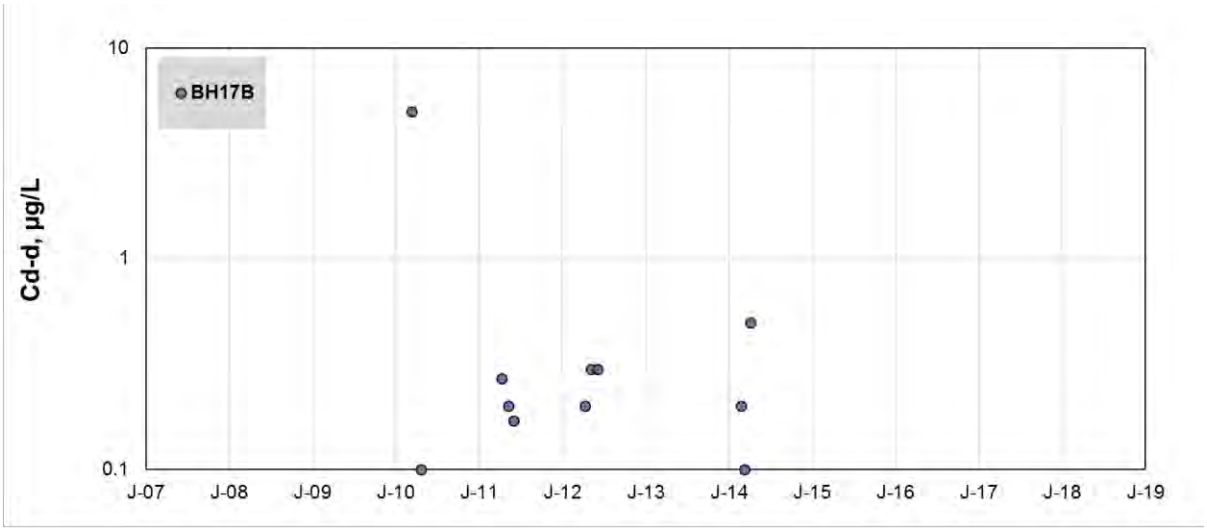
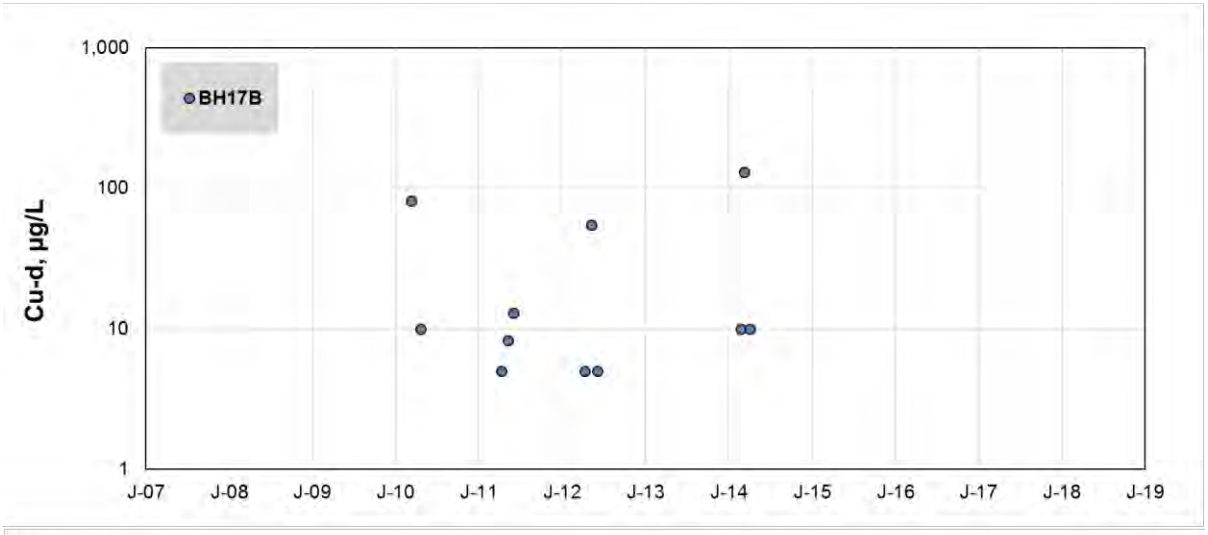


Figure D97. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore BH17B, 20010 to 2018





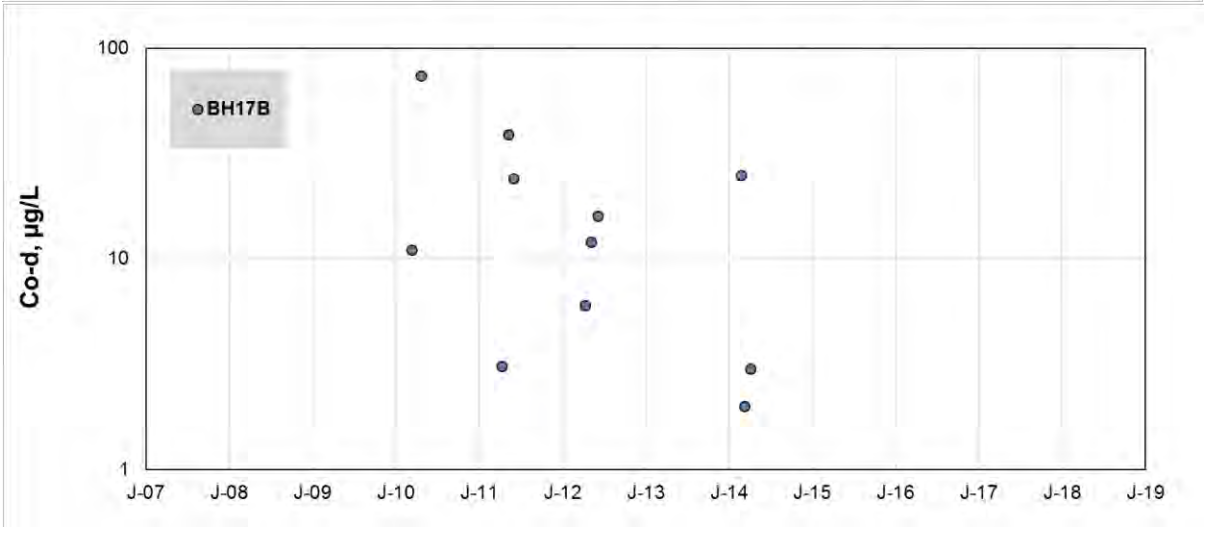


Figure D98. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore BH17B, 2010 to 2018

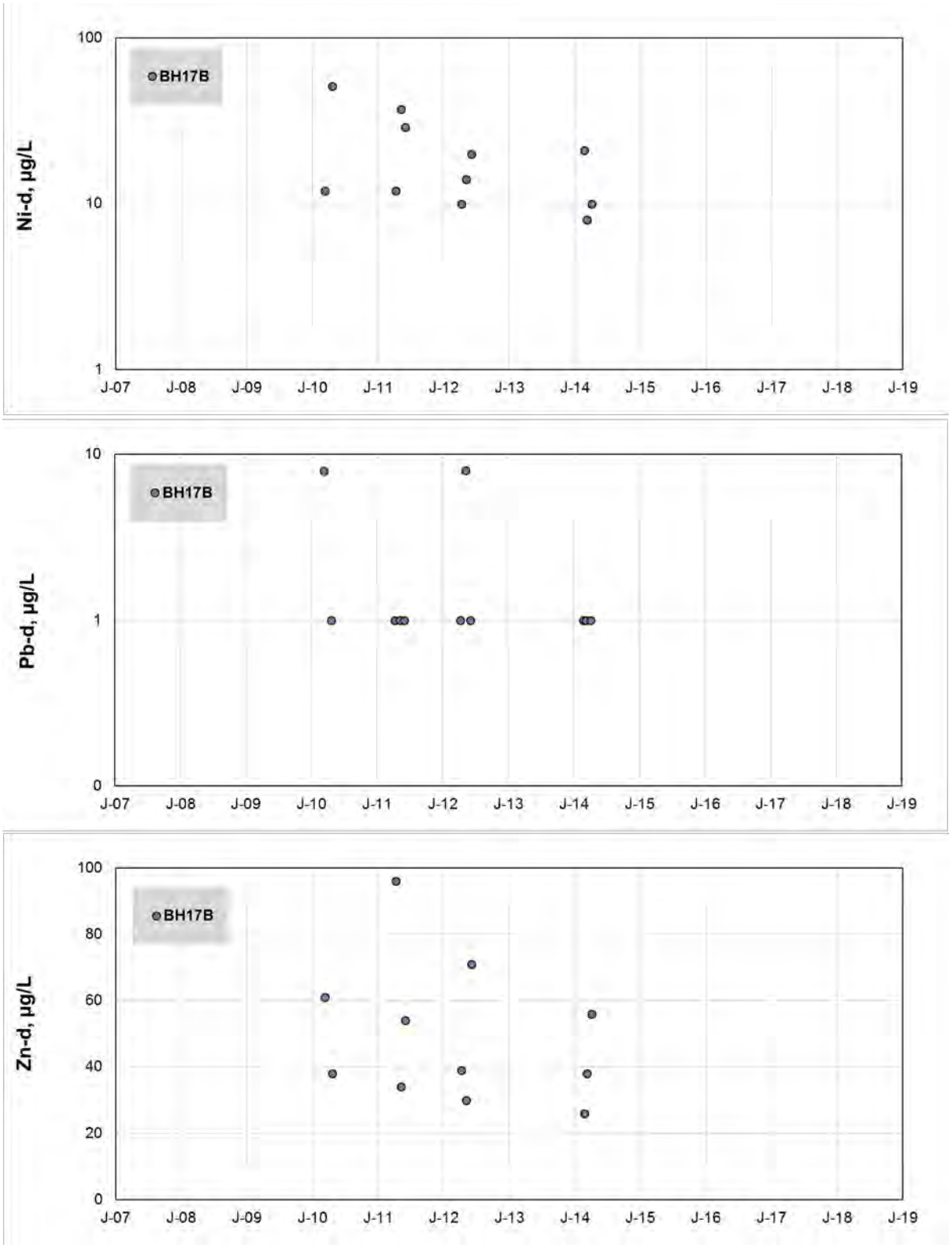


Figure D99. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore BH17B, 2010 to 2018

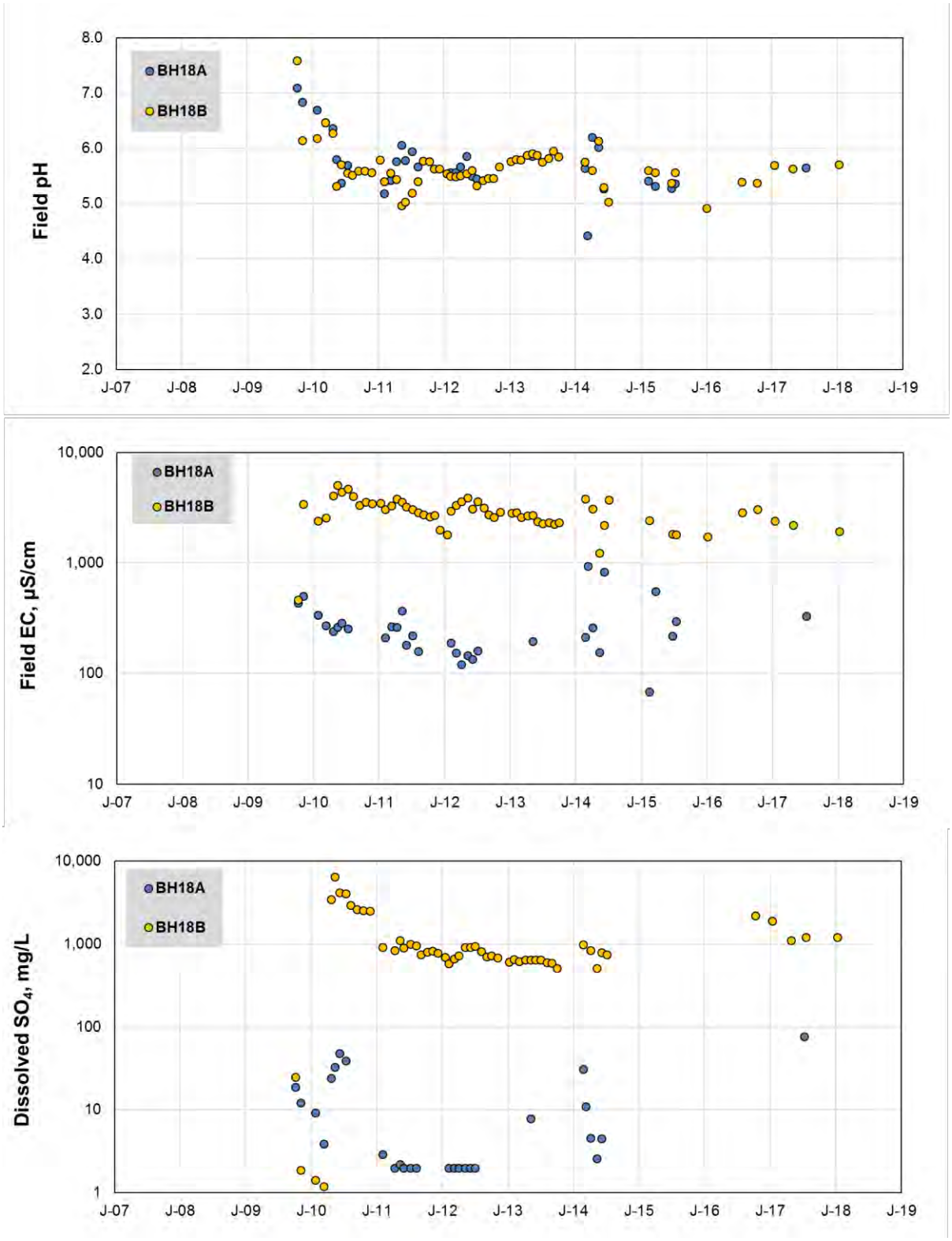


Figure D100. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores BH18A and BH18B, 2009 to 2018

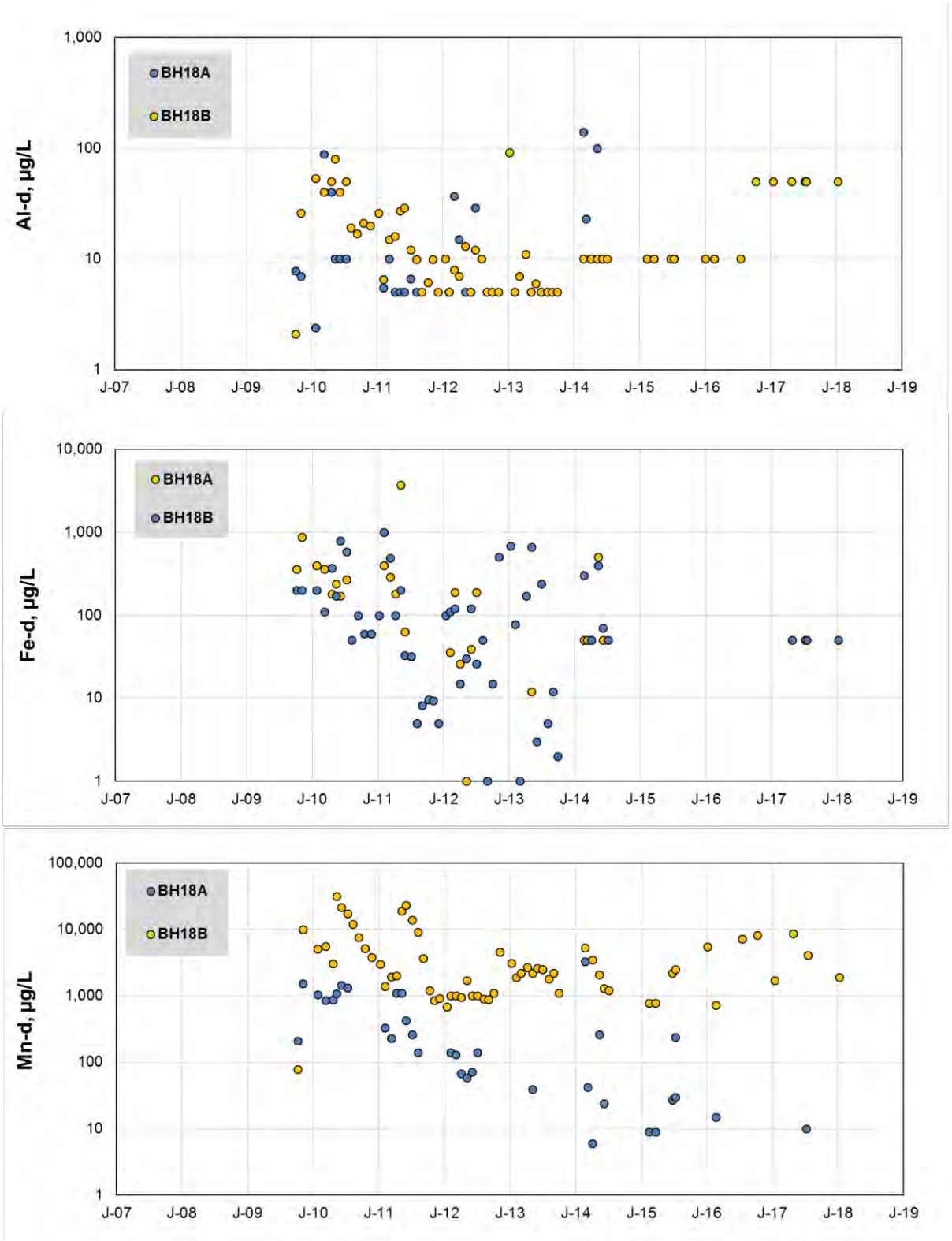


Figure D101. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores BH18A and BH18B, 2009 to 2018

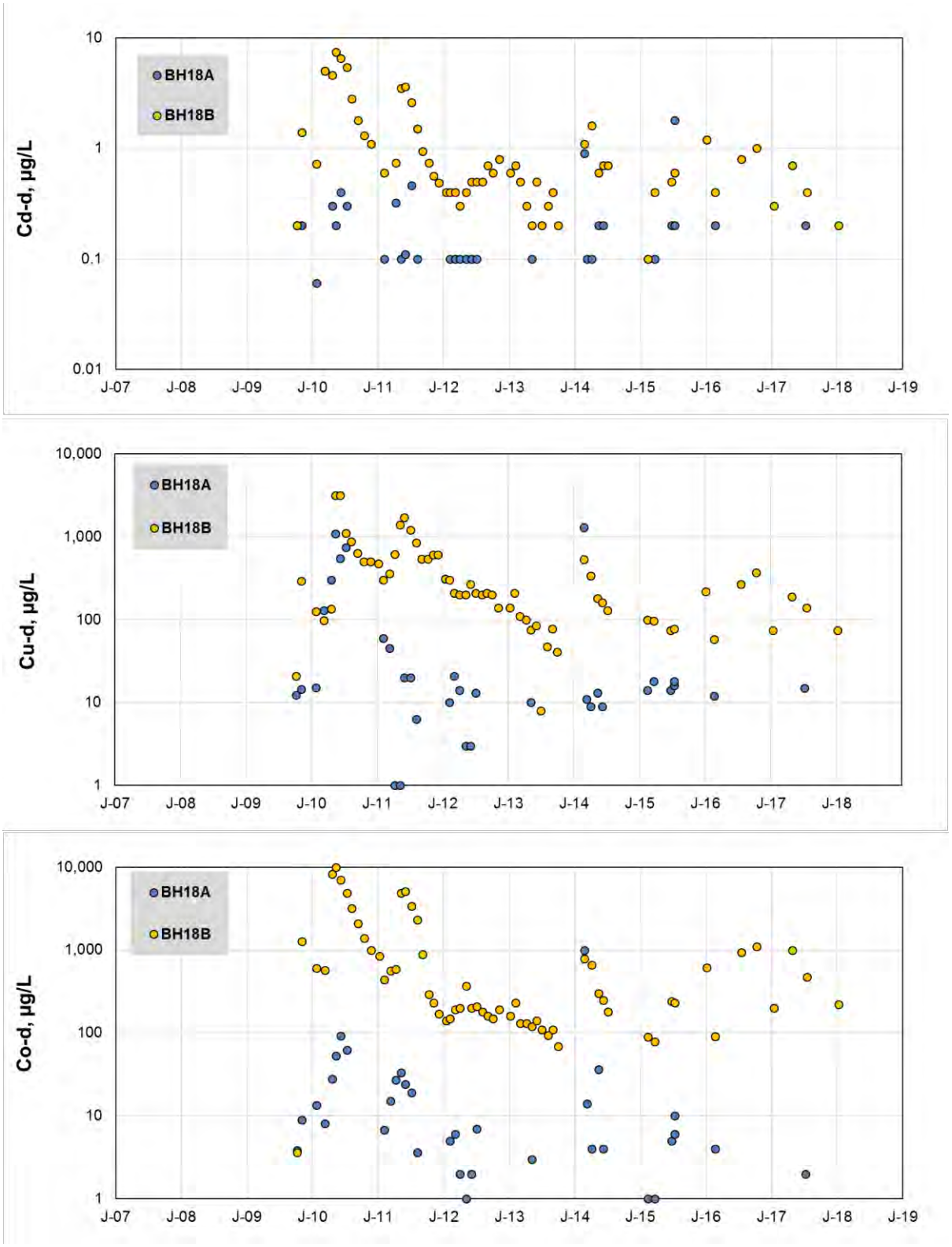
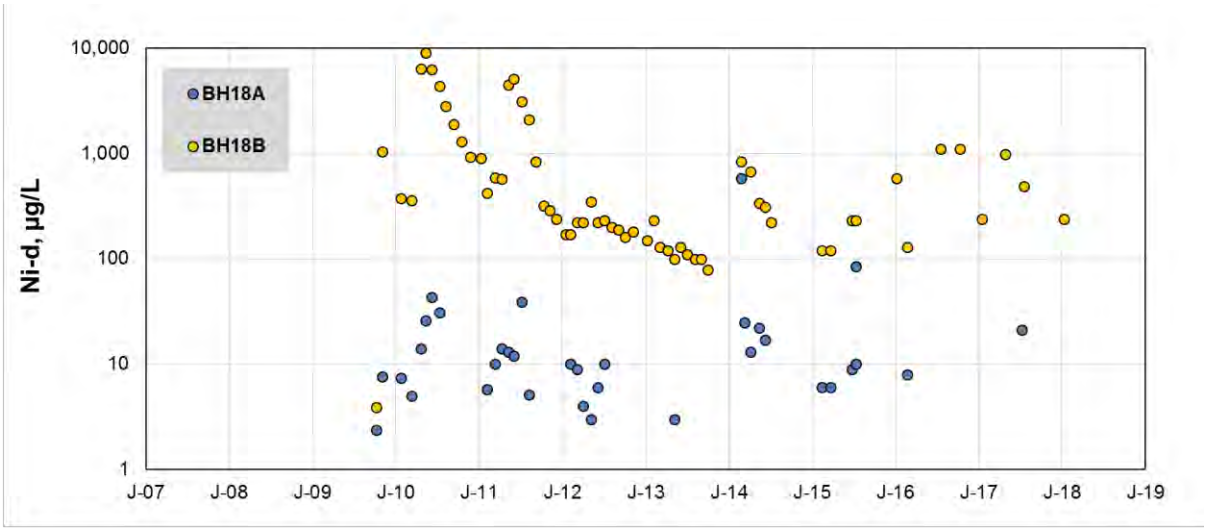
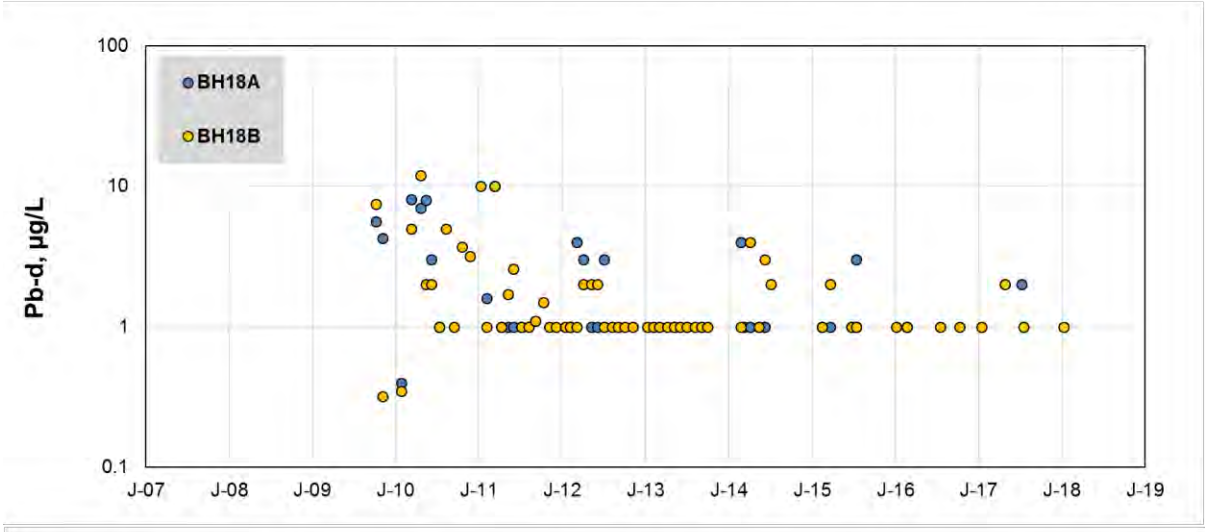


Figure D102. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores BH18A and BH18B, 2009 to 2018





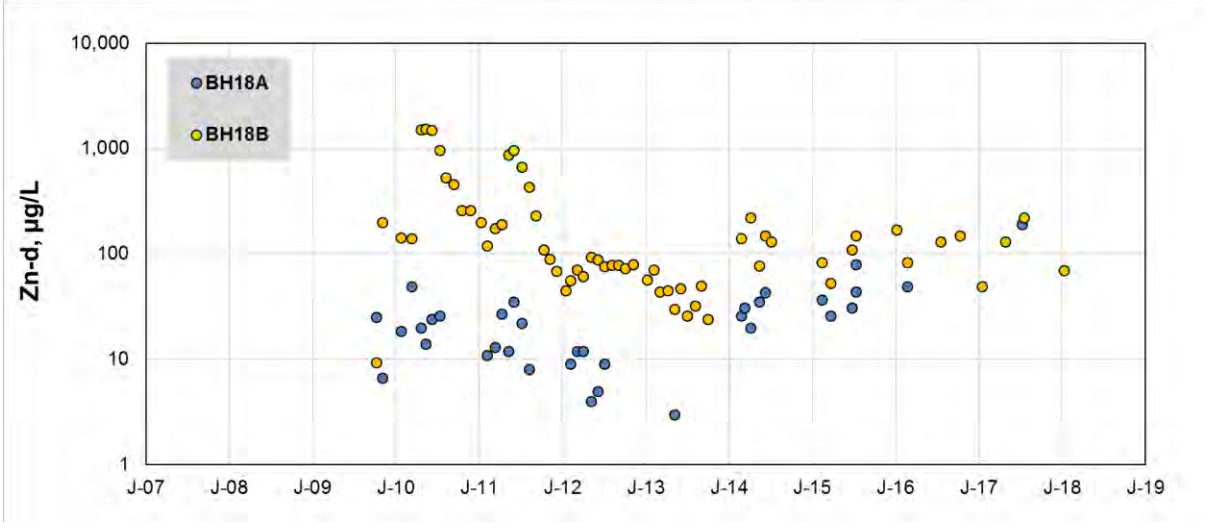


Figure D103. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores BH18A and BH18B, 2009 to 2018

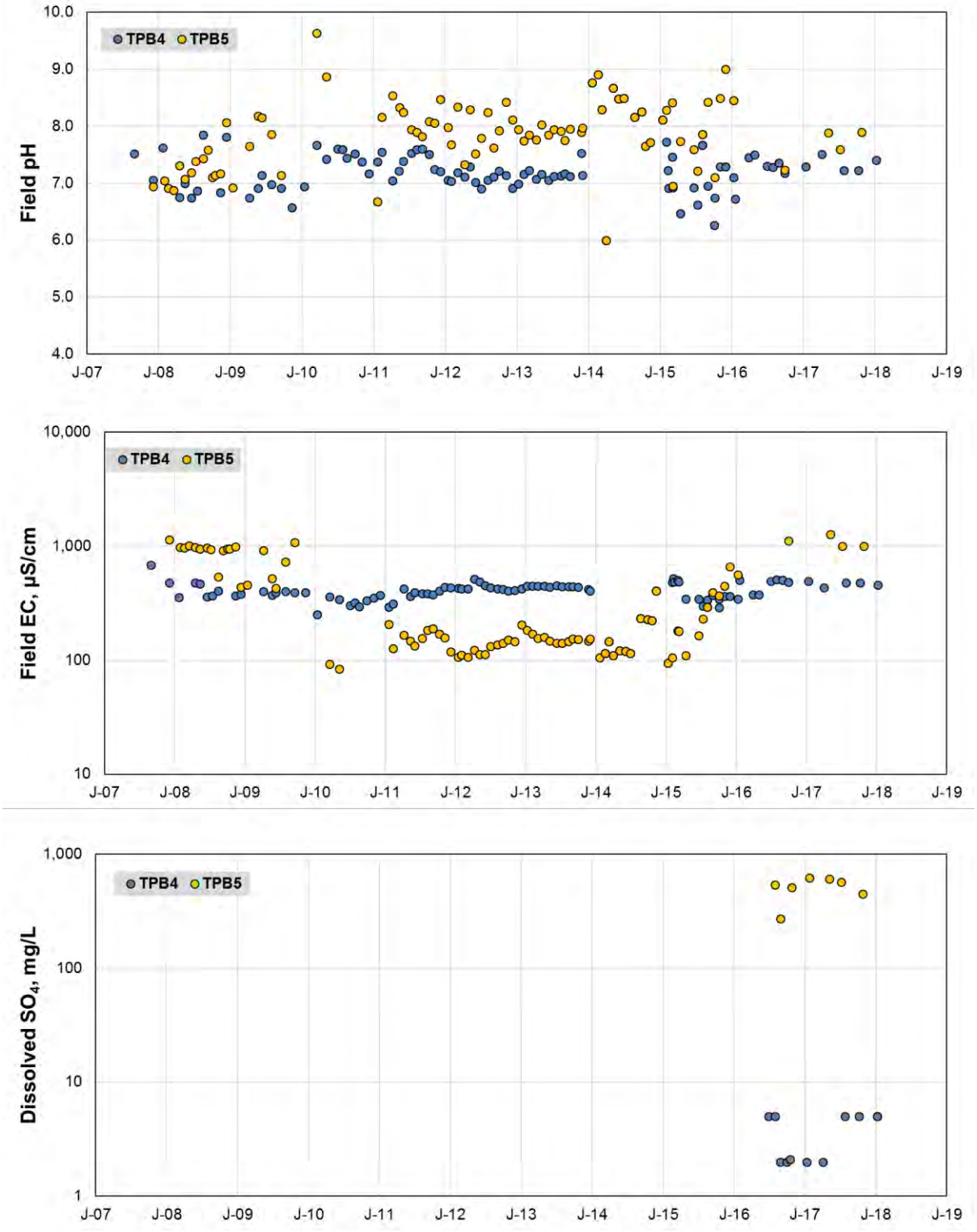


Figure D104. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores TPB4 and TPB5, 2007 to 2018

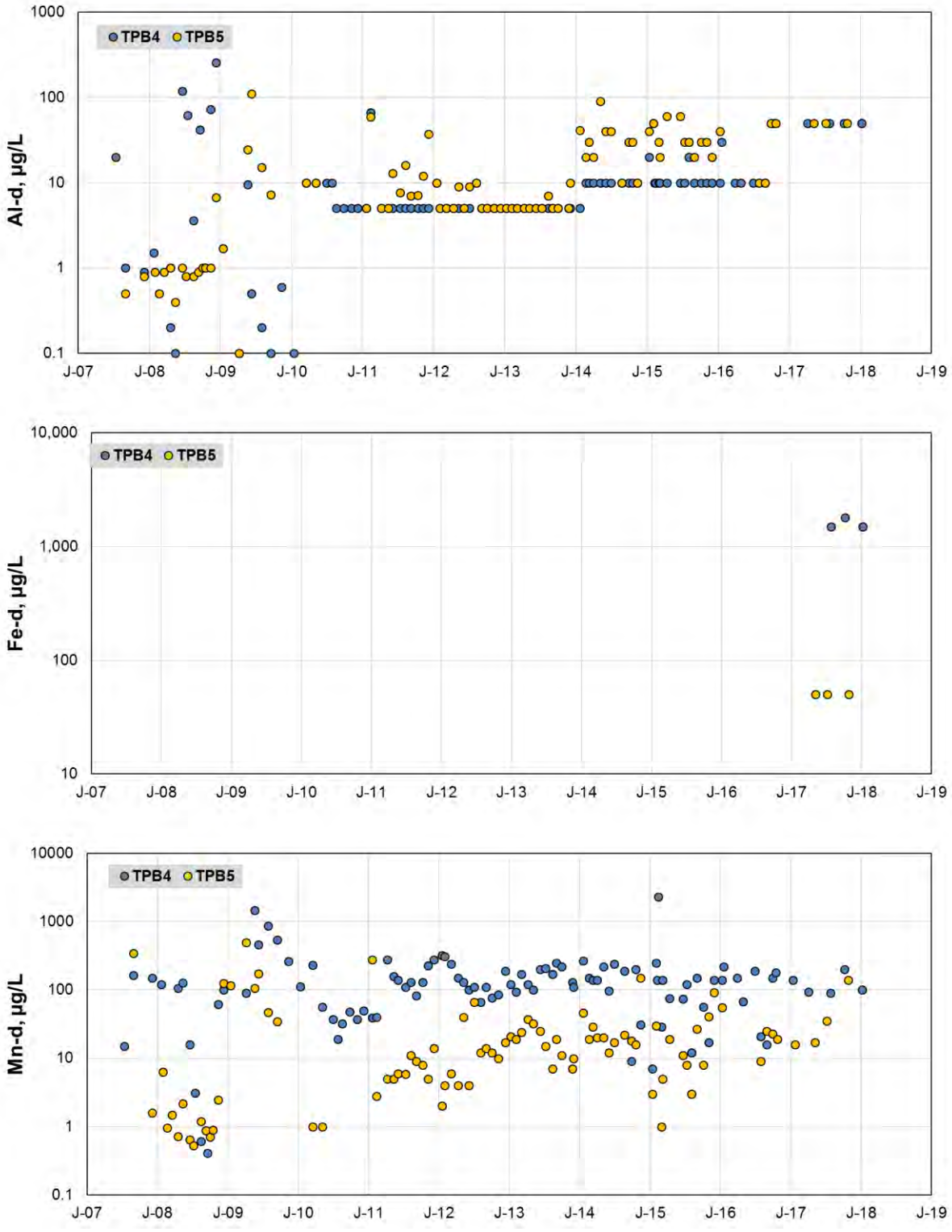


Figure D105. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores TPB4 and TPB5, 2007 to 2018

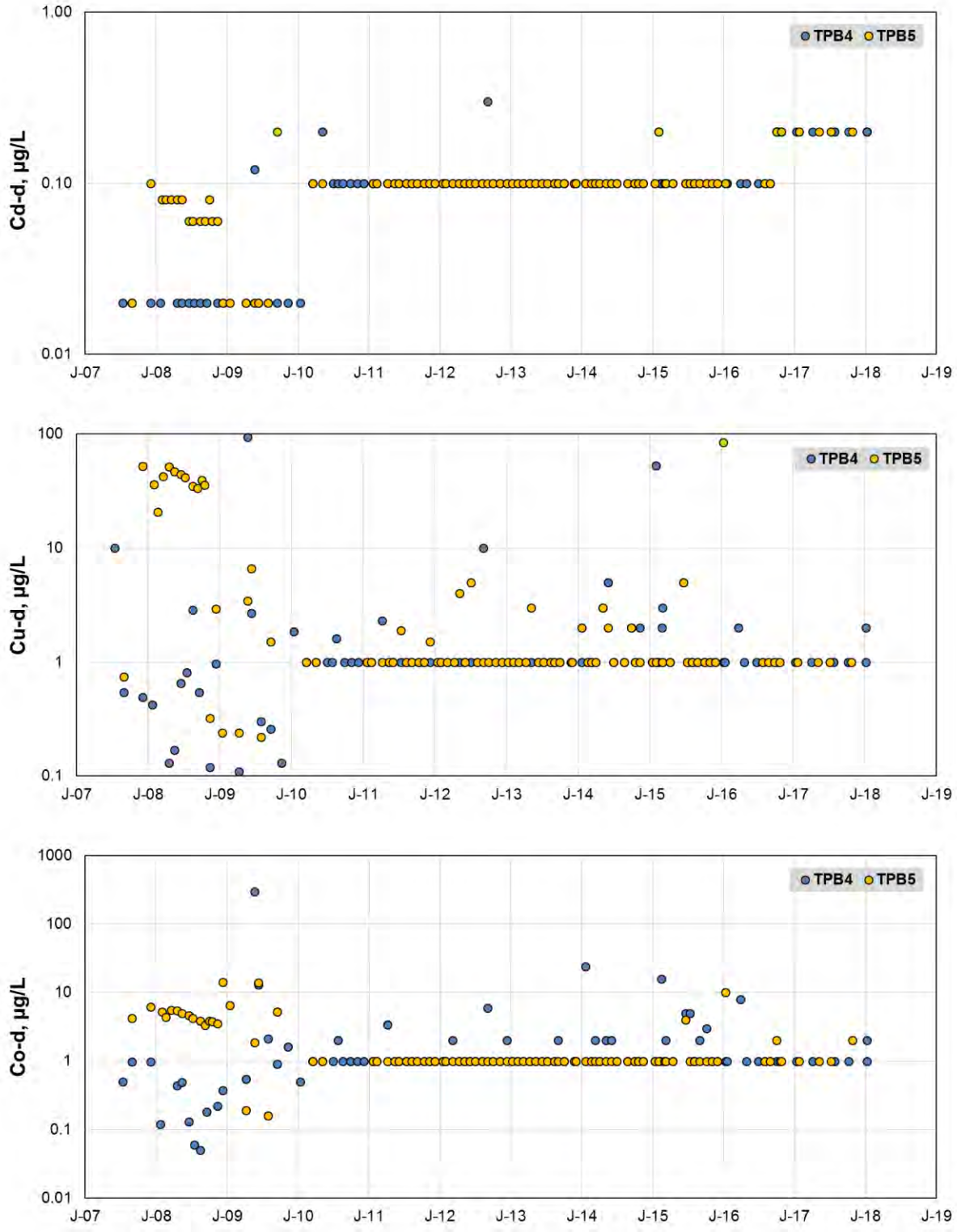


Figure D106. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores TPB4 and TPB5, 2007 to 2018

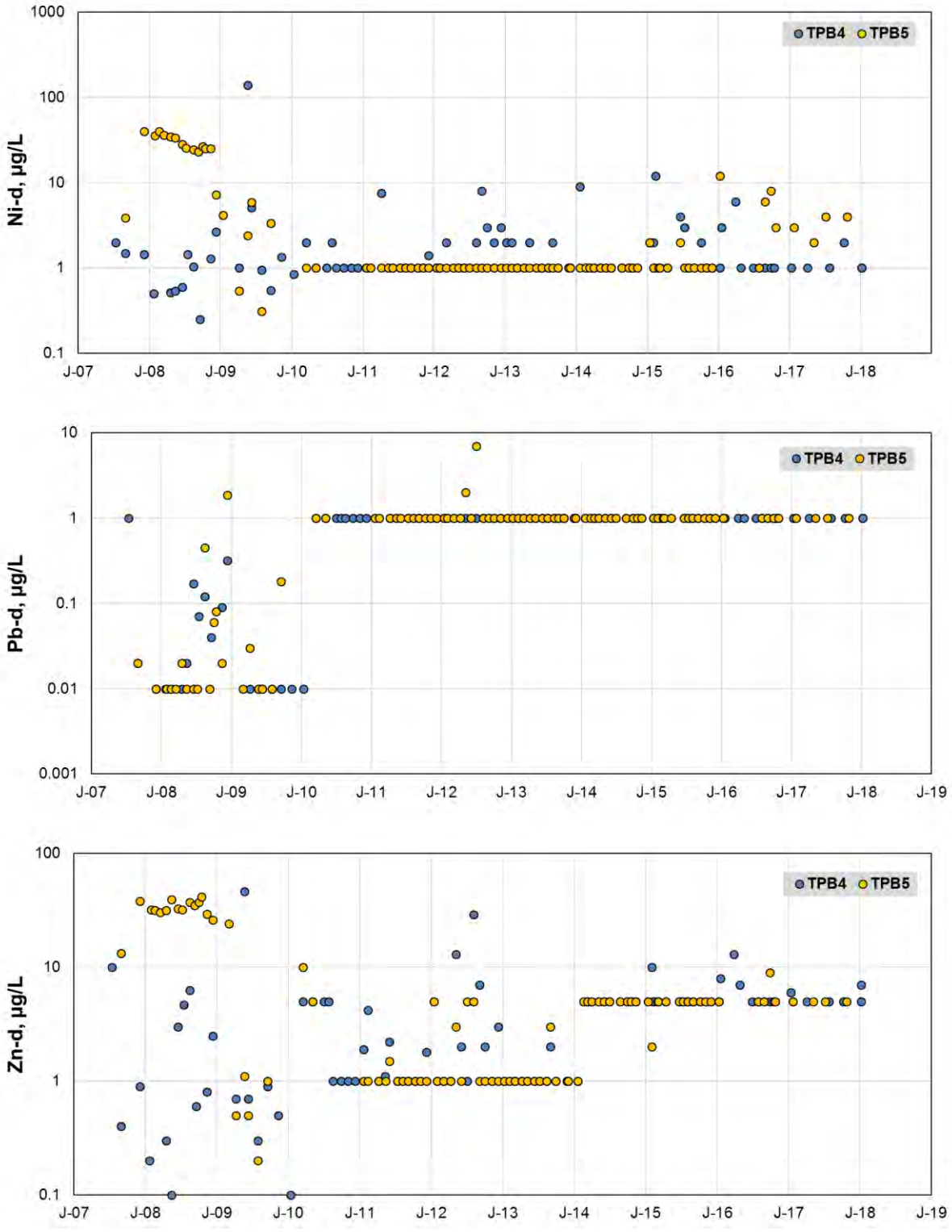


Figure D107. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores TPB4 and TPB5, 2007 to 2018

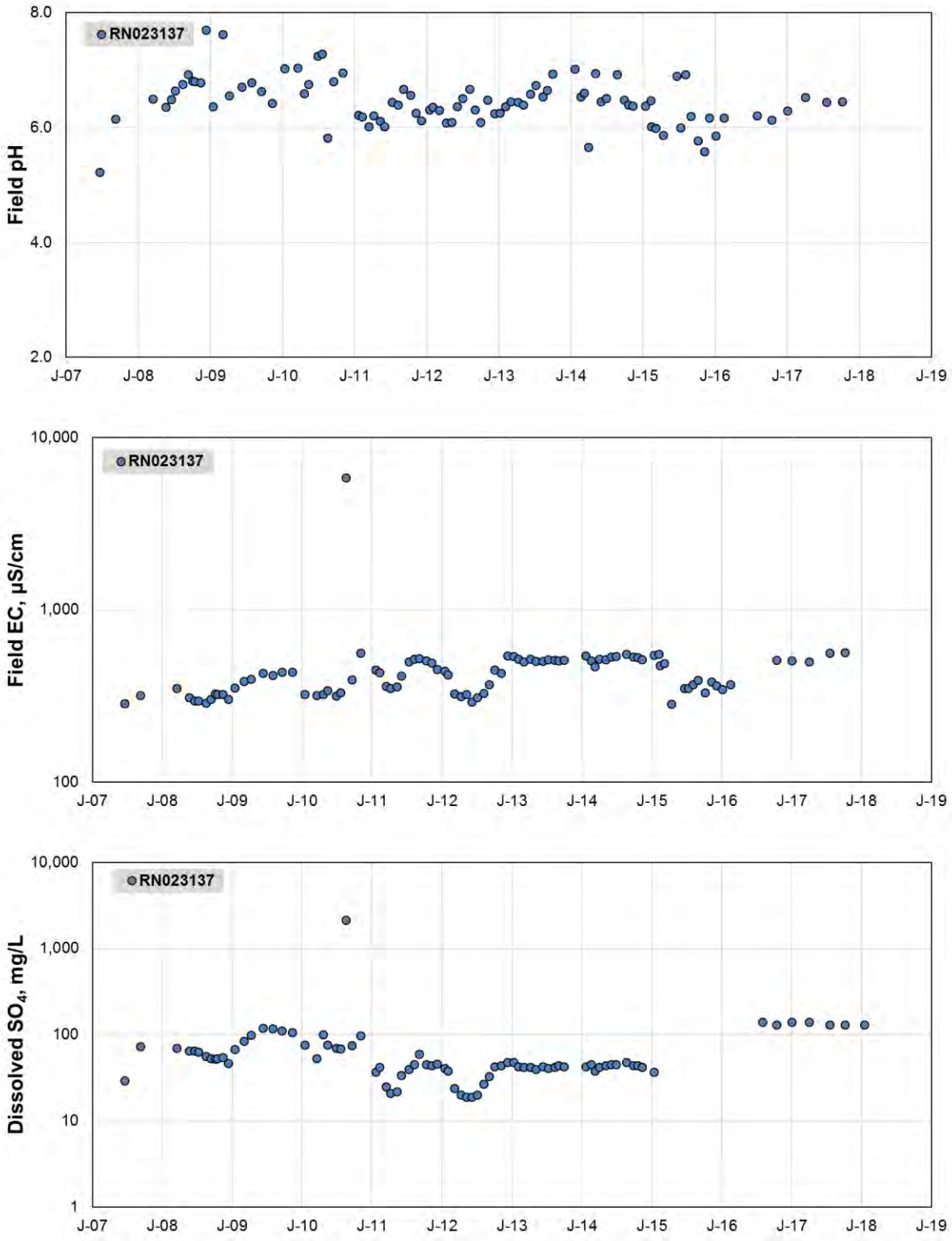


Figure D108. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bore RN023137, 2007 to 2018

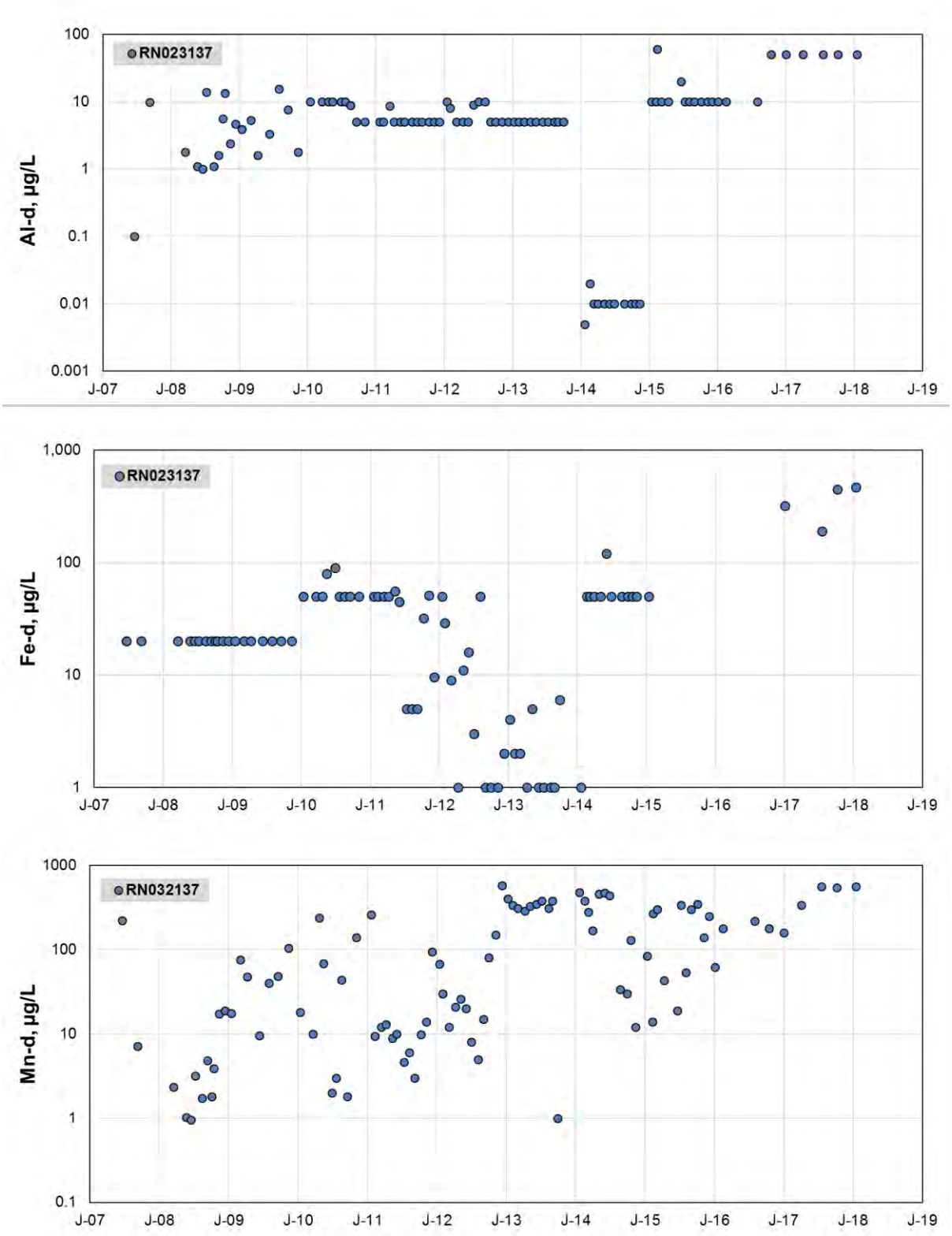


Figure D109. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bore RN023127, 2007 to 2018

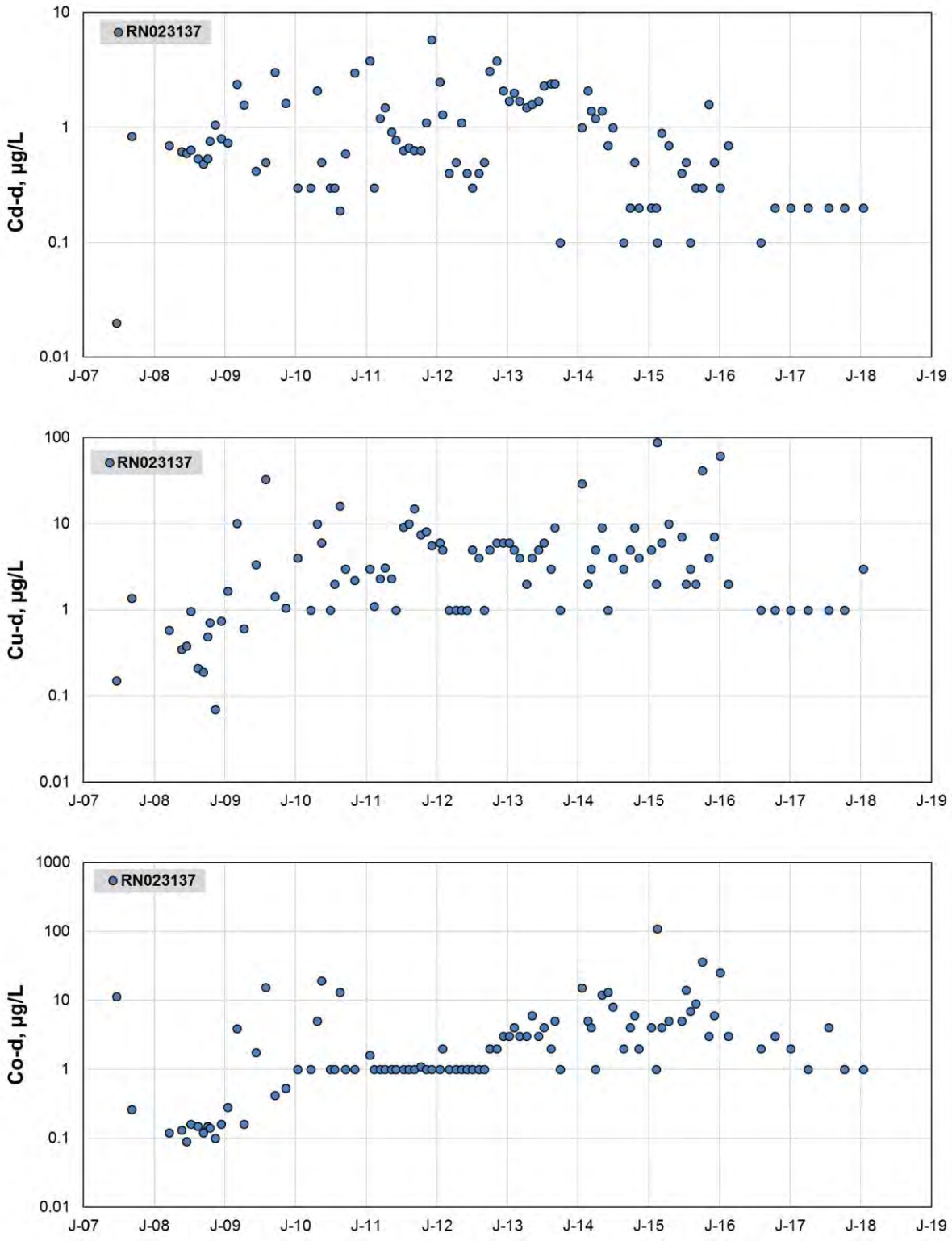


Figure D110. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bore RN023137, 2007 to 2018

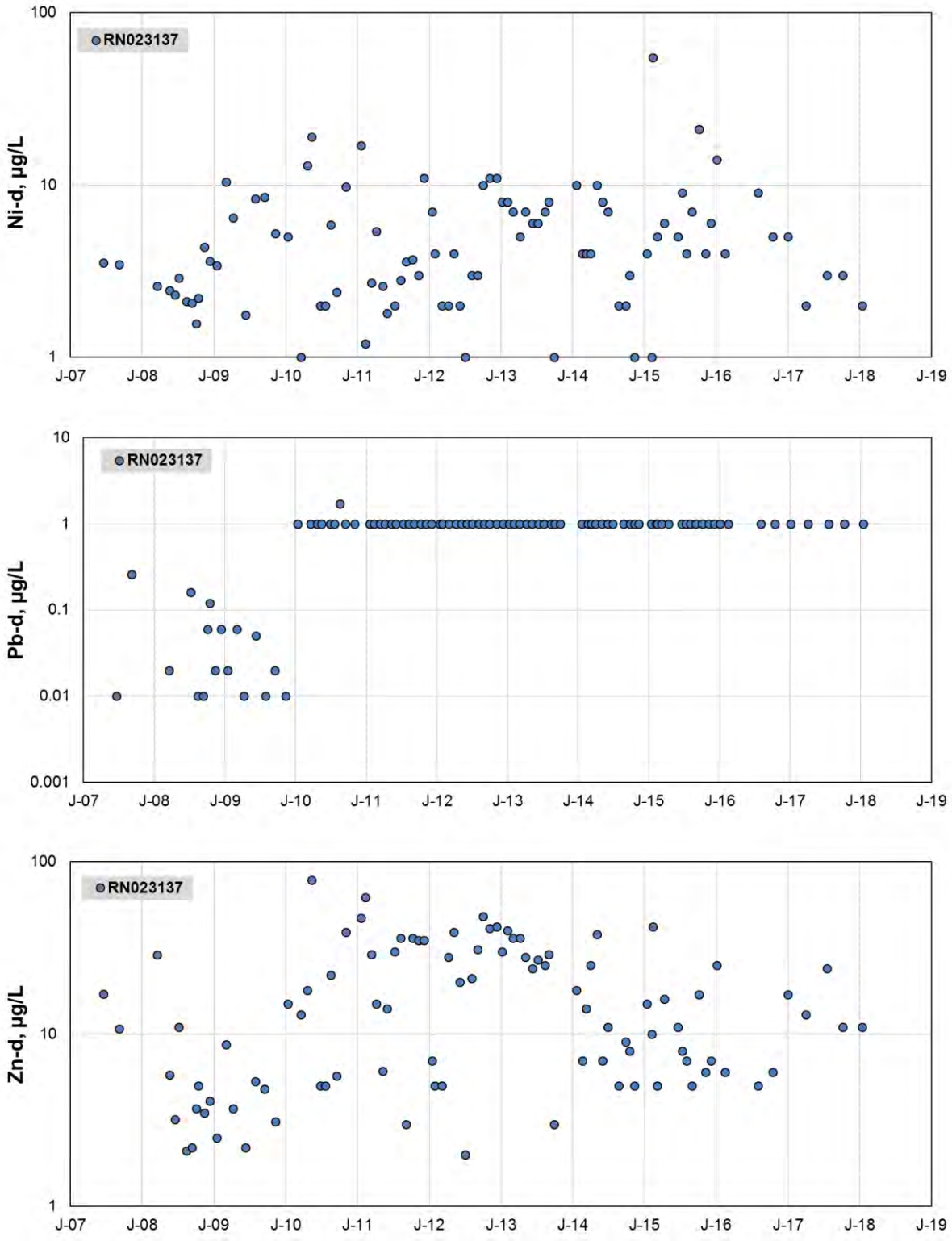


Figure D111. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bore RN023137, 2007 to 2018

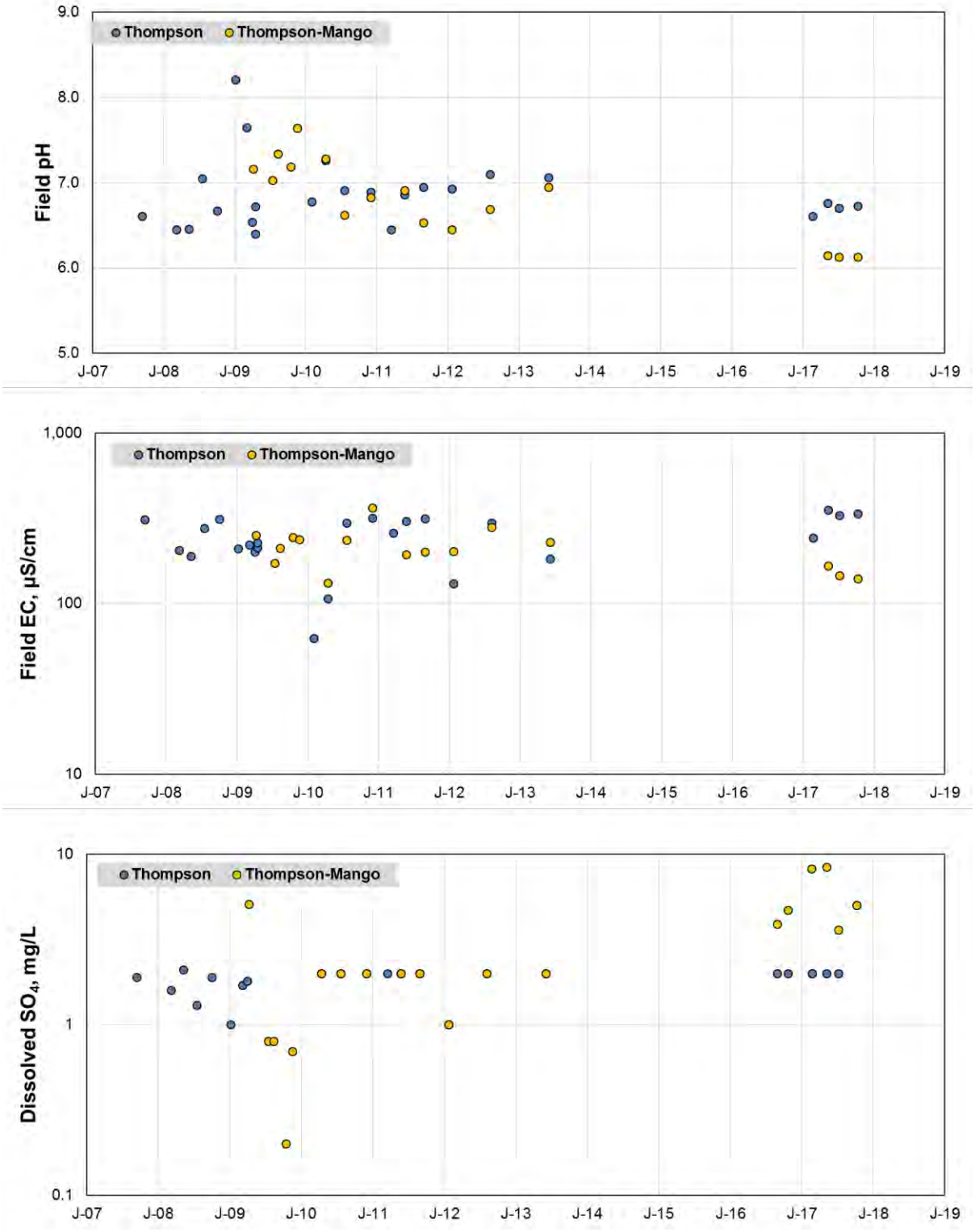
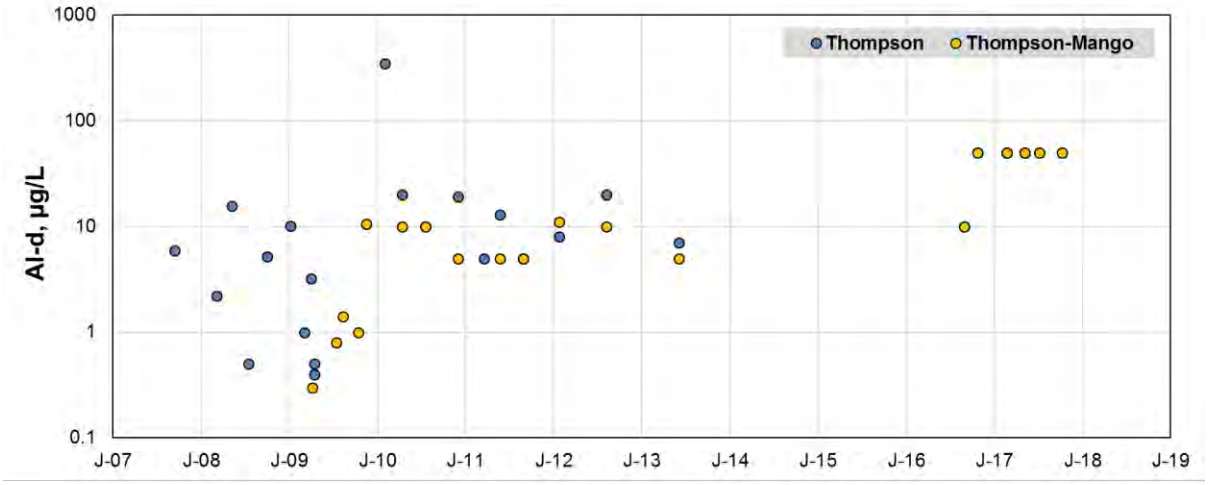
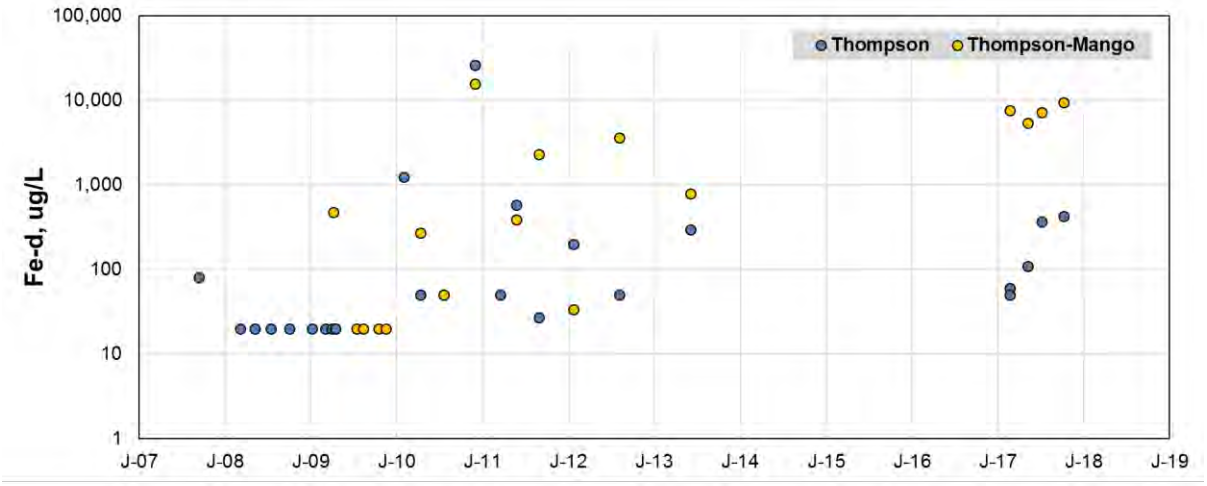


Figure D112. Field pH, Field EC, and Sulphate (SO_4) Concentrations in Groundwater from Bores Thompson and Thompson-Mango, 2007 to 2018





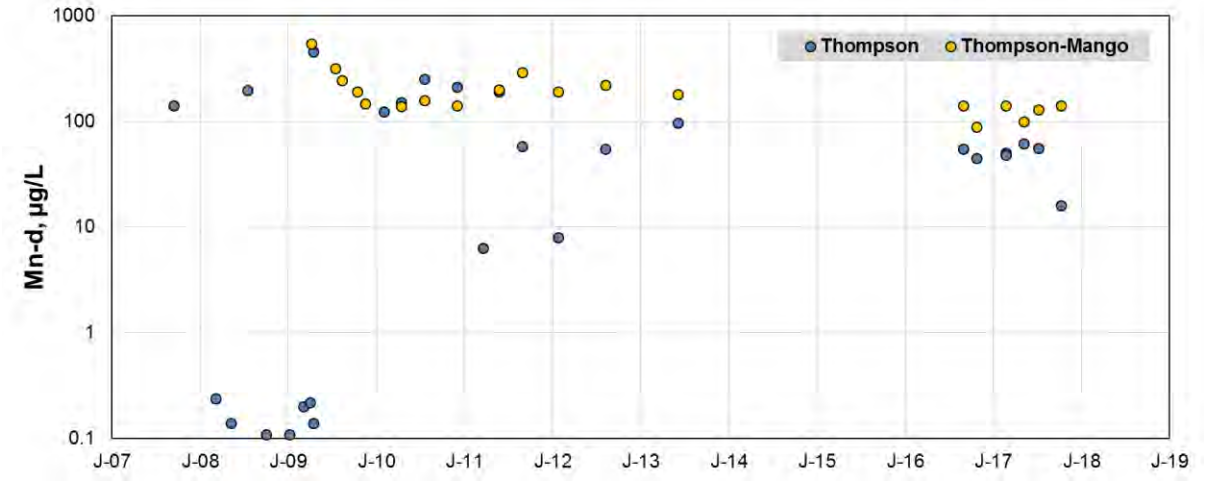


Figure D113. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations in Groundwater from Bores Thompson and Thompson-Mango, 2007 to 2018

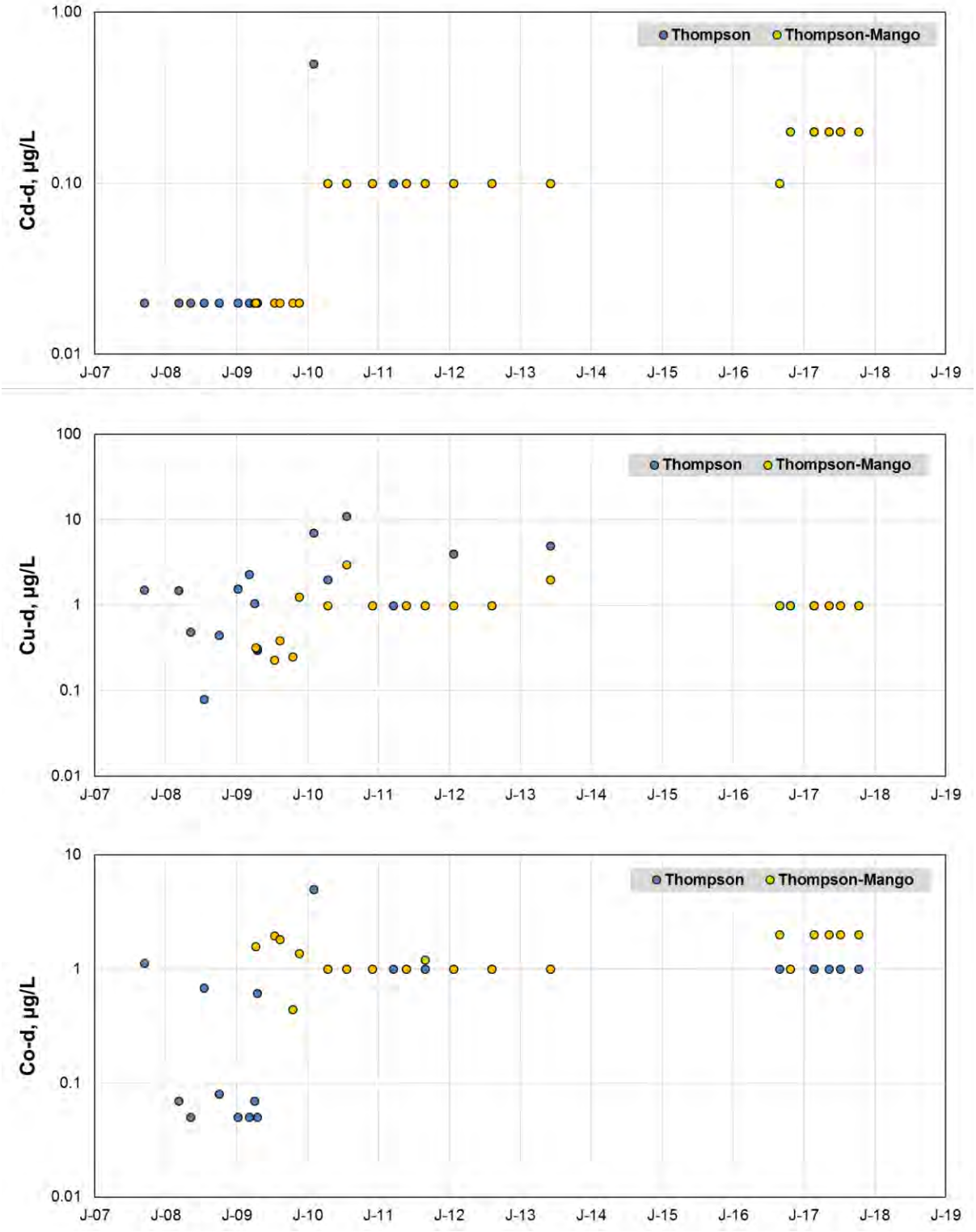


Figure D114. Cadmium (Cd), Copper (Cu), and Cobalt (Co) Concentrations in Groundwater from Bores Thompson and Thompson-Mango, 2007 to 2018

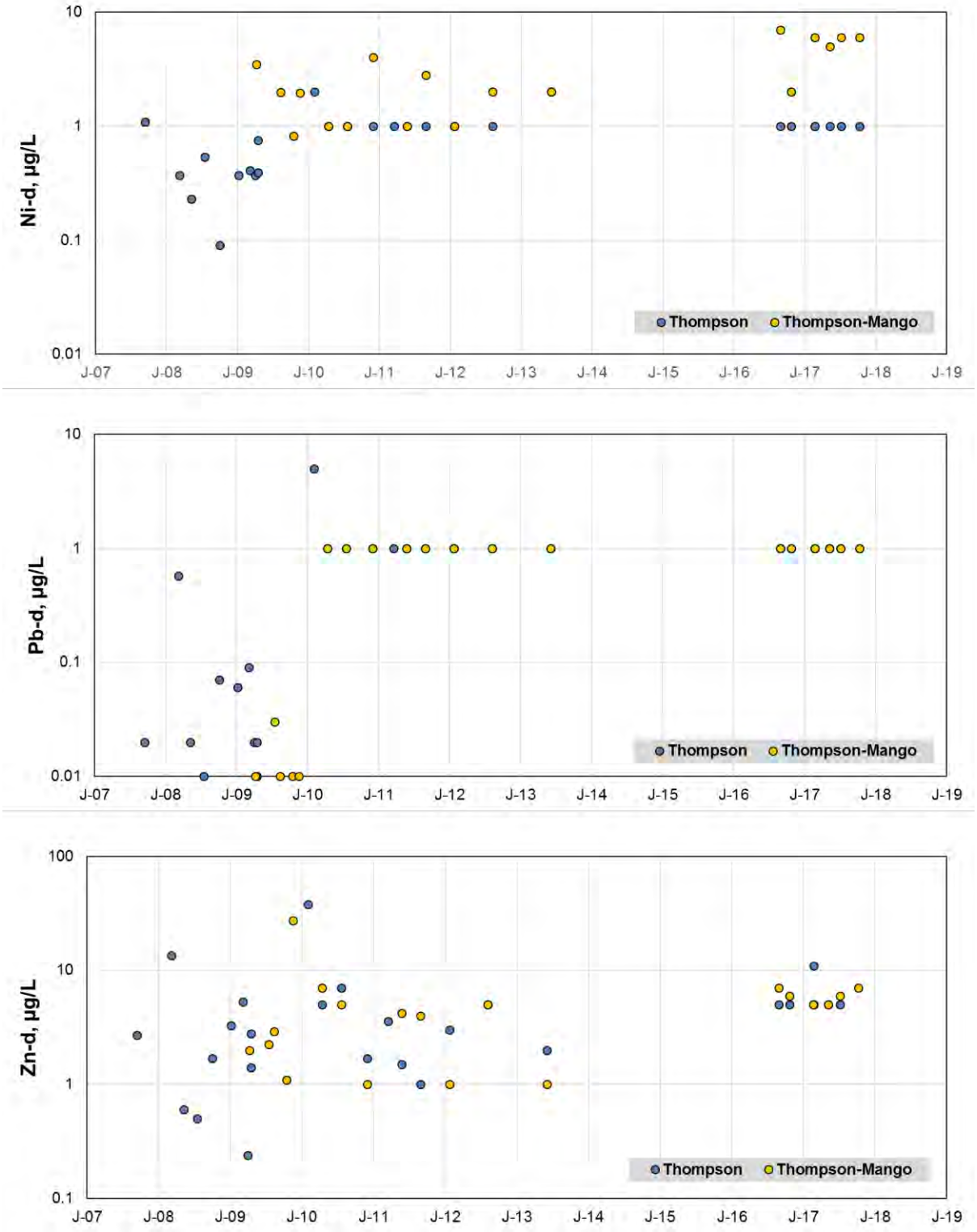


Figure D115. Nickel (Ni), Lead (Pb), and Zinc (Zn) Concentrations in Groundwater from Bores Thompson and Thompson-Mango, 2007 to 2018

APPENDIX E

STATISTICAL SUMMARY OF SURFACE WATER QUALITY

Appendix Table E1. Surface Water Quality at TREAT01, January 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
TREAT01	12/6/2016			75	92	240	5	19	62	49	2	50	0.2	9	36		91	21	1	5	12	21%
TREAT01	12/16/2016	9.3	771	150	105	260	13	16	68	53	2	50	0.2	10	35		92	32	4	5	16	0%
TREAT01	12/30/2016	8.9	655	58	71	220	5	15	47	42	1	50	0.2	60	130		130	83	1	5	7	10%
TREAT01	1/12/2017	8.1	503	56	41	200	4	18	40	46	1	50	1.3	34	210		760	120	110	5	11	14%
TREAT01	1/30/2017	8.9	583	110	83		23	15	37	25	1		0.2	11	49		76	39	5	5	10	
TREAT01	2/16/2017	8.0	335	27	33		2	6	11	22	1		1.9	19	290		760	170	180	5	30	
TREAT01	3/1/2017	9.3	526	66	49	150	4	14	40	34	1	50	0.2	13	20	50	17	17	7	5	7	19%
TREAT01	3/14/2017	9.0	537	370	117	150	3	13	33			50	0.2	28	7	50	6	5	6	5	5	
TREAT01	3/28/2017	9.5	584	130	51	140	4	7	29			50	0.2	3	2	50	5	2	1	5	5	
TREAT01	4/14/2017	9.1	538	100	76	160	4	15	42	35	1	50	0.2	1	18	50	32	13	1	5	5	5%
TREAT01	4/27/2017	9.6	810	200	101	140	12	5	35	72	1	50	0.2	3	3	50	5	5	2	5	5	15%
TREAT01	12/13/2017	9.0	748	150		270	5	25	83	51	2	50	0.2	8	29	50	71	32	1	5	7	
TREAT01	12/28/2017	9.3	730	77		290	14	26	44	38	2	50	0.2	9	2	50	5	15	2	5	5	
TREAT01	12/29/2017			58		270	30	25	60	27	2	50	0.2	4	1	50	5	2	1	5	5	
TREAT01	1/7/2018	10.1	331	50		110	3	24	26	4	1	50	0.2	2	1	50	5	1	15	5	5	
No. of sampling campaigns		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
No. of measurements		13	13	15	11	13	15	15	15	13	13	13	15	15	15	9	15	15	15	15	15	7
% of samples analyzed		87%	87%	100%	73%	87%	100%	100%	100%	87%	87%	87%	100%	100%	100%	60%	100%	100%	100%	100%	100%	47%
Minimum		8.0	331	27	33	110	2	5	11	4	1	50	0.2	1	1	50	5	1	1	5	5	0.0
Maximum		10.1	810	370	117	290	30	26	83	72	2	50	1.9	60	290	50	760	170	180	5	30	0.2
Mean		9.1	589	112	74	200	9	16	44	38	1	50	0.4	14	56	50	137	37	22	5	9	0.1
Median		9.1	583	77	76	200	5	15	40	38	1	50	0.2	9	20	50	32	17	2	5	7	0.1
Standard Deviation		0.6	153	86	28	62	8	7	18	17	1	-	0.5	16	87	0	256	49	52	-	7	0.1
80th Percentile		9.4	741	150	101	266	13	24	60	50	2	50	0.2	21	65	50	100	48	9	5	11	0.2

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E2. Surface Water Quality at SITE1, July 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
SITE1	7/15/2016	3.5	2,700	5	6	2,400	9	140	370	4	3	16,000	20.0	8,900	8,700		16,000	7,100	6	140	16,000	29%
SITE1	7/29/2016	3.3	3,330	5	6	3,300	8	160	460	4	3	13,000	23.0	5,000	9,000		15,000	7,600	7	130	18,000	40%
SITE1	8/14/2016	3.1	2,560	5	6	3,000	7	170	510	7	5	20,000	25.0	4,700	12,000		19,000	9,800	4	170	23,000	21%
SITE1	8/28/2016	3.1	3,900	5	6	330	1	160	450	4	2	21,000	28.0	4,700	12,000		19,000	9,900	6	180	23,000	146%
SITE1	9/12/2016	3.1	4,440	5	6		21	210	600	5	2		31.0	4,500	13,000		22,000	10,000	10	160	28,000	
SITE1	9/30/2016			5	6	3,000	10	190	510	4	3	24,000	27.0	8,200	11,000		20,000	9,800	21	200	22,000	19%
SITE1	10/10/2016	3.1	4,460	5	6	3,300	7	190	530	4	2	24,000	29.0	7,800	13,000		21,000	11,000	20	230	25,000	26%
SITE1	11/28/2016	4.2	1,343	5	6	960	6	56	140	3	1	6,500	9.8	3,900	2,700		10,000	2,300	9	13	4,900	33%
SITE1	12/16/2016	3.3	3,010	20	24	2,200	11	160	450	5	2	19,000	17.0	3,000	9,600		19,000	8,600	42	150	20,000	3%
SITE1	12/30/2016	6.6	201	14	17	72	2	5	15	2	1	140	0.2	68	50		240	53	1	5	69	15%
SITE1	1/12/2017	5.6	204	18	6	48	2	4	14	2	1	50	0.2	49	37		120	31	1	5	43	25%
SITE1	1/30/2017	5.6	143	20	24		12	3	9	3	1		0.2	53	30		100	27	1	5	39	
SITE1	2/16/2017	7.0	128	11	13		2	3	9	2	1		0.2	98	34		110	31	1	5	41	
SITE1	3/1/2017	7.1	184	13	16	62	2	6	17	3	1	50	0.2	73	55	50	170	49	1	5	66	15%
SITE1	3/14/2017	6.9	125	140	171	38	2	4	11			70	0.2	69	29	50	93	27	2	5	31	106%
SITE1	3/28/2017	6.9	155	14	17	28	2	3	8			50	0.2	10	23	50	82	21	1	5	27	10%
SITE1	4/14/2017	6.7	225	18	22	53	2	5	14	3	1	50	0.2	28	43	50	130	38	1	5	45	2%
SITE1	4/27/2017	7.0	329	20	24	52	1	9	22	4	1	50	0.3	87	92	140	330	85	1	5	110	48%
SITE1	5/16/2017	6.3	924	18	22	540	3	38	93	5	1	50	2.3	180	680	520	1,500	560	1	5	1,400	17%
SITE1	5/29/2017	4.6	2,392	5	6	1,800	6	120	330			4,000	13.0	2,000	4,400	17,000	7,800	3,600	1	38	11,000	13%
SITE1	6/15/2017	4.6	2,392	5	6	1,400	4	140	430	5	2	8,400	21.0	3,100	6,600	24,000	13,000	5,300	2	59	17,000	37%
SITE1	6/29/2017	4.2	2,916	5	6	1,900	50	140	420	10	5	17,000	30.0	5,600	8,700	26,000	16,000	9,200	12	180	23,000	3%
SITE1	7/13/2017	3.5	2,697	5	6	3,500	9	150	540	5	2	22,000	35.0	9,300	14,000	49,000	24,000	9,800	11	250	26,000	34%
SITE1	7/31/2017	3.1	2,770	20	24	2,700	3	160	590	4	1	26,000	30.0	7,900	13,000	50,000	21,000	12,000	13	220	27,000	0%
SITE1	8/15/2017	2.9	4,850	20	24	6,000	29	160	590	4	2	31,000	49.0	5,200	15,000	49,000	23,000	11,000	15	240	34,000	76%
SITE1	8/31/2017	3.1	680	20	24	4,200	2	240	870	4	2	44,000	55.0	8,400	19,000	58,000	28,000	17,000	22	390	50,000	5%
SITE1	9/13/2017	2.9	5,660	20	0	4,400	17	300	1,000	12	5	43,000	56	8,600	21,000	54,000	30,000	18,000	29	390	46,000	6%
SITE1	9/28/2017			20	0	4,500	14	320	1,200	6	5	51,000	47	9,700	22,000	50,000	32,000	19,000	67	520	49,000	20%
SITE1	10/16/2017	3.1	5,900	20	0	4,900	17	280	1,000	8	5	58,000	47	12,000	24,000	75,000	36,000	21,000	44	480	50,000	6%
SITE1	10/31/2017	4.0	2,194	20	0	1,500	15	140	330	7	6	11,000	13	3,100	5,500	11,000	9,500	3,900	32	110	11,000	9%
SITE1	11/16/2017	3.8	2,211	20	0	1,500	4	98	280	3	4	12,000	13	2,400	5,900	4,000	11,000	4,900	18	110	12,000	11%
SITE1	11/30/2017	4.7	1,337	20	0	860	5	69	180	4	3	2,700	6.4	1,500	2,700	5,400	6,600	2,200	5	49	5,300	2%
SITE1	12/13/2017	3.5	3,140	20	0	2,100	26	150	430	4	2	13,000	18	2,400	8,600	9,000	14,000	7,200	22	150	18,000	3%
SITE1	12/29/2017			20	0	1,200	34	92	260	3	2	4,900	12	2,000	4,300	15,000	7,400	3,700	9	84	9,600	1%
SITE1	1/17/2018	6.9	212	26	0	61	8	6	18	3	1	90	0.2	48	43	50	150	36	1	5	45	26%
No. of sampling campaigns		35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
No. of measurements		32	32	35	35	32	35	35	35	32	32	32	35	35	35	22	35	35	35	35	35	32
% of samples analyzed		91%	91%	100%	100%	91%	100%	100%	100%	91%	91%	91%	100%	100%	100%	63%	100%	100%	100%	100%	100%	91%
Minimum		2.9	125	5	0	28	1	3	8	2	1	50	0.2	10	23	50	82	21	1	5	27	0%
Maximum		7.1	5,900	140	171	6,000	50	320	1,200	12	6	58,000	56.0	12,000	24,000	75,000	36,000	21,000	67	520	50,000	146%
Mean		4.6	2,116	17	14	1,935	10	117	363	5	2	15,378	18.8	3,848	7,623	22,605	12,666	6,425	13	134	16,306	25%
Median		4.1	2,302	18	6	1,650	7	140	370	4	2	12,500	17.0	3,100	6,600	13,000	13,000	5,300	7	110	16,000	16%
Standard Deviation		1.6	1,757	22	29	1,691	11	92	319	2	2	16,030	17.4	3,572	7,123	24,377	10,734	6,101	15	141	15,697	32%
80th Percentile		6.7	3,292	20	22	3,300	15	174	550	5	4	24,000	30.2	7,960	13,000	49,800	21,200	10,200	21	222	26,200	34%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E3. Surface Water Quality at Site2, November 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
SITE2	12/16/2016	8.2	638	110	134	220	11	26	54	28	2	50	0.3	33	120		280	70	2	5	62	1%
SITE2	12/19/2016			120	134	220	12	26	55	28	2	50	0.4	40	120		260	73	3	5	59	0%
SITE2	12/30/2016	7.5	524	63	77	170	4	16	37	23	2	50	0.6	10	110		350	66	1	5	78	1%
SITE2	1/12/2017	7.2	437	55	6	140	4	14	34	26	1	50	0.5	34	110		340	70	5	5	53	40%
SITE2	1/13/2017	7.8	458	59	6	150	4	14	31	24	1	50	0.4	30	100		320	62	2	5	45	26%
SITE2	1/20/2017	7.7	488	53	65	140	4	14	33	28	1		0.4	17	77		270	54	2	5	34	13%
SITE2	2/22/2017	7.7	326	43	52	98	7	10	19	20	6	50	0.3	89	30	50	97	43	1	5	38	1%
SITE2	3/1/2017	8.3	379	41	50	100	3	12	25	23	1	50	0.2	10	1	50	5	20	1	5	12	21%
SITE2	4/11/2017	7.7	554	87	106	120	3	11	29	34	1	50	0.2	15	1	50	5	8	1		5	2%
SITE2	4/14/2017	8.1	534	68	83	94	3	11	31	33	1	50	0.2	11	1	50	7	10	1	5	7	29%
SITE2	4/18/2017	7.7	536	84	102	120	3	12	31	31	1	50	0.2	9	1	50	5	10	1	5	5	6%
SITE2	4/27/2017	8.0	541	89	109	120	5	12	30	31	1	50	0.2	17	1	50	5	10	1	5	7	1%
SITE2	5/16/2017	6.9	553	86	105	140	3		35	41	1	50	0.2	17	2	50	5	8	1	5	6	1%
SITE2	5/30/2017	7.7	577	98	120	150	4		36	45	1	50	0.2	13	1	50	5	8	1	5	6	5%
SITE2	6/15/2017	7.8	616	130	159	140	3	16	43	52	1	50	0.2	7	1	50	5	8	1	5	7	17%
SITE2	6/29/2017	7.4	573	140	171	130	10	13	36	42	1	50	0.2	14	2	50	9	9	1	5	6	6%
SITE2	7/13/2017	8.0	601	140	159	160	4	13	38	46	1	50	0.2	13	1	50	5	7	1	5	5	4%
SITE2	7/31/2017	7.8	641	130	146	170	16	16	42	48	1	50	0.2	13	1	50	5	5	1	5	5	1%
SITE2	8/15/2017	8.3	620	140	159	170	5	17	40	48	1	50	0.2	13	1	50	5	4	3	5	5	0%
SITE2	8/31/2017	8.4	719	170	183	190	5	18	42	51	1	50	0.2	16	1	50	5	4	1	5	5	7%
SITE2	9/13/2017	8.3	679	170	207	190	13	17	42	52	2	50	0.2	17	1	50	6	5	1	5	5	15%
SITE2	9/28/2017			160	195	200	14	21	50	67	2	50	0.2	16	5	50	17	9	1	5	11	5%
SITE2	10/16/2017	8.3	781	190	232	220	15	22	55	69	2	50	0.2	11	3	50	55	9	1	6	6	2%
SITE2	10/31/2017	8.2	736	170	207	220	13	23	56	68	1	50	0.2	1	17	50	190	17	2	9	5	5%
SITE2	11/16/2017	8.9	756	190	232	220	13	24	55	70	2	50	0.2	13	5	50	56	6	5	10	5	1%
SITE2	11/30/2017	8.9	687	160	195	200	8	20	46	58	2	50	0.2	14	6	50	13	7	5	10	5	3%
SITE2	12/13/2017	7.8	843	110	134	330	5	61	49	46	2	50	0.4	33	100	50	300	73	3	5	31	1%
SITE2	12/28/2017	9.4	747	110	134	280	61	38	45	40	2	50	0.3	15	4	50	6	45	2	5	23	28%
SITE2	12/29/2017			110	134	270	31	44	49	40	2	50	0.2	17	2	50	5	45	2	5	24	8%
SITE2	1/17/2018	7.3	539	70	85	180	15	30	37	24	2	5	0.2	12	1	50	21	11	1	5	10	1%
No. of sampling campaigns		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
No. of measurements		27	27	30	30	30	30	28	30	30	30	29	30	30	30	24	30	30	30	29	30	30
% of samples analyzed		90%	90%	100%	100%	100%	100%	93%	100%	100%	100%	97%	100%	100%	100%	80%	100%	100%	100%	97%	100%	100%
Minimum		6.9	326	41	6	94	3	10	19	20	1	5	0.2	1	1	50	5	4	1	5	5	0%
Maximum		9.4	843	190	232	330	61	61	56	70	6	50	0.6	89	120	50	350	73	5	10	78	40%
Mean		8.0	596	112	129	175	10	20	40	41	2	48	0.3	19	28	50	89	26	2	6	19	8%
Median		7.8	577	110	134	170	5	17	39	41	1	50	0.2	15	2	50	8	10	1	5	7	4%
Standard Deviation		0.5	124	45	60	56	11	11	10	15	1	8	0.1	16	45	0	127	26	1	1	21	11%
80th Percentile		8.3	713	160	185	220	13	25	49	52	2	50	0.3	20	82	50	262	56	2	5	35	16%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E4. Surface Water Quality at Site 3, January 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
SITE3	1/11/2016	6.9	228	45	55	40	0	8	24	21	2	10	0.1	15	1		1	20		1	28	63%
SITE3	1/21/2016	8.0	332	57	70	35	2	10	24	22	1	10	0.1	10	1		3	12		0.2	7	57%
SITE3	3/15/2016	7.6	360	60	73	90	3	12	24	17	1	10	0.1	7	1		1	14	1	0.1	12	6%
SITE3	3/21/2016	7.3	284	58	71	88	2	12	25	14	1	10	0.1	8	1		1	11	1	0.3	9	7%
SITE3	3/30/2016	7.5	283	62	76	99	3	15	26	14	1	10	0.1	7	1		5	13	1	0.1	8	4%
SITE3	4/1/2016	7.4	283	72	88	100	3	15	27	14	1	10	0.1	6	1		3	10	1	0.1	6	0%
SITE3	4/12/2016	7.5	398	72	88	110	4	15	28	16	1	10	0.1	7	1		5	8	1	0.1	7	2%
SITE3	4/28/2016	7.4	337	80	98	120	3	16	31	18	1	10	0.1	6	1		5	7	1	0.1	9	1%
SITE3	5/13/2016	7.8	322	69	84	110	3	17	32	19	1	10	0.1	4	1		7	5	1	0.2	5	14%
SITE3	6/14/2016	8.2	395	100	122	110	3	17	34	18	1	10	0.1	5	2		9	6	1	0.2	7	2%
SITE3	6/30/2016	8.0	459	90	110	110	3	19	36	20	1	10	0.1	5	1		5	8	6	0.2	7	14%
SITE3	7/15/2016	7.6	350	90	110	100	3	18	33	20	2	10	0.1	10	3		12	17	1	0.2	11	13%
SITE3	7/29/2016	7.5	402	90	110	130	3	16	31	18	1	10	0.1	5	1		7	3	1	0.2	5	10%
SITE3	8/28/2016			100	122	150	4	15	31	16	1	10	0.1	4	1		3	15	1	0.5	5	26%
SITE3	9/12/2016	7.9	527	96	117		5	18	35	20	1		0.1	3	1		1	8	1	0.54	5	78%
SITE3	9/30/2016			27	33	160	4	19	35	21	1	50	0.2	2	1		5	5	1	5	5	18%
SITE3	10/10/2016	7.5	548	76	93	170	4	20	40	34	2	50	0.2	7	1		5	3	2	5	5	10%
SITE3	10/25/2016	7.2	8	80	83	180	4	24	46	26	2	50	0.2	4	1		5	8	1	5	5	16%
No. of sampling campaigns		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
No. of measurements		16	16	18	18	17	18	18	18	18	18	17	18	18	18	0	18	18	16	18	18	18
% of samples analyzed		89%	89%	100%	100%	94%	100%	100%	100%	100%	100%	94%	100%	100%	100%	0%	100%	100%	89%	100%	100%	100%
Minimum		6.9	8	27	33	35	0	8	24	14	1	10	0.1	2	1	-	1	3	1	0.1	5	0%
Maximum		8.2	548	100	122	180	5	24	46	34	2	50	0.2	15	3	-	12	20	6	5.0	28	78%
Mean		7.6	345	74	89	112	3	16	31	19	1	17	0.1	6	1	-	5	10	1	1.1	8	19%
Median		7.5	344	74	88	110	3	16	31	19	1	10	0.1	6	1	-	5	8	1	0.2	7	11%
Standard Deviation		0.3	125	20	24	39	1	4	6	5	0	16	0.0	3	1	-	3	5	1	1.8	5	23%
80th Percentile		7.9	402	90	110	146	4	19	35	21	1	10	0.1	8	1	-	6	14	1	0.8	9	23%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E5. Surface Water Quality at SITE4, January 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
SITE4	1/11/2016	5.5	18	10	12	2	0	1	1	2	1	70	0.1	1	1		1	1		0.7	5	16%
SITE4	1/21/2016	7.8	12	9	11	5	1	1	1	2	1	130	0.1	1	1		4	1		0.1	5	48%
SITE4	3/15/2016			10	12	2	1	1	1	2	1	60	0.1	2	1		7	1	1	0.05	6	35%
SITE4	3/21/2016	5.6	24	10	12	2	1	1	2	2	1	50	0.1	1	1		1	1	1	0.2	5	2%
SITE4	3/30/2016	6.0	15	16	20	2	1	1	1	2	1	40	0.1	1	1		6	1	1	0.05	5	76%
SITE4	4/1/2016	6.3	22	14	17	2	2	1	1	2	1	30	0.1	1	1		5	1	1	0.05	5	63%
SITE4	4/12/2016			11	13	5	1	1	1	2	1	30	0.1	1	1		6	1	1	0.05	5	60%
SITE4	4/28/2016	6.2	27	20	24	2	1	1	1	3	1	80	0.1	1	1		21	1	1	0.05	10	49%
SITE4	12/29/2016	6.4	62	8	10	2	3	1	1	2	2	550	0.2	1	1		22	1	1	5	5	20%
SITE4	12/30/2016	7.7	28	6	7	2	2	1	2	1	2	530	0.2	1	1		10	1	1	5	5	26%
SITE4	1/12/2017	6.8	28	7	6	2	2	1	2	1	1	60	0.2	24	4		6	2	1	5	5	22%
SITE4	1/30/2017			20	0		1	1	1	2	1		0.2	1	1		6	1	1	5	5	136%
SITE4	2/16/2017	7.2	29	5	7		1	1	2	2	1		0.2	1	1		5	1	6	5	5	67%
SITE4	3/1/2017	6.7	49	6	7	2	1	1	1	2	1	50	0.2	1	1	100	5	1	1	5	5	11%
SITE4	3/14/2017	6.6	21	240	293	2	5	1	2	2	1	50	0.2	15	1	70	5	1	1	5	5	179%
SITE4	3/28/2017	7.3	85	7	9	2	1	1	1	2	1	50	0.2	1	1	50	5	1	1	5	5	30%
SITE4	4/14/2017	7.2	41	7	9	2	2	1	1	2	1	50	0.2	1	1	50	6	1	1	5	5	23%
SITE4	4/27/2017	7.1	75	20	24	5	2	1	1	2	1	50	0.2	1	1	180	10	1	1	5	5	89%
SITE4	5/16/2017	7.5	479	8	10	2	2					170	0.2	3	1	230	12	1	1	5	5	
SITE4	11/22/2017			20	0	5	2	1	1	1	2	120	0.2	1	1	100	22	1	1	5	5	
SITE4	1/17/2018	6.1	40	20	0	5	27	1	1	2	1	170	0.2	3	1	100	7	1	1	5	5	
No. of sampling campaigns		21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
No. of measurements		17	17	21	21	19	21	20	20	20	20	19	21	21	21	8	21	21	19	21	21	18
% of samples analyzed		81%	81%	100%	100%	90%	100%	95%	95%	95%	95%	90%	100%	100%	100%	38%	100%	100%	90%	100%	100%	86%
Minimum		5.5	12	5	0	2	0	1	1	1	1	30	0.1	1	1	50	1	1	1	0.1	5	2%
Maximum		7.8	479	240	293	5	27	1	2	3	2	550	0.2	24	4	230	22	2	6	5.0	10	179%
Mean		6.7	62	23	24	3	3	1	1	2	1	123	0.2	3	1	110	8	1	1	3.2	5	53%
Median		6.7	28	10	10	2	1	1	1	2	1	60	0.2	1	1	100	6	1	1	5.0	5	42%
Standard Deviation		0.7	109	50	62	1	6	0	1	1	0	153	0.0	6	1	64	6	0	1	2.4	1	45%
80th Percentile		7.3	59	20	17	5	2	1	2	2	1	146	0.2	2	1	148	10	1	1	5.0	5	72%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E6. Surface Water Quality at SITE5, January 2016 to May 2017

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
WDL177-06_SW Trigger Values												**80**	**0.4**	**2.5**	**13**		**2,500**	**13**	**6**		**15**	
WDL177-06_SW Trigger Values (2 x)												**160**	**0.8**	**5.0**	**26**		**5,000**	**26**	**12**		**30**	
SITE5	1/21/2016	7.5	77	31	38	3	1	5	6	4	1	70	0.1	5	3		31	4	1	0.1	7	24%
SITE5	3/15/2016	6.3	82	29	35	8	1	3	6	4	1	20	0.1	3	2		31	2	1	0.05	8	6%
SITE5	3/21/2016	6.3	213	50	61	62	2	10	19	10	1	10	0.1	3	1		1	3	1	0.2	5	7%
SITE5	3/30/2016	6.7	68	46	56	6	1	4	6	3	1	10	0.1	2	2		59	3	1	0.05	5	20%
SITE5	4/1/2016	6.9	183	62	76	48	3	11	17	9	1	10	0.1	2	3		62	3	1	0.05	5	3%
SITE5	4/12/2016	6.9	162	68	83	6	1	7	10	5	1	10	0.1	2	20		770	6	1	0.05	5	8%
SITE5	4/28/2016	7.1	311	170	207	40	2	25	26	15	1	10	0.1	1	25		1,500	6	1	0.1	5	5%
SITE5	5/13/2016	7.3	292	140	171	35	4	26	26	16	1	10	0.1	1	7		640	4	1	0.2	5	13%
SITE5	6/14/2016	7.5	487	230	281	50	1	42	40	18	1	10	0.1	1	2		170	3	1	0.4	5	9%
SITE5	6/30/2016	7.5	570	230	281	64	1	50	43	20	1	10	0.1	1	2		97	3	1	0.5	5	15%
SITE5	7/15/2016	7.3	480	220	268	73	8	42	36	19	4	10	0.1	3	3		140	4	1	0.59	5	3%
SITE5	7/29/2016	7.3	563	270	329	75	4	44	38	18	2	10	0.1	3	1		39	1	1	0.7	5	14%
SITE5	8/14/2016		1,160	260	317	110	1	45	39	19	1	10	0.1	1	1		92	2	2	0.3	5	18%
SITE5	8/28/2016	6.8	654	300	366	110	1	43	39	16	1	10	0.1	1	3		230	3	1	0.4	5	31%
SITE5	9/30/2016	7.2	773	190	232	140	6	54	44	21	1	50	0.2	4	5		370	6	1	5	5	6%
SITE5	12/29/2016	6.5	328	20	24	79	4	15	13	7	2	410	0.2	15	41		96	31	1	5	56	1%
SITE5	12/30/2016	6.9	285	32	39	66	4	12	14	10	2	120	0.2	6	14		110	10	1	5	15	5%
SITE5	1/12/2017	6.7	79	37	6	56	3	9	14	9	1	50	0.2	16	12		38	20	1	5	19	39%
SITE5	1/13/2017	7.2	231	21	6	10	2	3	5	1	1	50	0.2	16	5		18	10	1	5	13	50%
SITE5	1/20/2017	7.1	99	27	33	25	2	6	9	7	1		0.2	10	3		15	9	1	5	7	19%
SITE5	1/26/2017	7.0	471	20	24		2	3	6	4	1		0.2	3	2		7	6	1	5	6	
SITE5	1/30/2017	6.2	80	25	31		2	3	4	3	1		0.2	9	3		21	9	1	5	10	
SITE5	2/2/2017	6.9	95	20	24		2	3	5	3	1		0.2	8	2		19	7	1	5	8	
SITE5	2/5/2017	7.8	45	10	12		1	1	2	1	1		0.2	3	1		9	1	1	5	7	
SITE5	2/16/2017	6.8	151	24	29		2	5	9	6	1		0.2	7	2		17	8	2	5	7	
SITE5	2/22/2017	6.8	227	35	43	56	2	38	110	1,200	56	50	0.2	6	3	50	32	10	1	5	7	188%
SITE5	3/1/2017	7.2	103	17	21	5	1	3	5	3	1	50	0.2	7	5	270	63	6	1	5	5	33%
SITE5	3/5/2017	7.2	194	27	33	36	4	7	12	10	2	50	0.2	6	9	100	100	9	1	5	5	26%
SITE5	3/12/2017	6.9	74	230	281	10	2	3	5	3	2	50	0.2	9	2	120	14	4	1	5	13	151%
SITE5	3/14/2017	6.9	162	310	378	37	2	6	11	9	1	50	0.2	31	9	50	23	11	3	5	8	126%
SITE5	3/28/2017	6.3	261	21	26	5	1	3	5	3	1	50	0.2	1	2	80	20	4	1	5	5	21%
SITE5	4/11/2017	6.5	253	63	77	40	3	10	16	13	2	50	0.2	7	15	130	260	8	1		5	10%
SITE5	4/14/2017	7.1	175	35	43	13	2	5	9	7	1	50	0.2	1	2	50	38	3	1	5	5	23%
SITE5	4/18/2017	6.7	107	26	32	7	2	3	6	3	1	50	0.2	2	2	100	20	2	1	5	5	13%
SITE5	4/27/2017	7.2	246	45	55	11	11	5	8	5	1	50	0.2	4	4	110	92	4	1	5	5	22%
No. of sampling campaigns		35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
No. of measurements		34	35	35	35	30	35	35	35	35	35	29	35	35	35	10	35	35	35	34	35	30
% of samples analyzed		97%	100%	100%	100%	86%	100%	100%	100%	100%	100%	83%	100%	100%	100%	29%	100%	100%	100%	97%	100%	86%
Minimum		6.2	45	10	6	3	1	1	2	1	1	10	0	1	1	50	1	1	1	0	5	1%
Maximum		7.8	1,160	310	378	140	11	54	110	1,200	56	410	0	31	41	270	1,500	31	3	5	56	188%
Mean		7.0	278	95	115	43	3	16	19	43	3	48	0	6	6	106	150	6	1	3	8	30%
Median		6.9	213	37	43	39	2	7	11	7	1	50	0	3	3	100	39	4	1	5	5	16%
Standard Deviation		0.4	240	99	122	36	2	17	21	201	9	74	0	6	8	65	290	6	0	2	9	45%
80th Percentile		7.2	473	222	271	67	4	39	36	16	2	50	0	8	9	122	146	9	1	5	8	32%

Concentration higher than trigger value

Concentration greater than or equal to two times the trigger value

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E7. Surface Water Quality at SITE5, May 2017 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
WDL177-06_SW Trigger Values												**80**	**0.4**	**2.5**	**13**		**2,500**	**13**	**6**		**15**	
WDL177-06_SW Trigger Values (2 x)												**160**	**0.8**	**5.0**	**26**		**5,000**	**26**	**12**		**30**	
SITE5	5/16/2017	6.9	351	91	111	33	1					50	0.2	7	47	400	1,500	12	1	5	5	
SITE5	5/30/2017	6.8	525	150	183	71	3					50	0.2	5	48	270	1,800	13	1	5	6	
SITE5	6/15/2017	6.7	643	200	244	75	2	34	39	23	1	50	0.2	1	20	50	730	6	1	5	5	5%
SITE5	11/22/2017				0	330	11	52	47	13	5	90	1.4	210	340	210	780	190	2	5	290	0%
SITE5	11/30/2017	3.6	2,396		0	1,500	5	270				2,500	13	2,100	3,800	2,100	11,000	2,000	380	13	3,100	
SITE5	12/29/2017				0	1,700	5	350	250	38	1	1,900	9.5	1,800	2,900	1,800	8,100	1,800	390	9	2,400	11%
SITE5	1/17/2018	6.7	157		0	47	27	11				50	0.3	33	61	33	230	52	1	5	70	
No. of sampling campaigns		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
No. of measurements		5	5	3	7	7	7	5	3	3	3	7	7	7	7	7	7	7	7	7	7	3
% of samples analyzed		71%	71%	43%	100%	100%	100%	71%	43%	43%	43%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	43%
Minimum		3.6	157	91	0	33	1	11	39	13	1	50	0	1	20	33	230	6	1	5	5	0%
Maximum		6.9	2,396	200	244	1,700	27	350	250	38	5	2,500	13	2,100	3,800	2,100	11,000	2,000	390	13	3,100	11%
Mean		6.2	814	147	77	537	8	143	112	25	2	670	4	594	1,031	695	3,449	582	111	7	839	6%
Median		6.7	525	150	0	75	5	52	47	23	1	50	0	33	61	270	1,500	52	1	5	70	5%
Standard Deviation		1.4	903	55	103	736	9	155	120	13	3	1,060	5	933	1,609	871	4,283	905	187	3	1,325	5%
80th Percentile		6.8	994	180	169	1,266	10	286	169	32	4	1,538	8	1,482	2,388	1,520	6,840	1,478	304	8	1,978	9%

Concentration higher than trigger value

Concentration greater than or equal to two times the trigger value

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E8. Surface Water Quality at DAM1, January 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
DAM1	12/30/2016	7.9	527	61	74	170	4	15	33	21	2	50	0.2	3	65		350	26	1	5	26	10%
DAM1	1/13/2017	7.9	454	58	6	150	4	14	32	26	1	50	0.5	41	120		360	72	4	5	51	30%
DAM1	1/20/2017	7.0	471	54	66	750	18	14	33	28	1		0.4	17	78		270	56	2	5	35	115%
DAM1	1/26/2017	7.8	446	49	60		3	13	32	29	1		0.4	10	73		240	53	1	5	33	
DAM1	1/30/2017	7.1	456	75	92		4	11	25	22	1		0.2	13	50		160	43	3	5	21	
DAM1	2/2/2017	7.7	481	56	68		4	13	34	30	1		0.2	9	18		41	29	1	5	11	
DAM1	2/5/2017	7.9	452	53	65		3	12	32	27	1		0.2	28	32		120	32	8	5	29	
DAM1	2/16/2017	7.3	301	38	46		2	9	18	14	1		0.2	13	19		100	33	3	5	28	
DAM1	2/22/2017	7.1	317	43	52	98	2	10	20	18	1	50	0.2	11	15	50	90	31	1	5	18	
DAM1	3/5/2017	7.9	385	43	52	110	3	11	27			50	0.2	10	3	50	23	22	1	5	13	16%
DAM1	3/12/2017	7.6	310	220	268	100	3	12	25			50	0.2	21	9	50	59	23	3	5	19	85%
DAM1	4/11/2017	7.6	557	87	106	120	3	12	30	35	1	50	0.2	14	1	50	5	8	2		5	6%
DAM1	4/18/2017	7.6	558	83	101	120	3	12	32	33	1	50	0.2	10	1	50	5	10	1	5	5	10%
No. of sampling campaigns		13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
No. of measurements		13	13	13	13	8	13	13	13	11	11	7	13	13	13	5	13	13	13	12	13	7
% of samples analyzed		100%	100%	100%	100%	62%	100%	100%	100%	85%	85%	54%	100%	100%	100%	38%	100%	100%	100%	92%	100%	54%
Minimum		7.0	301	38	6	98	2	9	18	13	1	50	0.2	3	1	50	5	8	1	3.1	5	5%
Maximum		7.9	994	220	268	1,266	18	286	169	35	4	1,538	7.9	1,482	2,388	1,520	6,840	1,478	304	8.2	1,978	115%
Mean		7.6	507	77	89	362	5	40	44	25	1	328	1.1	174	299	377	863	188	35	5.1	240	32%
Median		7.6	456	56	68	135	3	12	32	27	1	50	0.2	13	32	50	120	32	2	5.0	26	10%
Standard Deviation		0.3	250	55	65	396	4	74	42	11	1	521	2.2	408	668	537	1,866	399	84	2.0	554	39%
80th Percentile		7.9	557	84	104	739	5	14	33	31	2	454	0.4	31	86	707	352	59	5	5.0	38	52%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E9. Surface Water Quality at RWTSF, RWPIT, RUMWHITE, and RUMINTER, February 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
RWTSF	2/22/2016			5	0	590	2	140	26	4	1	9,800	2.1	23,000	3,500		1,300	2,600	780	92	750	28%
RWTSF	7/15/2016	4.0		5	0	2,100	5	330	100	5	1	45,000	6.7	89,000	16,000		4,600	11,000	600	430	3,000	55%
RWTSF	1/12/2017	4.5	772	5	0	480	3	110	29	3	1	4,400	1.6	15,000	2,700		1,000	1,900	910	67	570	23%
RWTSF	4/27/2017	4.6	703	20	0	280	2	71	17	4	1	3,700	1.5	13,000	2,100	60	990	1,500	590	50	530	14%
RWTSF	7/31/2017	7.5	1,095	60	73	570	4	190	34	37	1	50	0.6	65	530	50	510	260	8	5	27	5%
RWTSF	10/31/2017	4.0	3,160	20		2,500	23	350	200	62	2	79,000	9.6	110,000	24,000	2,200	8,200	18,000	260	500	3,400	
RWTSF	1/17/2018	4.2	1,146	20		580	19	160	49	3	1	12,000	3.2	32,000	6,100	80	1,700	4,100	620	150	1,100	
No. of sampling campaigns		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
No. of measurements		6	5	7	5	7	7	7	7	7	7	7	7	7	7	4	7	7	7	7	7	5
% of samples analyzed		86%	71%	100%	71%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	57%	100%	100%	100%	100%	100%	71%
Minimum		4.0	703	5	0	280	2	71	17	3	1	50	0.6	65	530	50	510	260	8	5	27	5%
Maximum		7.5	3,160	60	73	2,500	23	350	200	62	2	79,000	9.6	110,000	24,000	2,200	8,200	18,000	910	500	3,400	55%
Mean		4.8	1,375	19	15	1,014	8	193	65	17	1	21,993	3.6	40,295	7,847	598	2,614	5,623	538	185	1,340	25%
Median		4.3	1,095	20	0	580	4	160	34	4	1	9,800	2.1	23,000	3,500	70	1,300	2,600	600	92	750	23%
Standard Deviation		1.4	1,016	19	33	892	9	107	66	24	1	29,307	3.3	42,036	8,779	1,068	2,810	6,496	308	197	1,315	19%
80th Percentile		4.6	1,549	20	15	1,798	16	302	90	31	1	38,400	6.0	77,600	14,020	928	4,020	9,620	748	374	2,620	34%
RWPIT	2/22/2016			26	32	180	4	16	44	4	1	10	0.8	31	300		650	170	17	0.1	89	6%
RWPIT	3/15/2016			53	65	160	1	17	42	5	1	30	0.8	19	230		690	120	7	0.05	79	3%
RWPIT	7/15/2016	7.5		75	92	210	5	26	63	7	2	50	0.7	32	190		740	110	1	0.1	160	13%
RWPIT	11/23/2016			49	60	260	6	23	58	8	2	50	0.5	4	100		380	65	1	5	63	4%
RWPIT	7/31/2017	7.6	644	81	99	240	17	23	68	7	1	50	0.2	10	75	50	290	67	4	5	45	0%
RWPIT	1/17/2018	7.74	597	85	104	220	23	27	65	10	2	50	0.3	31	26	50	110	33	4	5	16	3%
No. of sampling campaigns		7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		4	3	7	6	6	6	6	6	6	6	6	6	6	6	2	6	6	6	6	6	6
% of samples analyzed		57%	43%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	33%	100%	100%	100%	100%	100%	100%
Minimum		7.5	597	26	32	160	1	16	42	4	1	10	0.2	4	26	50	110	33	1	0	16	0%
Maximum		7.7	644	85	104	260	23	27	68	10	2	50	0.8	32	300	50	740	170	17	5	160	13%
Mean		7.6	621	62	75	212	9	22	57	7	1	40	0.6	21	154	50	477	94	6	3	75	5%
Median		7.6	621	64	78	215	5	23	61	7	2	50	0.6	25	145	50	515	89	4	3	71	4%
Standard Deviation		0.1	33	23	28	37	9	5	11	2	0	17	0.3	12	104	0	254	49	6	3	49	4%
80th Percentile		7.7	635	81	99	240	17	26	65	8	2	50	0.8	31	230	50	690	120	7	5	89	6%
RUMWHITE	1/12/2017	6.1	157	14	17	48	2	6	11	3	1	50	0.2	33	37		230	34	1	5	8	1%
RUMINTER	1/12/2017	6.3	158	15	18	49	2	6	11	1	1	50	0.2	55	35		240	36	1	5	10	7%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E10. Surface Water Quality at RWSRO and RWPOND, March 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
RWSRO	3/15/2016			5	0	21	100	2	3	1	1	240	0.4	380	68		270	52	370	0.1	89	160%
RWSRO	7/15/2016	4.1		5	0	160	1	7	12	1	1	8,600	1.9	2,100	320		790	300	530	0.9	350	85%
RWSRO	1/12/2017	4.4	79	5	0	29	2	1	3	1	1	290	0.3	360	53		170	44	560	5	64	63%
RWSRO	4/27/2017	6.3	42	20	0	8	1	1	1	1	1	50	0.2	45	19	50	130	11	70	5	22	0%
RWSRO	10/31/2017	4.1	284	20	0	110	16	5	11	1	1	6,900	1.6	2,000	320	230	1,100	260	970	6	250	75%
RWSRO	1/17/2018	6.7	59	20	0	12	8	1	2	1	1	90	0.2	200	42	50	210	28	290	5	51	50%
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		5	4	6	6	6	6	6	6	6	6	6	6	6	6	3	6	6	6	6	6	6
% of samples analyzed		83%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%
Minimum		4.1	42	5	0	8	1	1	1	1	1	50	0.2	45	19	50	130	11	70	0	22	0%
Maximum		6.7	284	20	0	160	100	7	12	1	1	8,600	1.9	2,100	320	230	1,100	300	970	6	350	160%
Mean		5.1	116	13	0	57	21	3	5	1	1	2,695	0.8	848	137	110	445	116	465	4	138	72%
Median		4.4	69	13	0	25	5	1	3	1	1	265	0.4	370	61	50	240	48	450	5	77	69%
Standard Deviation		1.3	113	8	0	63	39	2	5	0	0	3,953	0.8	940	143	104	402	129	305	2	131	52%
80th Percentile		6.4	161	20	0	110	16	5	11	1	1	6,900	1.6	2,000	320	158	790	260	560	5	250	85%
RWPOND	3/15/2016			100	122	160	4	20	49	14	1	10	0.1	2	1		3	3	1	0.3	5	4%
RWPOND	7/15/2016	7.7		92	112	170	4	29	58	12	2	10	0.2	6	3		3	16	1	0.5	6	21%
RWPOND	1/12/2017	6.5	416	25	6	67	2	18	40	6	1	50	0.3	91	40		110	43	16	5	40	97%
RWPOND	7/31/2017	7.2	7	93	113	240	15	25	69	8	1	50	0.3	19	51	50	210	64	6	5	36	0%
RWPOND	1/17/2018	7.3	659	74		210	29	23	64	6	2	50	0.2	9	13	50	55	22	4	5	10	26%
No. of sampling campaigns		6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
No. of measurements		5	3	5	4	5	5	5	5	5	5	5	5	5	5	2	5	5	5	5	5	5
% of samples analyzed		83%	60%	100%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	40%	100%	100%	100%	100%	100%	100%
Minimum		6.4	7	25	6	67	2	18	40	6	1	10	0.1	2	1	50	3	3	1	0	5	0%
Maximum		7.7	659	100	122	240	29	29	69	14	2	50	0.3	91	51	50	210	64	16	5	40	97%
Mean		7.0	361	77	88	169	11	23	56	9	1	34	0.2	25	22	50	76	30	6	3	19	30%
Median		7.2	416	92	113	170	4	23	58	8	1	50	0.2	9	13	50	55	22	4	5	10	21%
Standard Deviation		0.6	329	31	55	66	11	4	12	4	0	22	0.1	37	23	0	87	24	6	3	17	39%
80th Percentile		7.4	562	94	117	216	18	26	65	12	2	50	0.3	33	42	50	130	47	8	5	37	40%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E11. Surface Water Quality at RWBSS and RWSP3, July 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
RWBSS	7/15/2016	3.3		5	6	390	1	30	110	1	1	53,000	17.0	300,000	33,000		18,000	21,000	1,300	1,200	7,400	25%
RWBSS	10/25/2016	3.1	5,220	5	0	5,700	9	110	460	3	1	180,000	66.0	970,000	110,000		74,000	72,000	190	4,100	26,000	93%
RWBSS	1/12/2017	4.0	536	5	0	310	2	11	22	1	1	4,300	3.5	55,000	5,100		3,500	3,200	1,900	180	1,200	
RWBSS	4/27/2017	4.1	545	20	0	110	1	9	16	1	1	4,000	2.9	55,000	5,300	110	4,100	2,700	2,300	150	990	24%
RWBSS	10/31/2017	3.3	2,180	20		1,600	17	31	120	1	1	54,000	17	350,000	34,000	4,900	21,000	22,000	1,600	1,300	7,800	
RWBSS	1/17/2018	3.6	723	20		330	22	13	29	1	1	9,100	4.3	77,000	7,300	360	5,200	4,500	1,500	260	1,600	
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		6	5	6	4	6	6	6	6	6	6	6	6	6	6	3	6	6	6	6	6	3
% of samples analyzed		100%	83%	100%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	50%
Minimum		3.1	536	5	0	110	1	9	16	1	1	4,000	2.9	55,000	5,100	110	3,500	2,700	190	150	990	24%
Maximum		4.1	5,220	20	6	5,700	22	110	460	3	1	180,000	66.0	970,000	110,000	4,900	74,000	72,000	2,300	4,100	26,000	93%
Mean		3.6	1,841	13	2	1,407	9	34	126	1	1	50,733	18.5	301,167	32,450	1,790	20,967	20,900	1,465	1,198	7,498	47%
Median		3.5	723	13	0	360	5	22	70	1	1	31,050	10.7	188,500	20,150	360	11,600	12,750	1,550	730	4,500	25%
Standard Deviation		0.4	2,010	8	3	2,170	9	38	170	1	0	67,526	24.2	352,469	40,335	2,696	27,054	26,555	715	1,513	9,584	39%
80th Percentile		4.0	2,788	20	2	1,600	17	31	120	1	1	54,000	17.0	350,000	34,000	3,084	21,000	22,000	1,900	1,300	7,800	66%
RWSP3	7/15/2016	5.1		5	0	95	2	9	13	2	2	220	2.7	2,700	680		2,100	380	950	0.1	770	23%
RWSP3	10/25/2016			5	6	320	6	28	50	5	4	50	10.0	23,000	4,800		10,000	2,600	3,000	5	3,300	17%
RWSP3	1/12/2017	4.2	382	5	0	220	2	6	15	1	1	4,800	11.0	22,000	3,100		2,800	2,200	2,300	30	3,200	97%
RWSP3	4/27/2017	5.6	479	20	0	170	11	20	25	2	1	340	4.8	8,600	1,500	50	3,200	1,000	1,400	6	1,300	19%
RWSP3	10/31/2017	5.4	403	20		160	10	19	21	2	2	130	3.5	5,500	1,200	50	3,500	650	1,700	5	850	
RWSP3	1/17/2018	7.5	68	20		20	7	3	4	1	1	50	0.5	280	110	50	350	67	260	5	110	
No. of sampling campaigns		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No. of measurements		5	4	6	4	6	6	6	6	6	6	6	6	6	6	3	6	6	6	6	6	4
% of samples analyzed		83%	67%	100%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	67%
Minimum		4.2	68	5	0	20	2	3	4	1	1	50	0.5	280	110	50	350	67	260	0	110	17%
Maximum		7.5	479	20	6	320	11	28	50	5	4	4,800	11.0	23,000	4,800	50	10,000	2,600	3,000	30	3,300	97%
Mean		5.6	333	13	2	164	6	14	21	2	1	932	5.4	10,347	1,898	50	3,658	1,150	1,602	9	1,588	39%
Median		5.4	393	13	0	165	6	14	18	2	1	175	4.2	7,050	1,350	50	3,000	825	1,550	5	1,075	21%
Standard Deviation		1.2	181	8	3	103	4	10	16	2	1	1,898	4.2	9,821	1,743	0	3,303	1,024	971	11	1,342	39%
80th Percentile		6.0	433	20	2	220	10	20	25	2	2	340	10.0	22,000	3,100	50	3,500	2,200	2,300	6	3,200	53%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

Appendix Table E12. Surface Water Quality at RWPAF, January 2016 to January 2018

Location Code	Sampling Date	Field pH	Field EC	Total Alkalinity	HCO3	SO4	Cl	Ca	Mg	Na	K	Al-f	Cd-f	Cu-f	Co-f	Fe-f	Mn-f	Ni-f	Pb-f	U-f	Zn-f	RPD (CBA)
		-	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	µg/L	µg/L	
RWPAF	7/15/2016	3.1		5	0	3,700	6	23	160	1	1	170,000	190.0	470,000	63,000		30,000	48,000	790	730	62,000	137%
RWPAF	10/25/2016	2.8	8	5	0	6,900	10	65	620	2	1	560,000	680.0	1,500,000	200,000		140,000	150,000	310	2,500	220,000	90%
RWPAF	1/12/2017	3.6	906	5	0	620	2	10	37	1	1	20,000	34.0	75,000	10,000		7,700	7,100	2,000	130	10,000	114%
RWPAF	4/27/2017	3.8	670	20	0	330	1	8	21	1	1	18,000	23.0	66,000	8,800	260	7,800	7,400	3,200	92	7,200	104%
RWPAF	7/31/2017	7.5	1,095	60	73	570	4	190	34	37		50	0.6	65	530	50	510	260	8	5	27	5%
RWPAF	10/31/2017	4.0	3,160	20	0	2,500	23	350	200	62		79,000	9.6	110,000	24,000	2,200	8,200	18,000	260	500	3,400	36%
RWPAF	1/17/2018	4.2	1,146	20	0	580	19	160	49	3		12,000	3.2	32,000	6,100	80	1,700	4,100	620	150	1,100	4%
No. of sampling campaigns		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
No. of measurements		7	6	7	7	7	7	7	7	7	4	7	7	7	7	4	7	7	7	7	7	7
% of samples analyzed		100%	86%	100%	100%	100%	100%	100%	100%	100%	57%	100%	100%	100%	100%	57%	100%	100%	100%	100%	100%	100%
Minimum		2.8	8	5	0	330	1	8	21	1	1	50	1	65	530	50	510	260	8	5	27	4%
Maximum		7.5	3160	60	73	6,900	23	350	620	62	1	560,000	680	1,500,000	200,000	2,200	140,000	150,000	3,200	2,500	220,000	137%
Mean		4.1	1164	19	10	2,171	9	115	160	15	1	122,721	134	321,866	44,633	648	27,987	33,551	1,027	587	43,390	70%
Median		3.8	1001	20	0	620	6	65	49	2	1	20,000	23	75,000	10,000	170	7,800	7,400	620	150	7,200	90%
Standard Deviation		1.6	1062	19	28	2,439	9	127	214	24	0	201,736	250	542,958	71,665	1,039	50,345	53,805	1,157	882	80,860	54%
80th Percentile		4.2	1146	20	0	3,460	17	184	192	30	1	151,800	159	398,000	55,200	1,036	25,640	42,000	1,758	684	51,600	112%

Note: Numbers in red denote a concentration below the indicated detection (reporting) limit

APPENDIX F

ADDITIONAL SURFACE WATER QUALITY TIME TRENDS

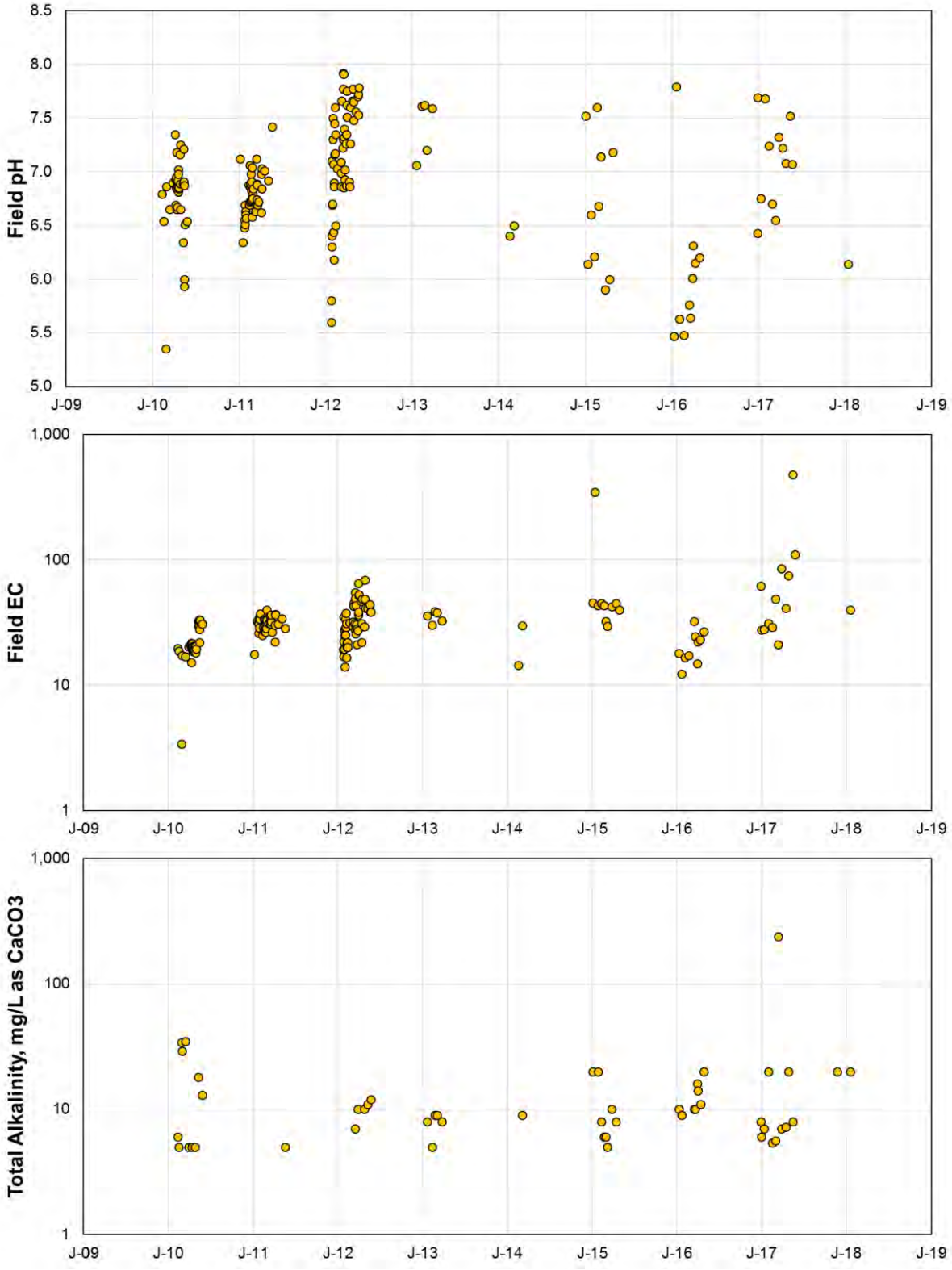


Figure F1. Field pH, Field EC, and Alkalinity at Site 4, 2010 to 2018

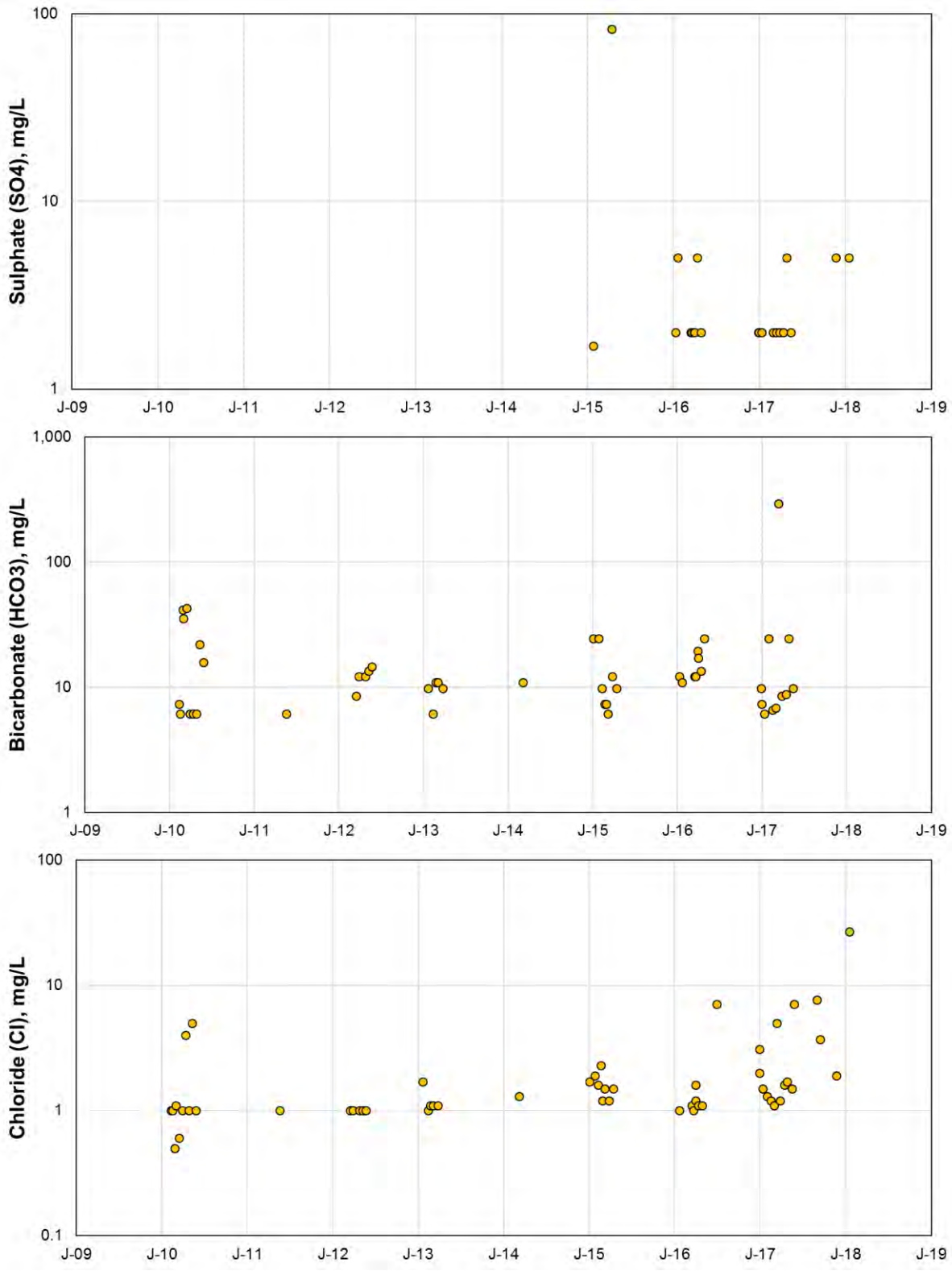


Figure F2. Sulphate (SO_4), Bicarbonate (HCO_3), and Chloride (Cl) Concentrations at Site 4, 2010 to 2018

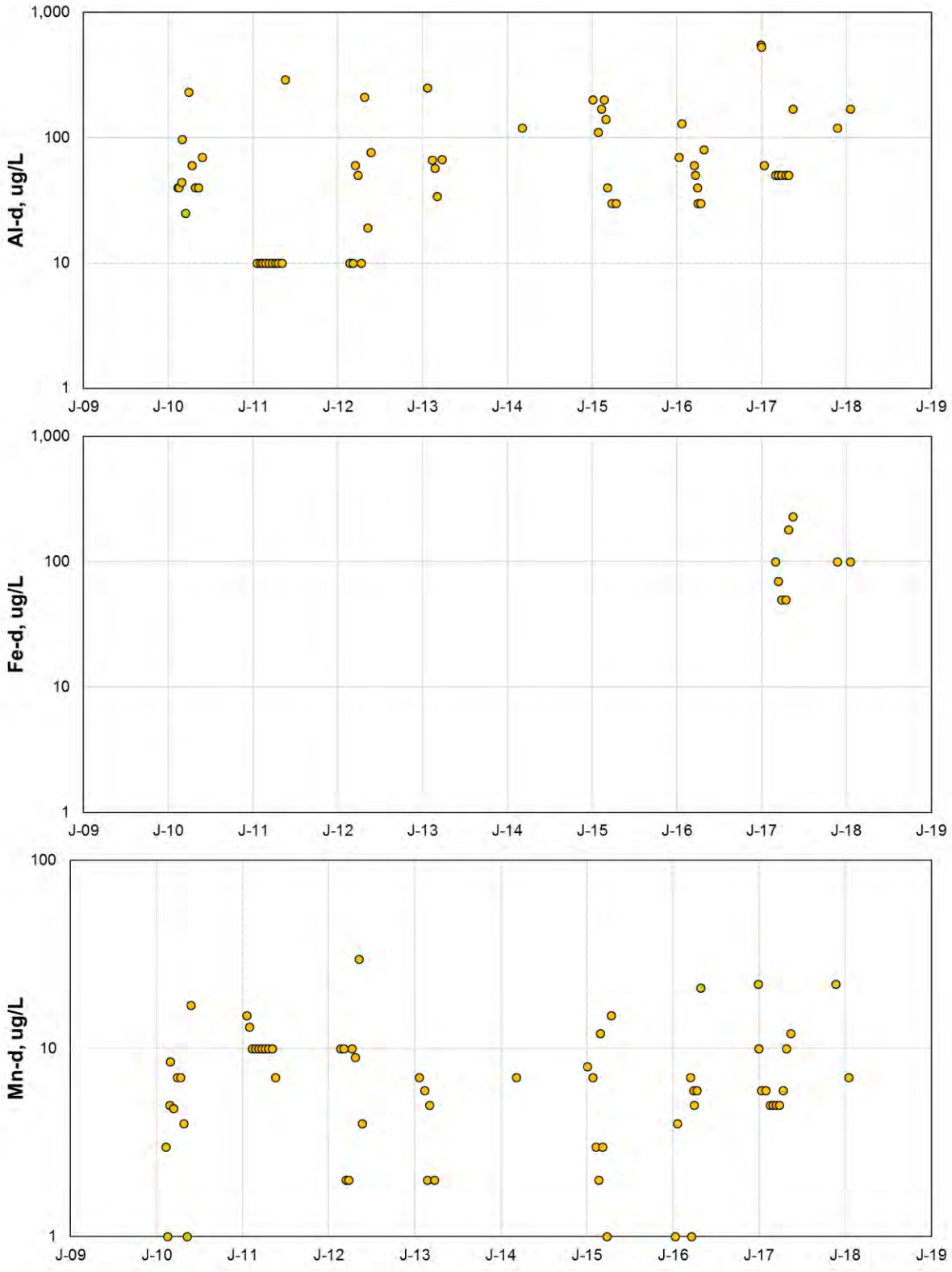


Figure F3. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 4, 2010 to 2018

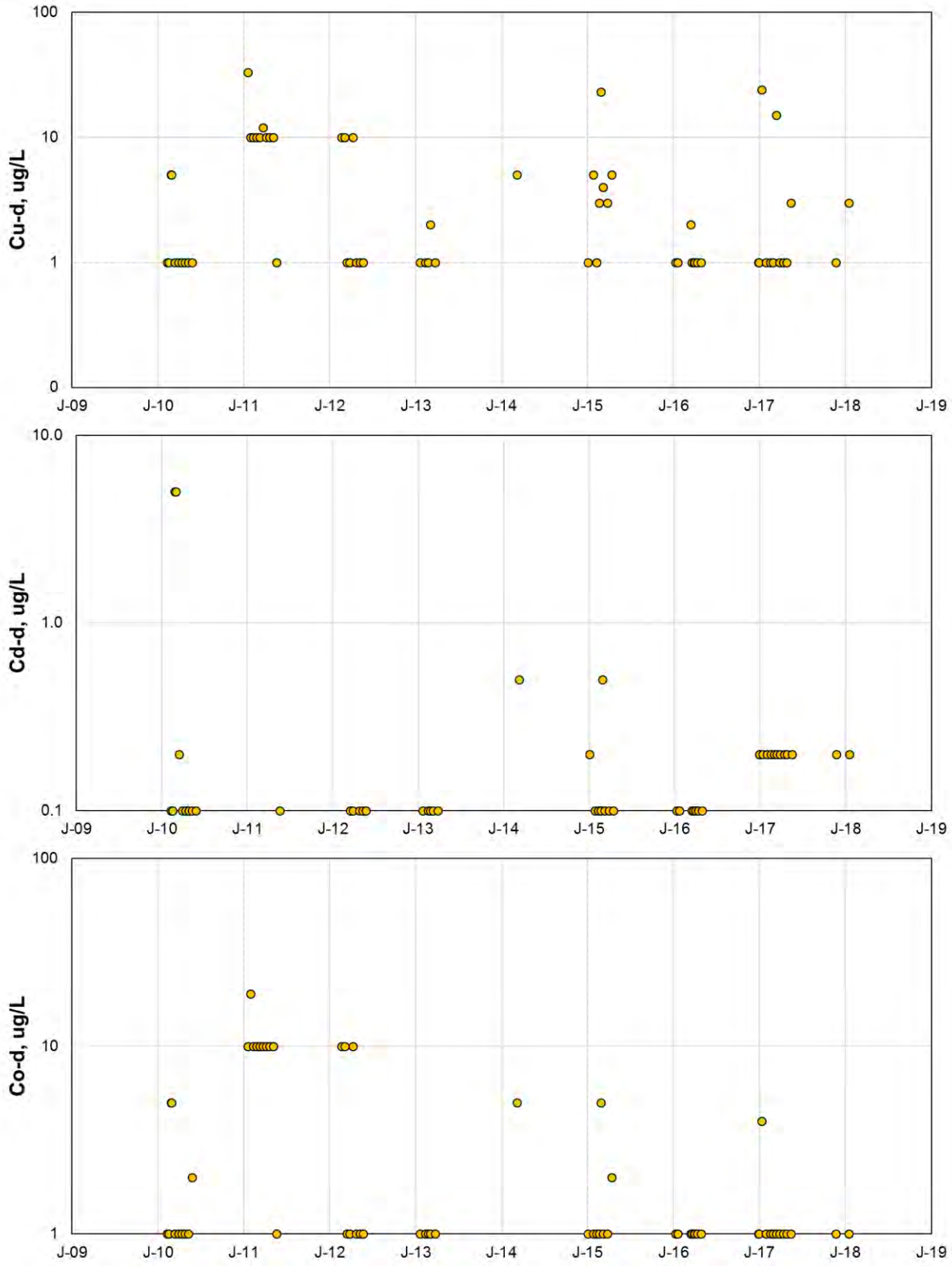


Figure F4. Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 4, 2010 to 2018

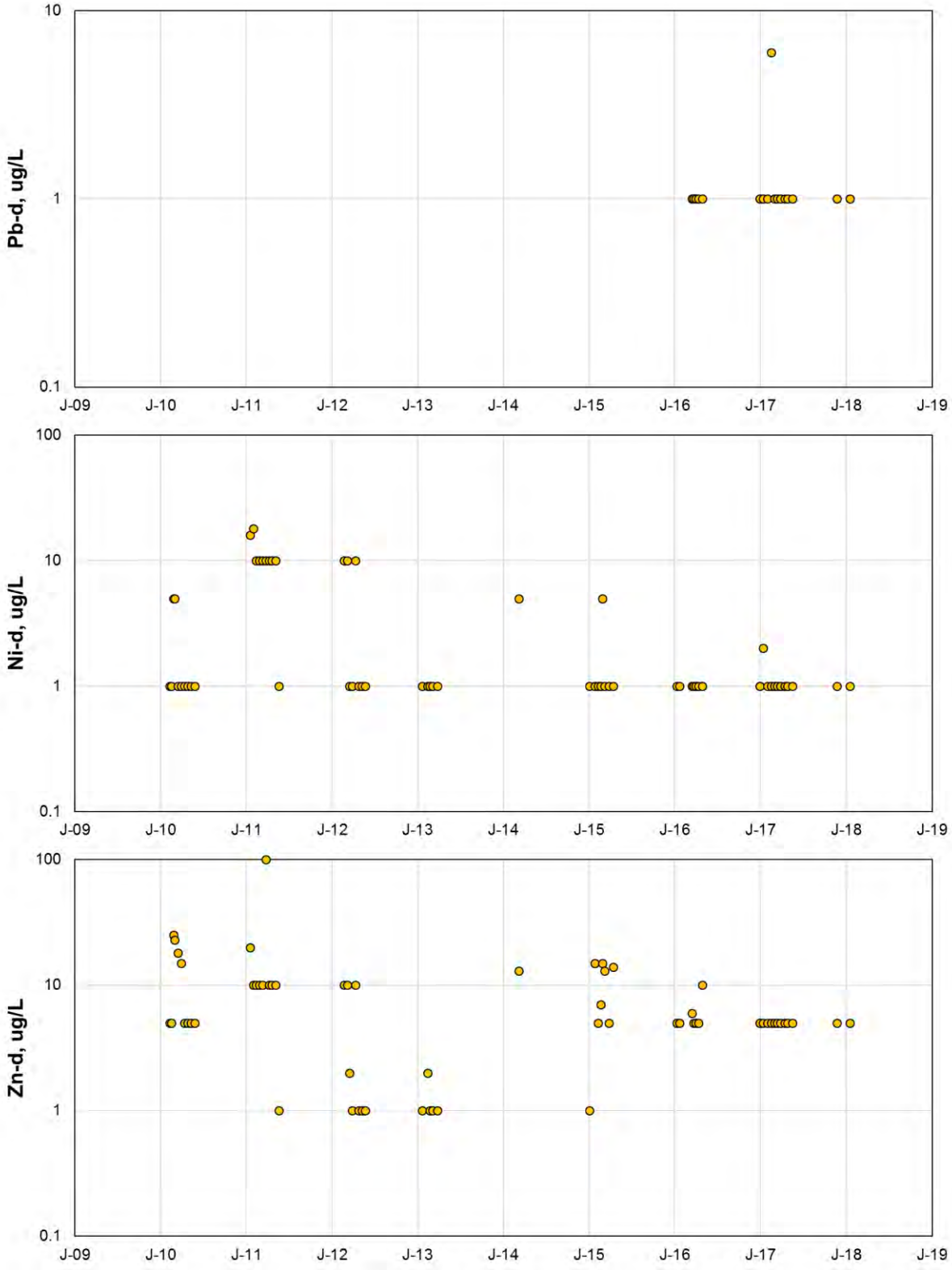


Figure F5. Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 4, 2010 to 2018

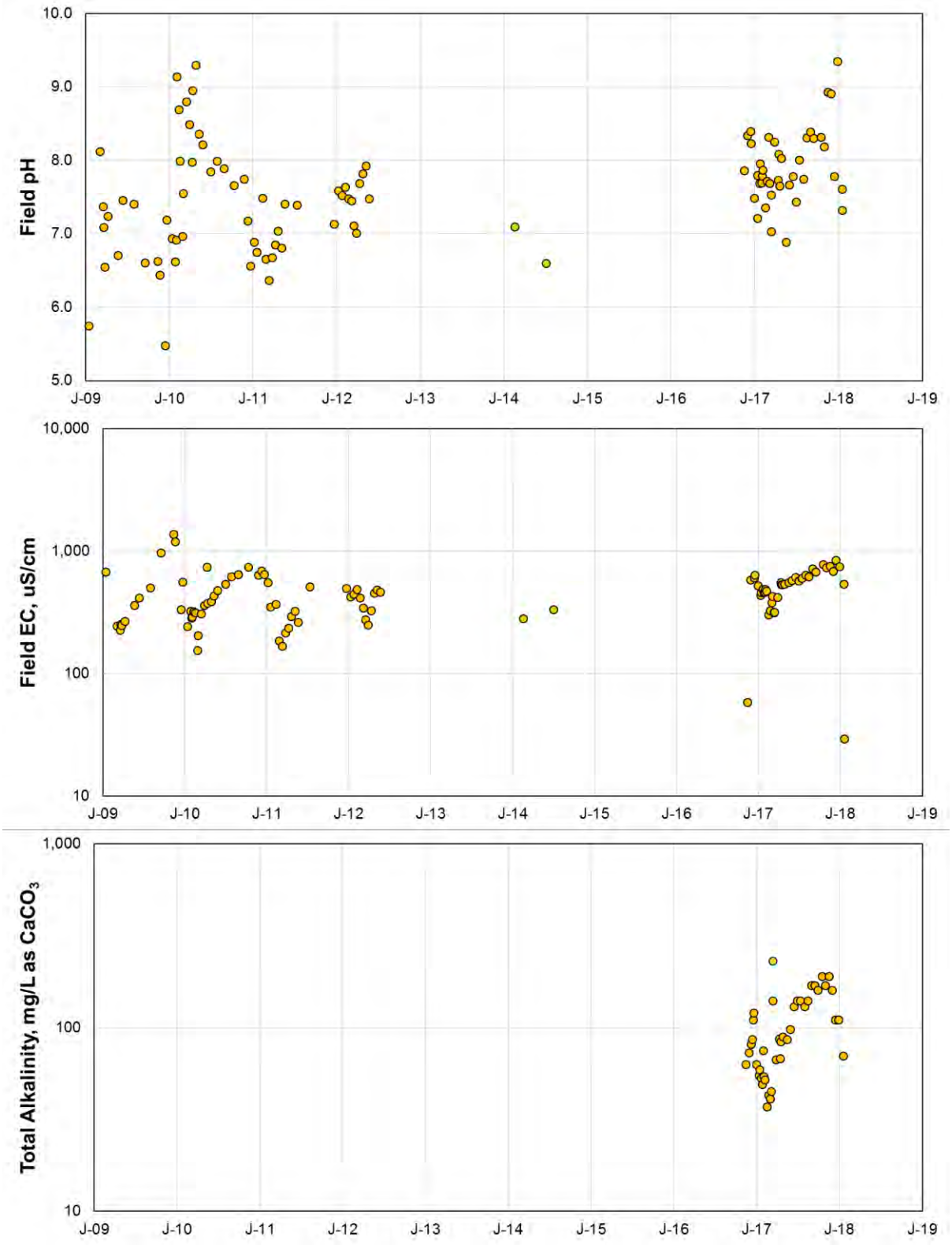


Figure F6. Field pH, Field EC, and Alkalinity at Site 2, 2009 to 2018

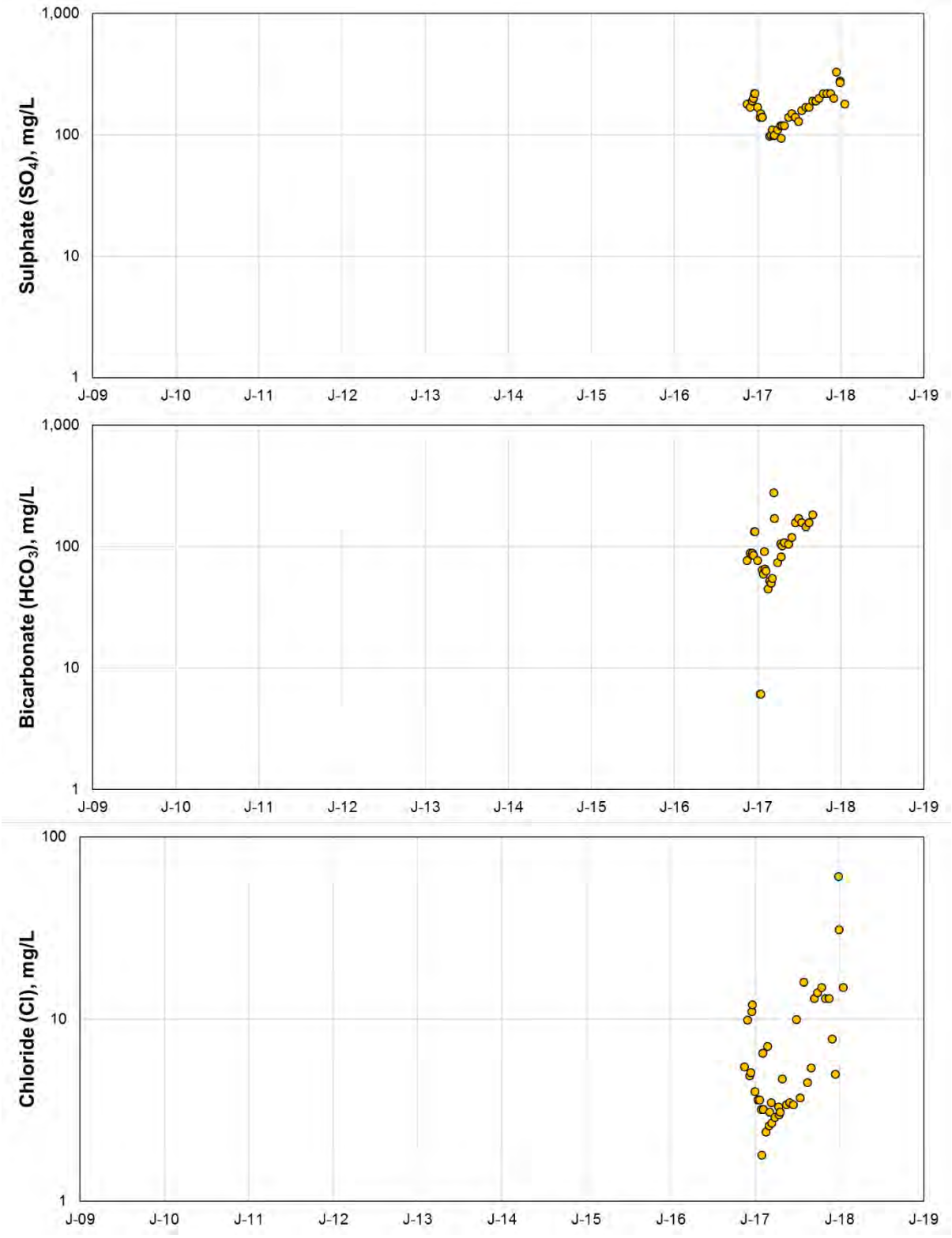


Figure F7. Sulphate (SO_4), Bicarbonate (HCO_3), and Chloride (Cl) Concentrations at Site 2, 2009 to 2018

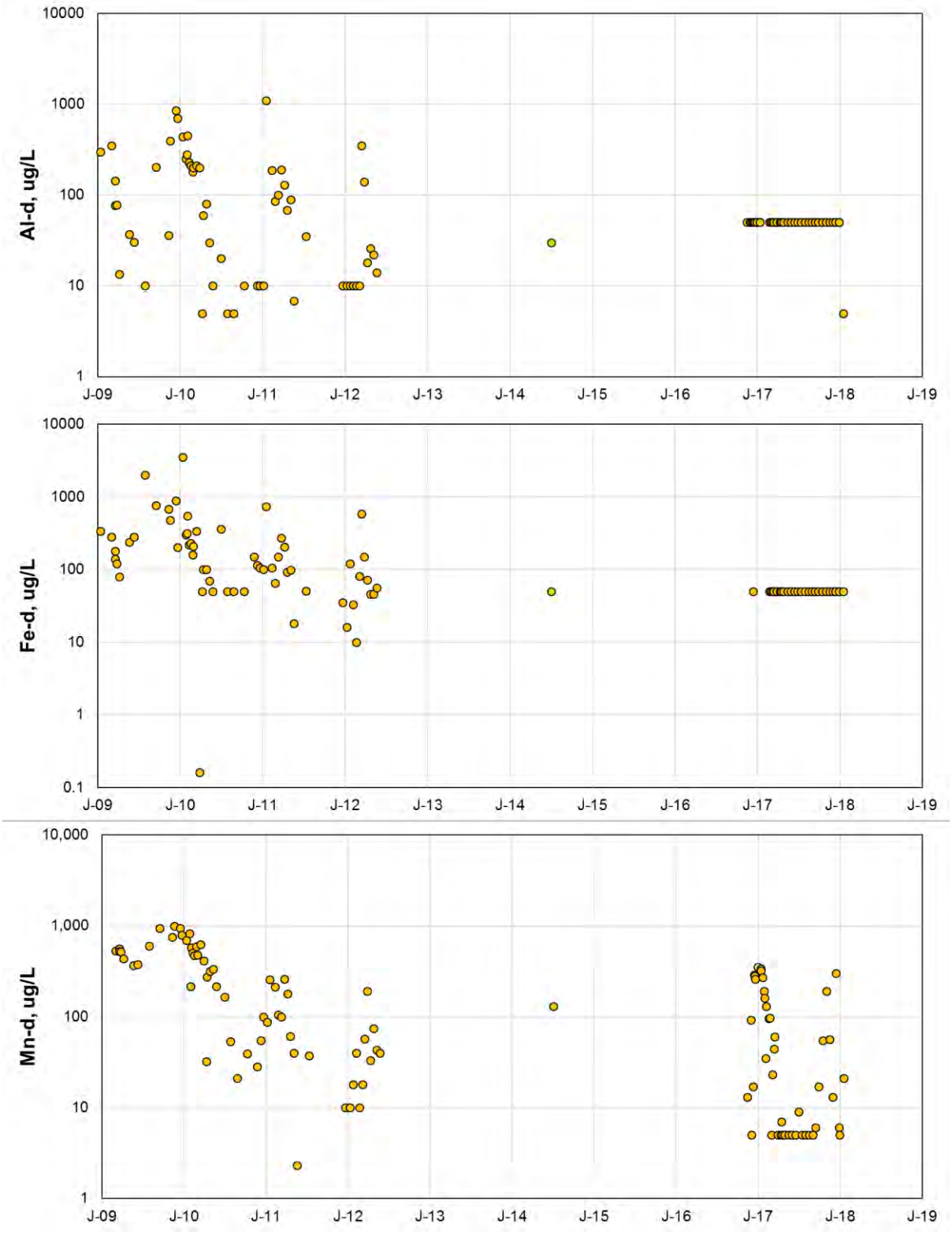


Figure F8. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 2, 2009 to 2018

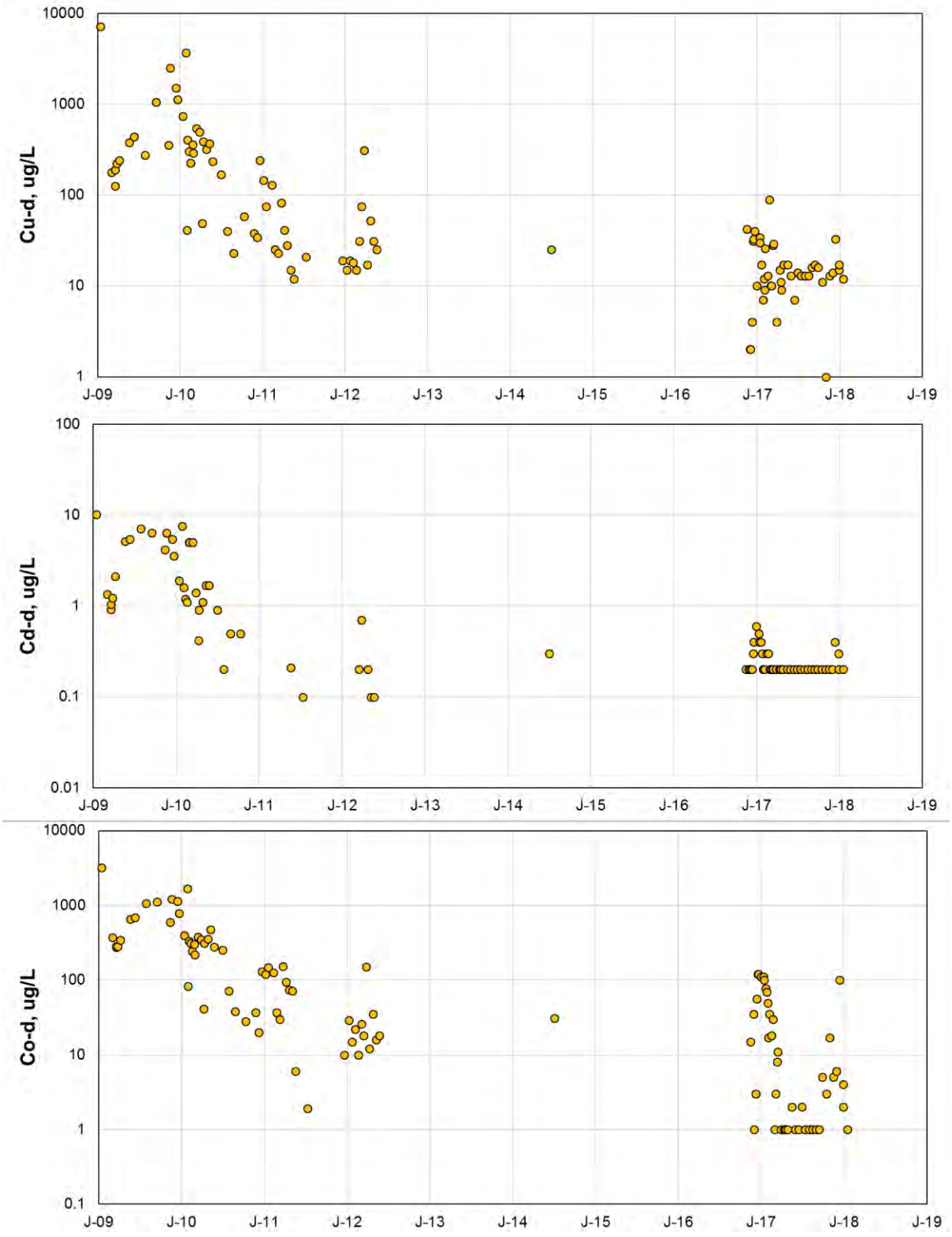


Figure F9. Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 2, 2009 to 2018

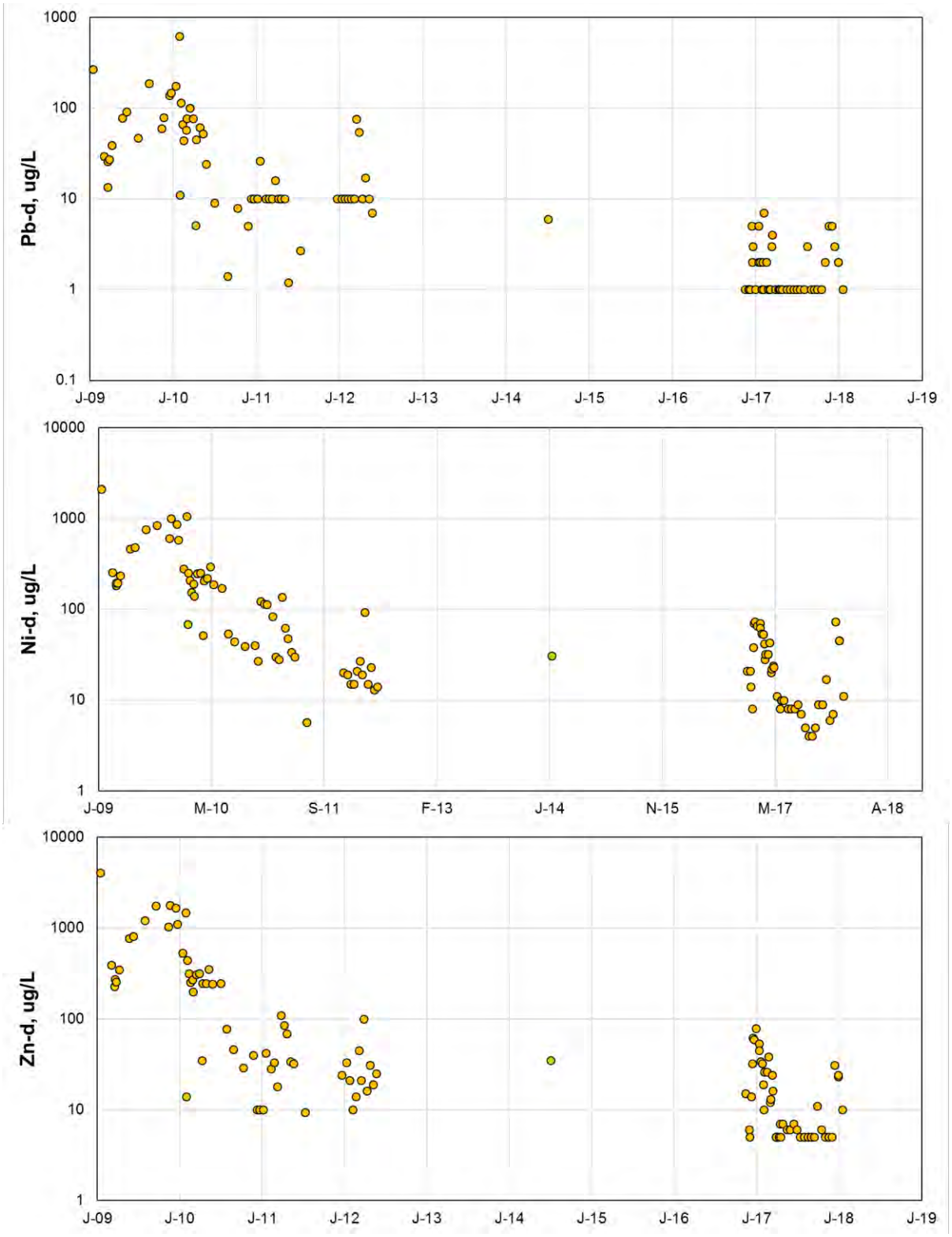


Figure F10. Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 2, 2009 to 2018

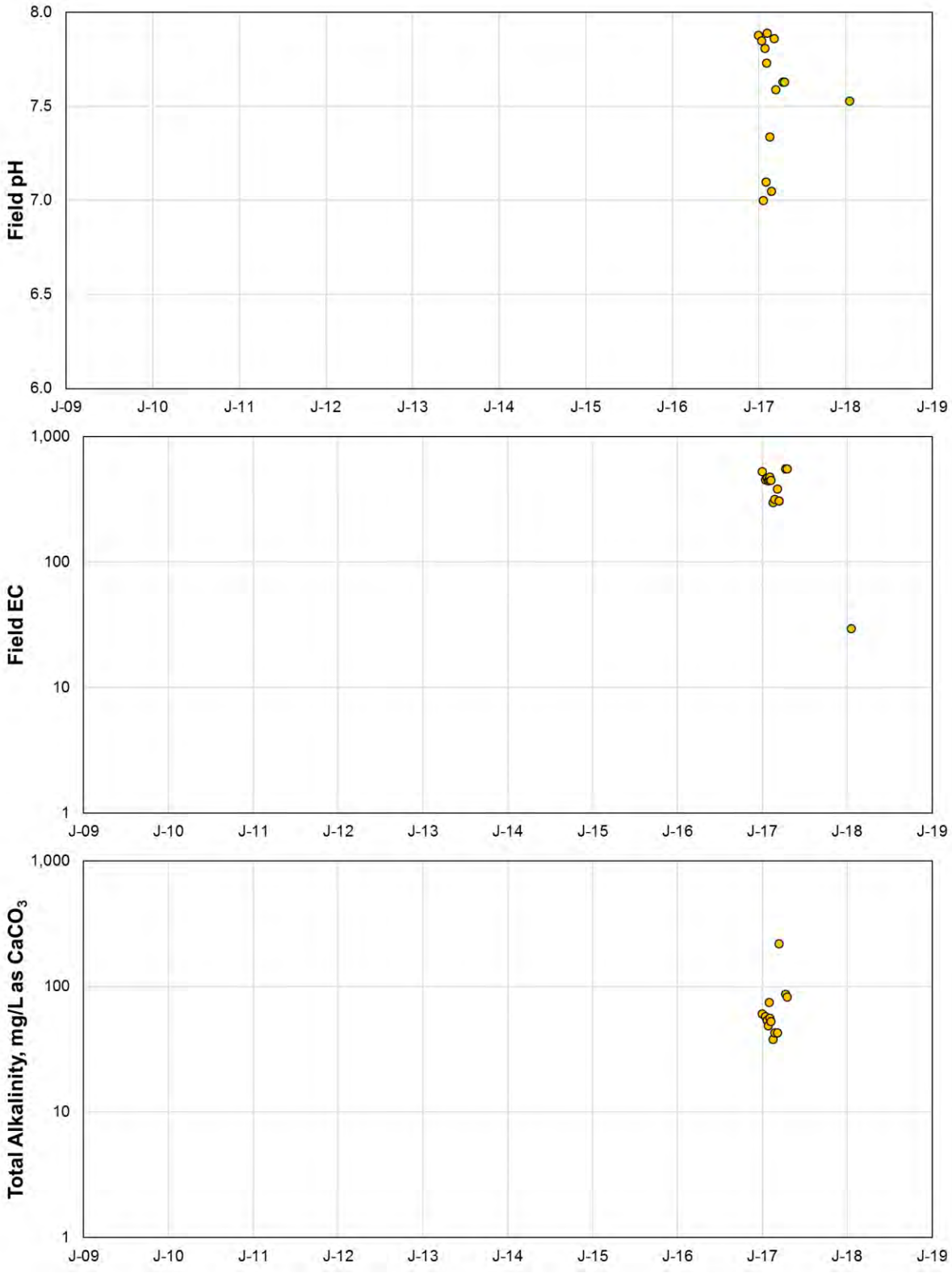


Figure F11. Field pH, Field EC, and Alkalinity at DAMOUT1, 2016 to 2018

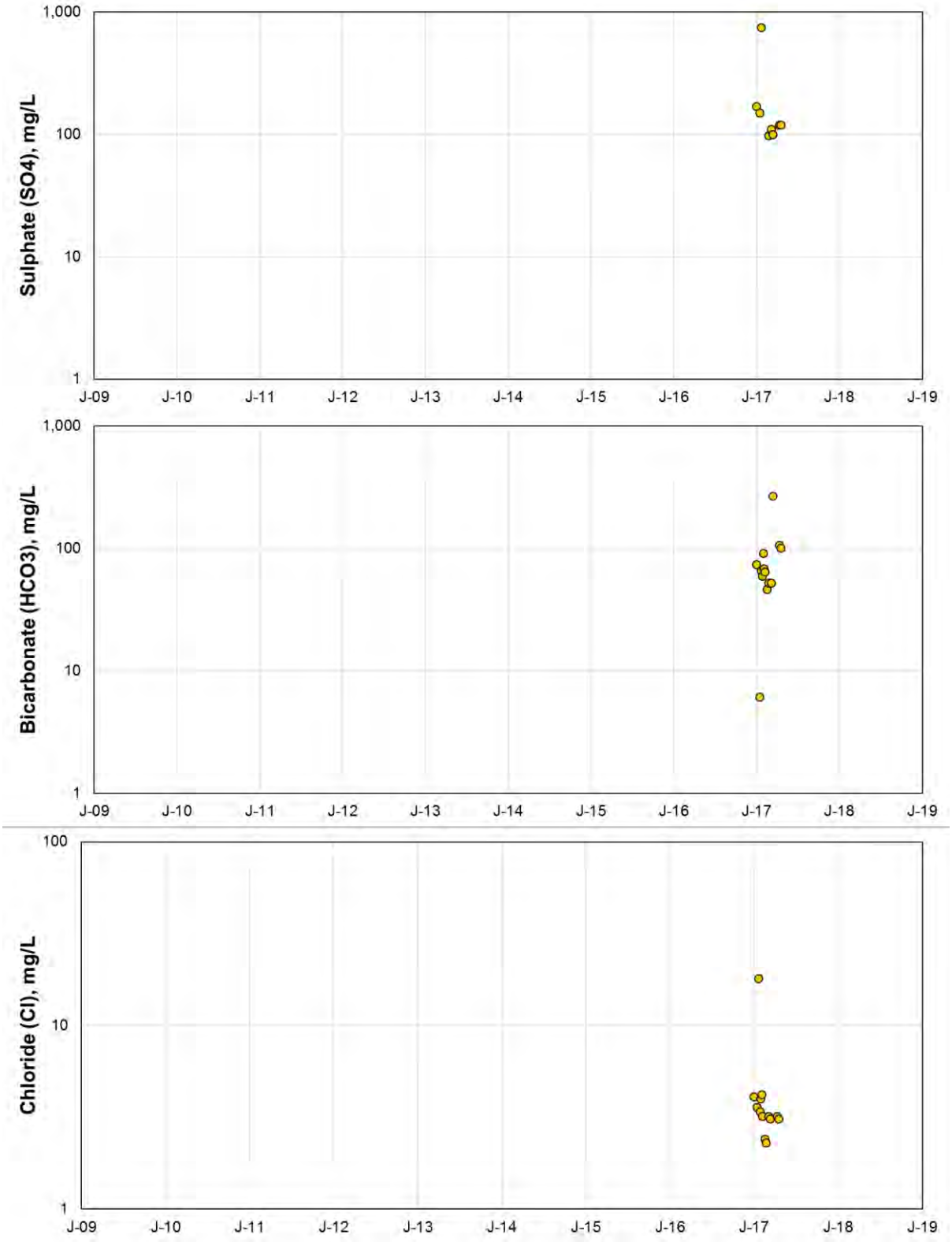


Figure F12. Sulphate (SO_4), Bicarbonate (HCO_3), and Chloride (Cl) Concentrations at DAMOUT1, 2016 to 2018

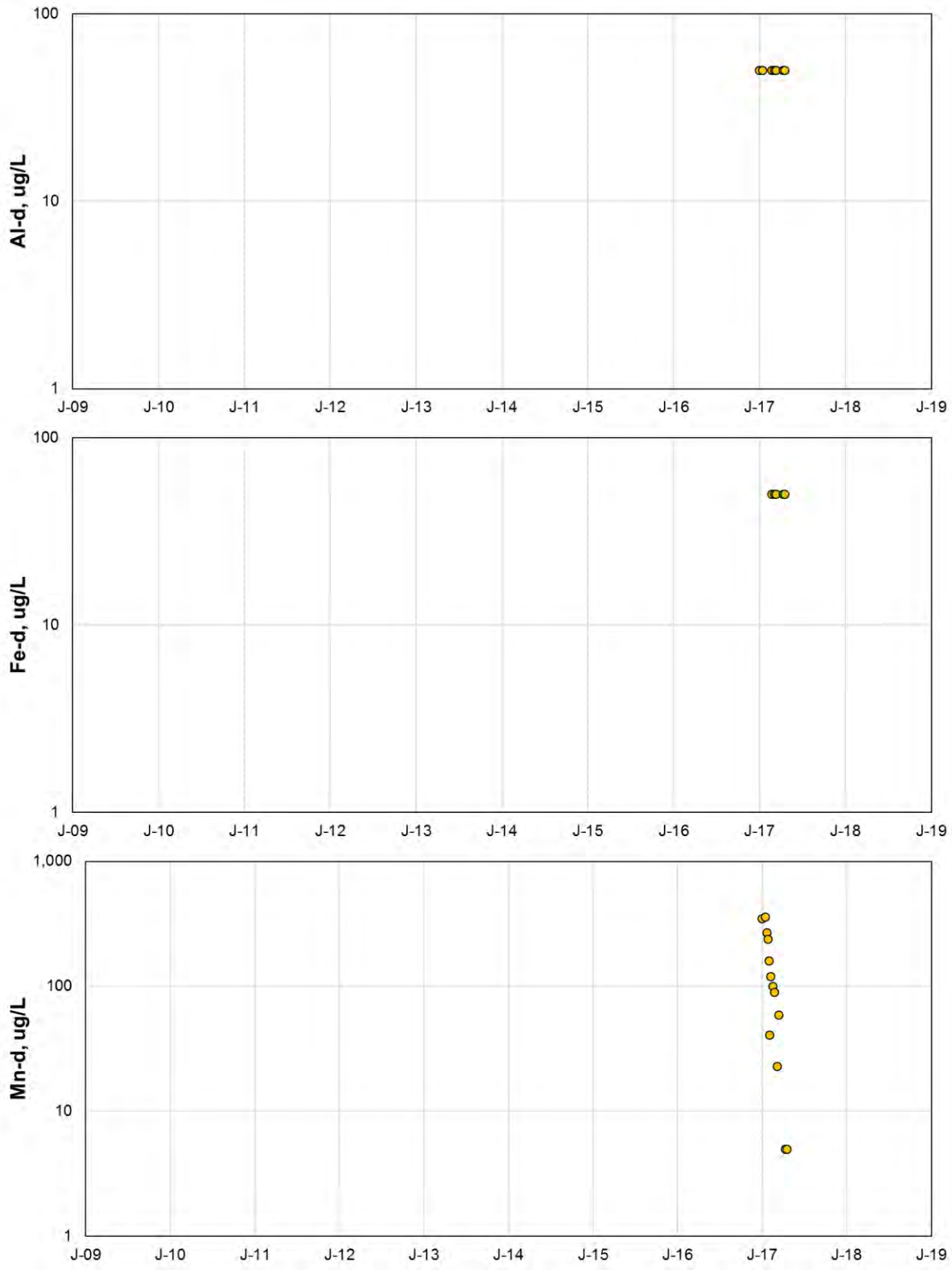


Figure F13. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations at DAMOUT1, 2016 to 2018

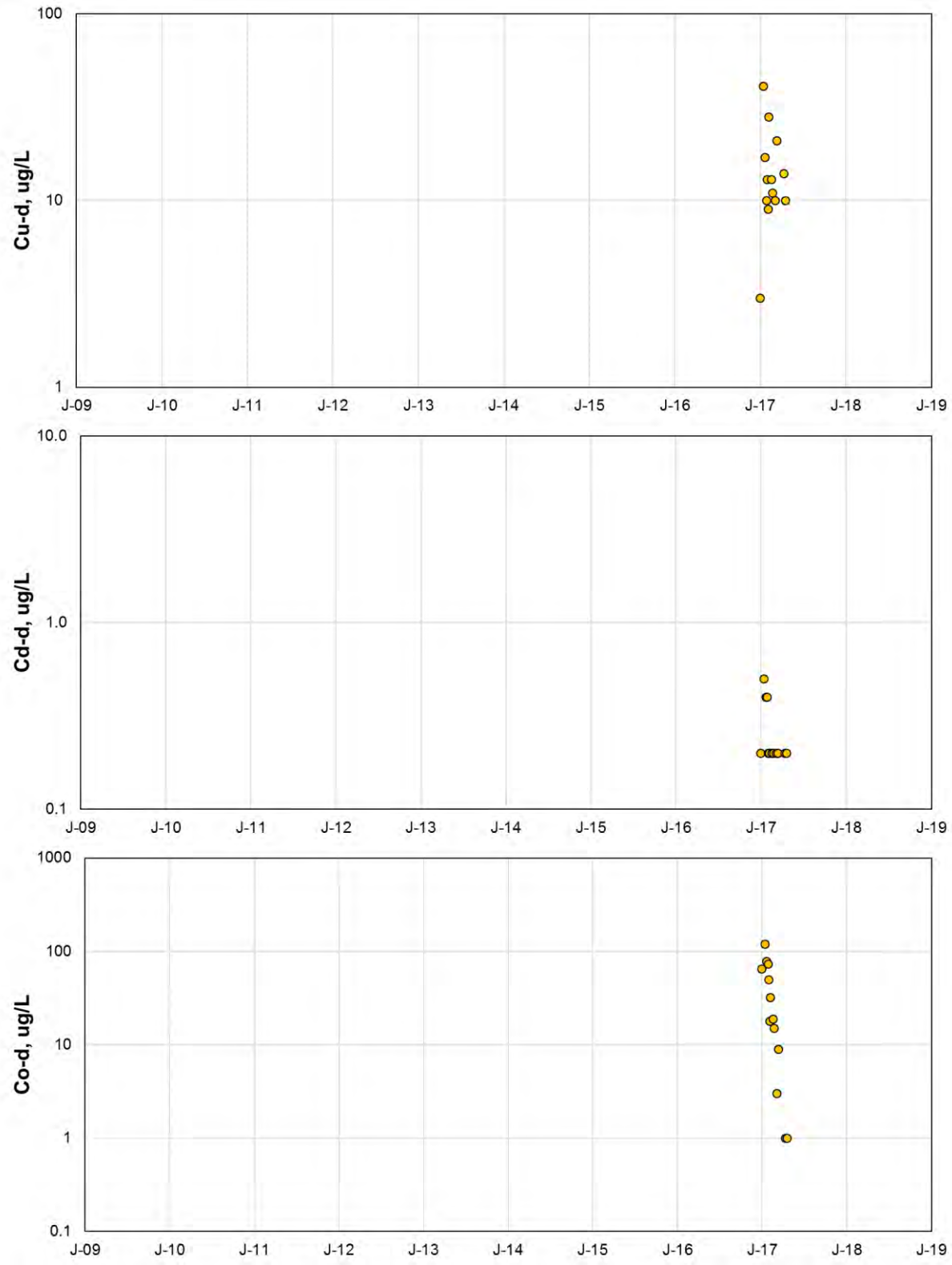


Figure F14. Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at DAMOUT1, 2016 to 2018

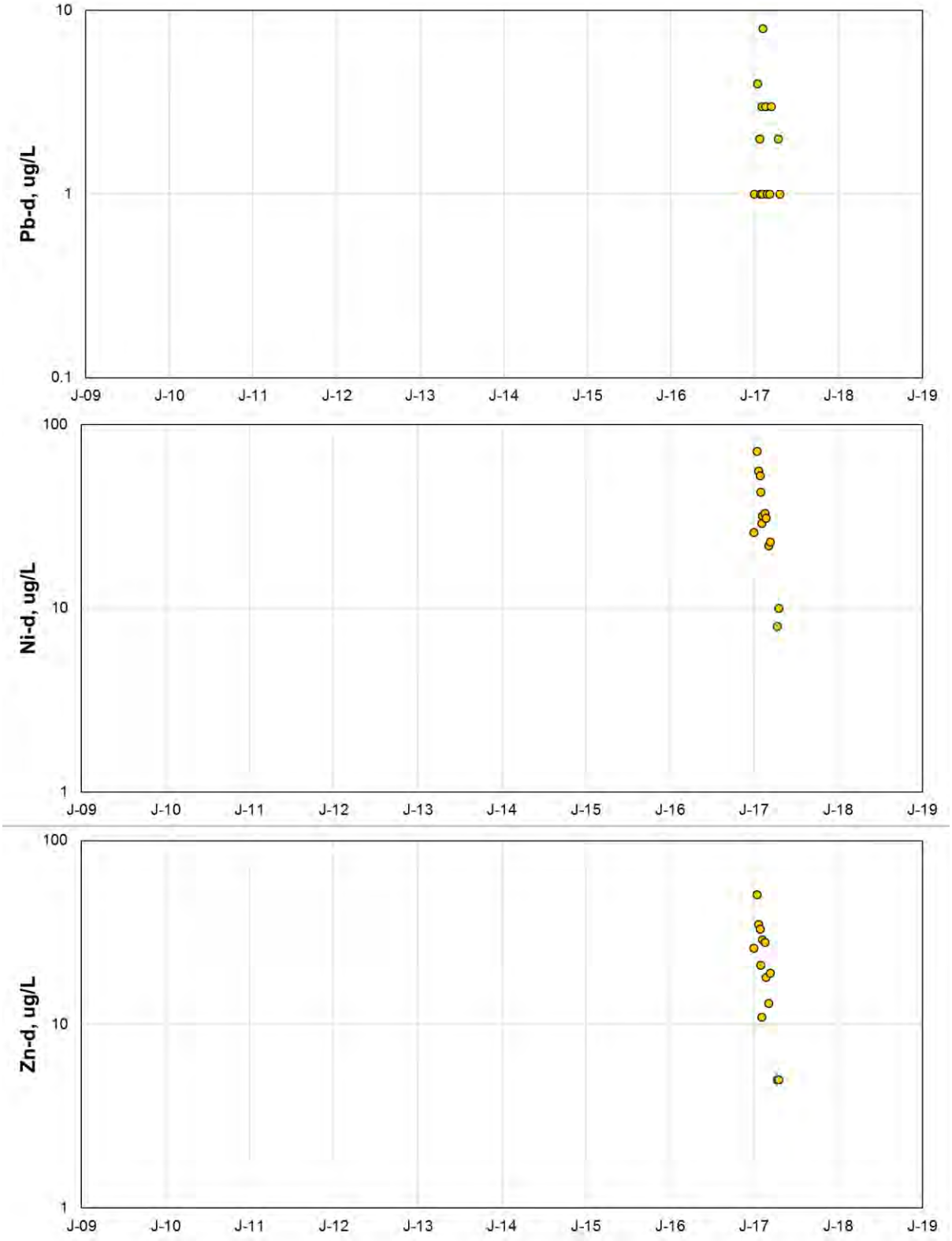


Figure F15. Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at DAMOUT1, 2017 to 2018

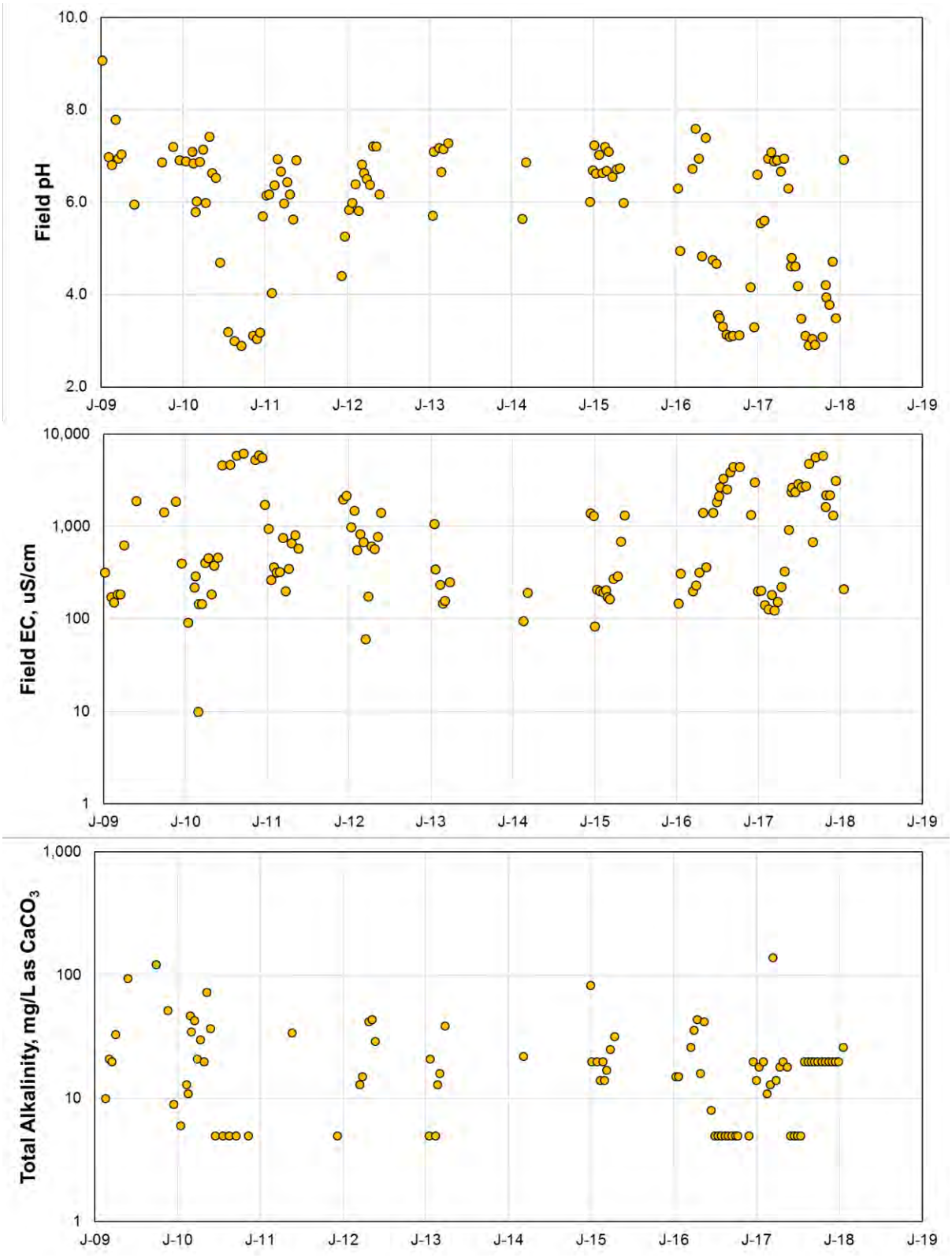


Figure F16. Field pH, Field EC, and Alkalinity at Site 1, 2009 to 2018

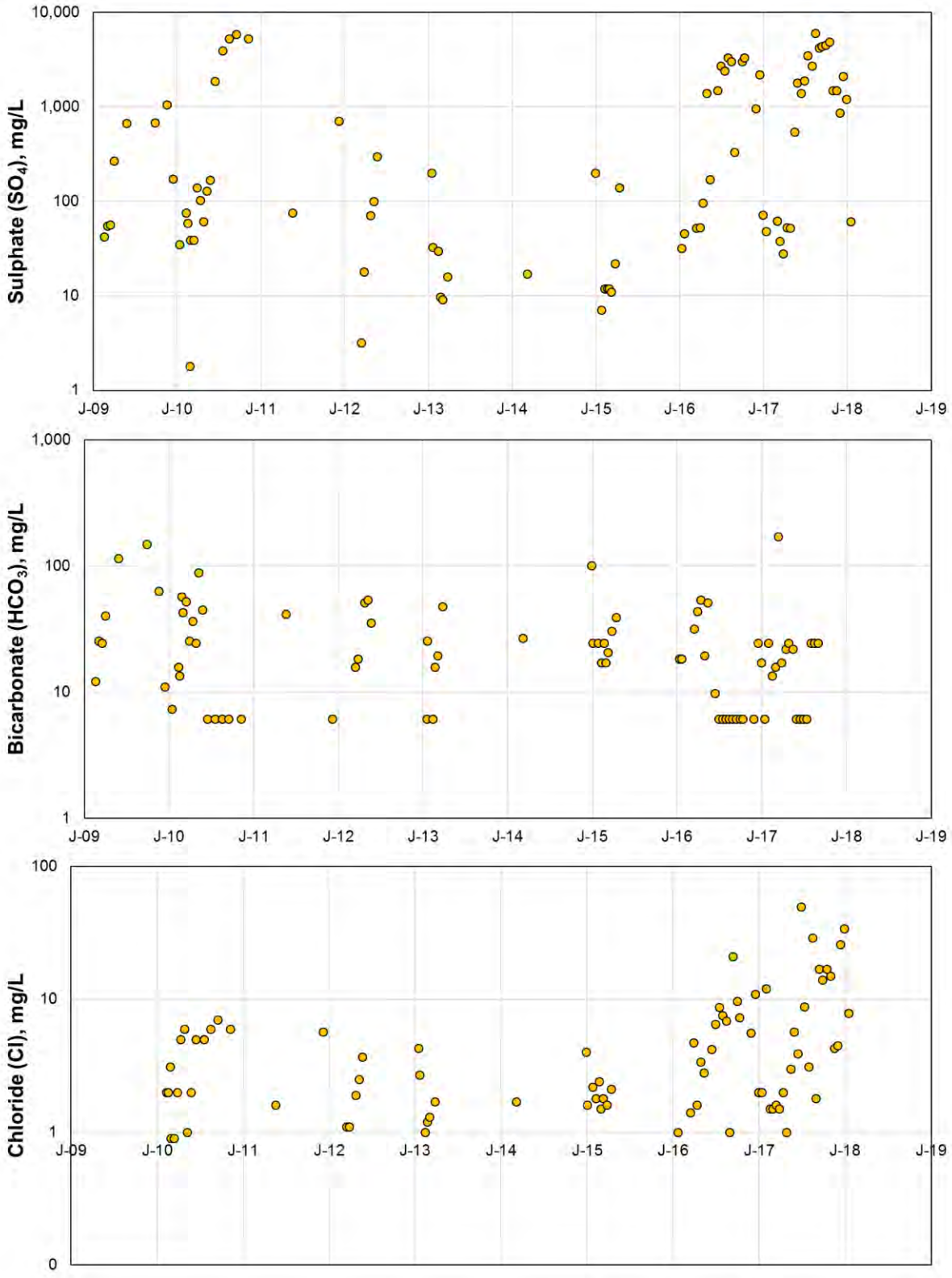


Figure F16. Sulphate (SO_4), Bicarbonate (HCO_3), and Chloride (Cl) Concentrations at Site 1, 2009 to 2018

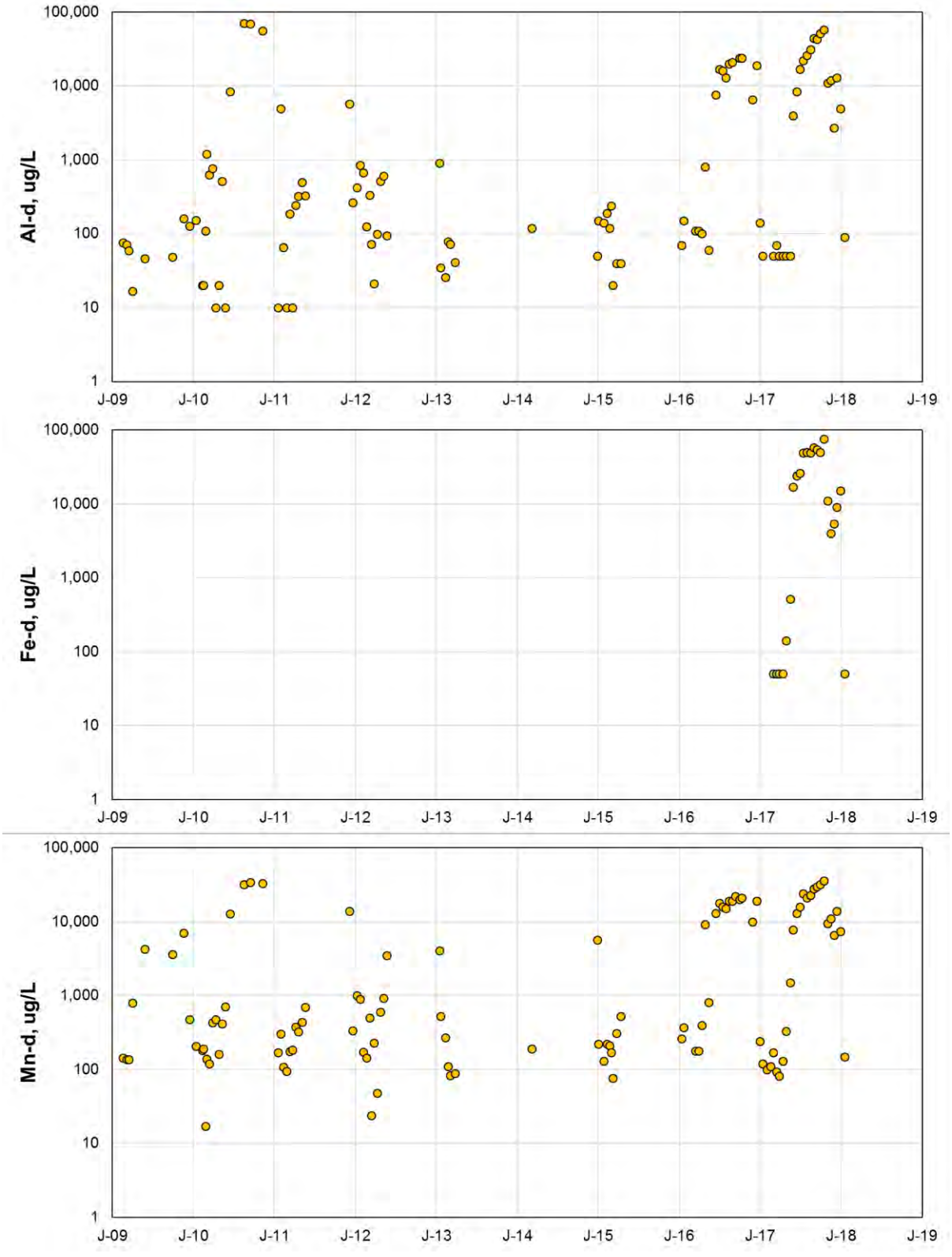


Figure F17. Aluminum (Al), Iron (Fe), and Manganese (Mn) Concentrations at Site 1, 2009 to 2018

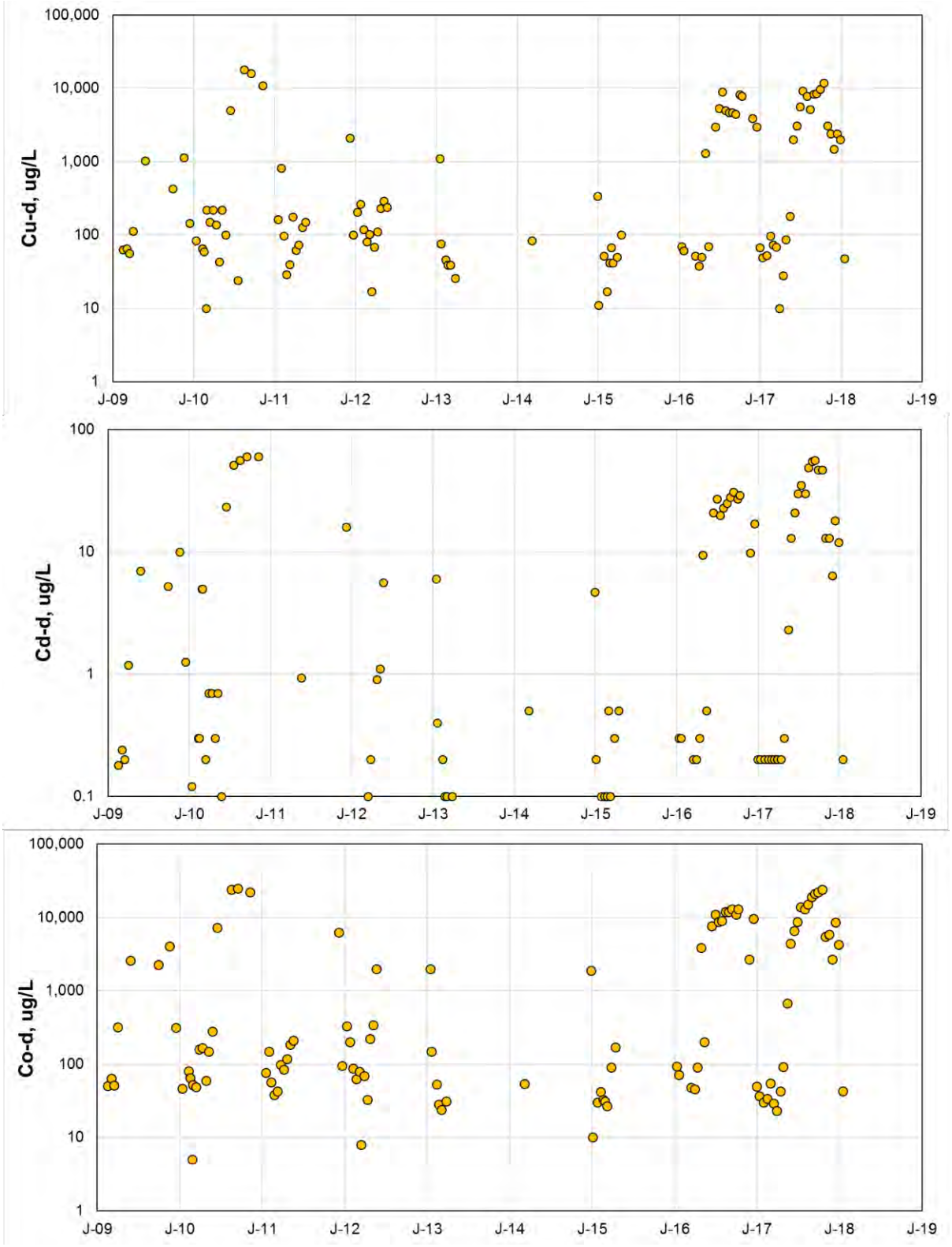


Figure F18. Copper (Cu), Cadmium (Cd), and Cobalt (Co) Concentrations at Site 1, 2009 to 2018

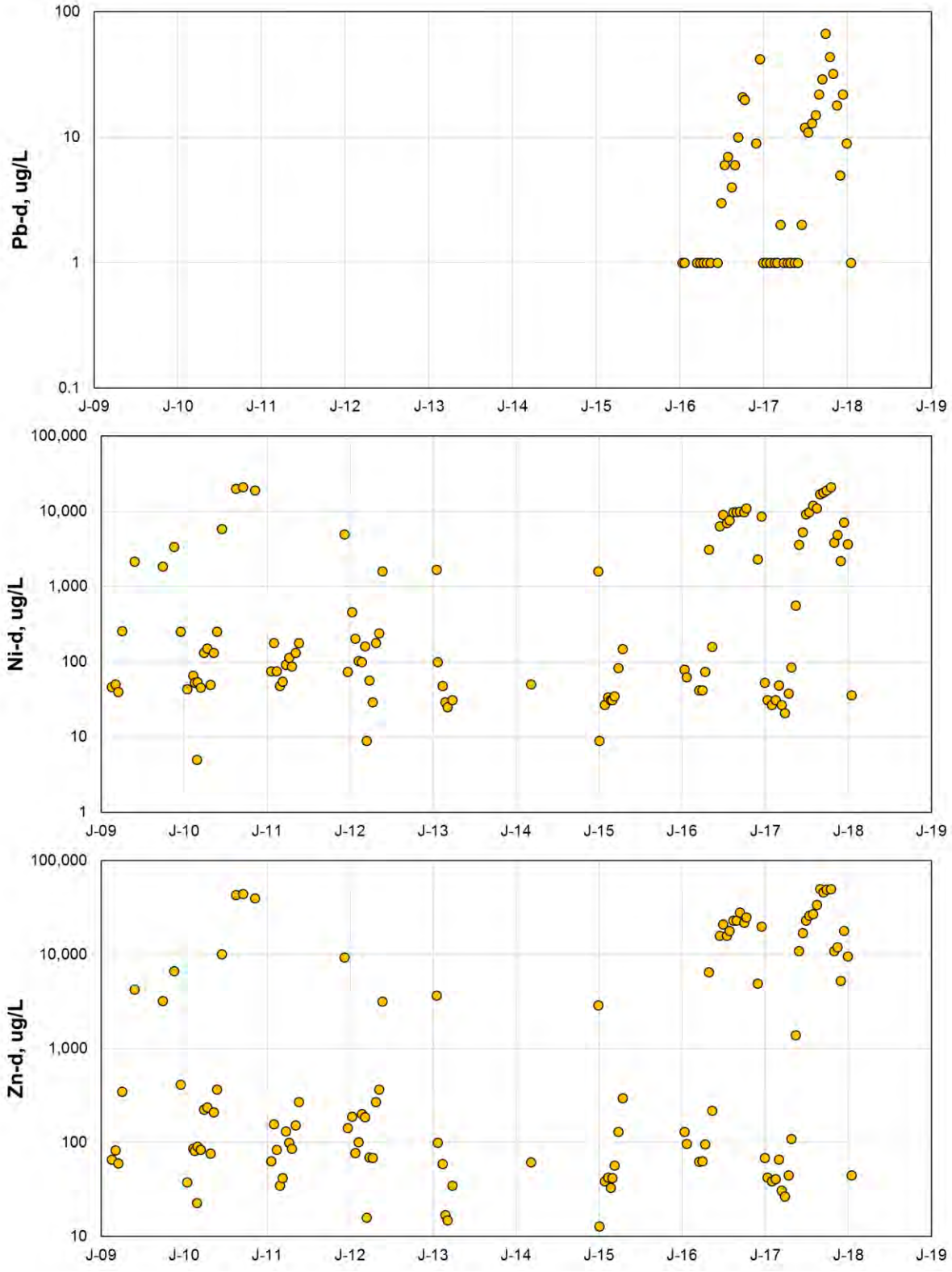


Figure F19. Lead (Pb), Nickel (Ni), and Zinc (Zn) Concentrations at Site 1, 2009 to 2018

APPENDIX G

NON-COMPLIANCE NOTIFICATIONS

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-001
20 January 2017

NT Environmental Protection Authority
Pollution Control
c/-Daniel Spelchan
Email: pollution@nt.gov.au

Dear Daniel,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report water quality exceedances at Site 5 where some of the parameters recorded greater than or equal to two times the trigger value.

Analytical data from Site 5 water is presented in the table below. Data collected on the 29 December 2016 was taken as part of scheduled fortnightly monitoring while the 30 December was taken as part of discharge monitoring.

	Field	Metals				
	pH (Field)	Aluminium (filtered)	Cobalt (filtered)	Copper (filtered)	Nickel (filtered)	Zinc (filtered)
	-	ug/L	ug/L	ug/L	ug/L	ug/L
WDL177-05_Double Trigger Value		160	26	5	26	30
WDL177-05_SW Trigger Values		80	13	2.5	13	15
29/12/2016	6.46	410	41	15	31	56
30/12/2016	6.90	120	14	6	10	15

Licence condition 38.1 No values have exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 On the 29 December 2016 aluminium, cobalt, copper, nickel and zinc recorded, on a single occasion, parameters that measured greater than or equal to two times the trigger value. On the 30 December 2016 copper exceeded the trigger value by more than double.

Information required under licence condition 39 is given below.

Licence condition 39.1	Exceedances were detected today, the 20 January 2017, by Natasha Rodwell.
Licence condition 39.2	Sample dates for these exceedances were the 29 and 30 December 2016.
Licence condition 39.3	The sample from the 29 December 2016 were taken following a large rain event where over 85mm of rain fell in the 24 hours prior to sampling. The exceedances recorded may be representative of 'first flush' water quality. The sample from 30 December 2016 was taken 'upon' discharge from main sediment dam (DAMOUT1) as required under WDL 177-05. In addition, at the time of sampling there was significant rain on site and therefore considerable dilution taking place from this rain. This is evident in the significant decrease in the concentrations of all the metals when compared to the 30 December 2016 sample.
Licence Condition 39.4	The environmental risk of this is exceedance is considered as low, due to the significant dilution of the rain that persisted for many days after this sampling event.
Licence Condition 39.5	This is the first round of water quality data at Site 5 for the 2016/17 wet season. As such water quality will continue to be monitored as per WDL177-05.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref COP-ENV-REG-001).

Please let me know should you require any additional information.

Yours sincerely
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-006
3 February 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report water quality exceedances at Site 5 where some of the parameters recorded greater than the trigger values on more than one occasion. The last results reported to your department where those taken on the 29 and 30 December 2016. As such all data recorded after this data has been reported below and include the 12, 13 and 20 January 2017.

Date	Metals	
	Copper (filtered) ug/L	**Zinc** (filtered) ug/L
WDL177-05_Double Trigger Value	**5**	**30**
WDL177-05_SW Trigger Values	**2.5**	**15**
29/12/2016	**15**	**56**
30/12/2016	**6**	**15**
12/1/2017	**16**	**19**
13/1/2017	**16**	13
20/1/2017	**10**	7

Licence condition 38.1 Both copper and zinc values exceeded the trigger value on three consecutive occasions. Zinc values have remained under the trigger values since the 13 January 2017.

Licence condition 38.2 Copper has recorded values greater than two times the trigger value on 5 occasions. On the 29 December 2017, Zinc had one occasion where the recorded value was greater than two times the trigger value, which was reported to your department in a previous report.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 6 February 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 29 and 30 December 2016 and the 12, 13 and 20 January 2017. Zinc recorded exceedances on 29 and 30 December 2016 and the 12 January 2017.

Licence condition 39.3 Samples from 13 and 20 January 2017 was taken 'upon' discharge as required under WDL 177-05.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of January.

Licence Condition 39.5 Northern Territories Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR have installed addition rock weirs within the settling ponds to allow more time for settling and filtering of sediment from the treated water and stormwater, as is makes its way to the Main Sediment Dam.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421541299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-007
10 February 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions. This notification is reporting values recorded on the 26th January 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	**5**
WDL177-05_SW Trigger Values	**2.5**
13/1/2017	**16**
20/1/2017	**10**
26/1/2017	**3**

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 No metals recorded value was greater than two times the trigger value on the 26th January 2017.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 10 February 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 13th, 20th and 26th January 2017. These values have significantly decreased during this time. On the

26th January the recorded value was only 0.5ug/L greater than the trigger value.

Licence condition 39.3 Improvements have been made to the water treatment process and a decrease the copper concentration is believed to be a combination of these changes and significant rainfall that has fallen within the catchment area during this time.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of January.

Licence Condition 39.5 Northern Territories Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR have installed addition rock weirs within the settling ponds to allow more time for settling and filtering of sediment from the treated water and stormwater, as is makes its way to the Main Sediment Dam.

NTR are working towards a transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-009
14 February 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions. This notification is to report values recorded on the 30th January 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	**5**
WDL177-05_SW Trigger Values	**2.5**
20/1/2017	**10**
26/1/2017	**3**
30/1/2017	**9**

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 Copper metals recorded value was greater than two times the trigger value on the 30th January 2017.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 14 February 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 20th, 26th and the 30th January 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Fluctuations of values recorded on the three separate sampling events (20th, 26th and the 30th January) are believed to be the result of the varying rainfall patterns over this 10 day period.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of January.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR are in the process of setting up for the transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

NTR have installed addition rock weirs within the settling ponds to allow more time for settling and filtering of sediment from the treated water and stormwater, as is makes its way to the Main Sediment Dam.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-010
15 February 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and is also greater than two times the trigger value. This notification is to report values recorded on the 2nd February 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	**5**
WDL177-05_SW Trigger Values	**2.5**
26/01/2017	**3**
30/01/2017	**9**
02/02/2017	**8**

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 Copper metals recorded value was greater than two times the trigger value on the 30th January and the 2nd February 2017.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 15 February 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 26th and the 30th January and 2nd February 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Fluctuations of values recorded on the three separate sampling events (26th and 30th January and 2nd February) are believed to be the result of the varying rainfall patterns over this 10 day period.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of January.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR are in the process of setting up for the transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-011
21st February 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions. This notification is to report values recorded on the 5th February 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	**5**
WDL177-05_SW Trigger Values	**2.5**
30/01/2017	**9**
02/02/2017	**8**
05/02/2017	**3**

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 5th February was **not** greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 21 February 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 30th January and 2nd and 5th February 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

The copper value has significantly decreased since the previous samples and is now only 0.5 µg/L above the trigger value.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of January.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR are in the process of setting up for the transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-015
1st March 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and greater than two times the trigger value. This notification is to report values recorded on the 16th February 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
02/02/2017	8
05/02/2017	3
16/02/2017	7

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 16th February was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 1st March 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 2nd, 5th and 16th February 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of February.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR are in the process of setting up for the transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-017
7th March 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and greater than two times the trigger value. This notification is to report values recorded on the 22nd February 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
05/02/2017	3
16/02/2017	7
22/02/2017	6

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 22nd February was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 7th March 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 5th, 16th and 22nd February 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of February.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are investigating opportunities to further reduce exceedances.

NTR are in the process of setting up for the transition from Sodium Carbonate to a Lime Slurry reagent to be used in the water treatment process. This has recently been approved by the Department of Primary Industry and Resources. It is believed that this change will improve the effectiveness of the water treatment program.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

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ABN 78 124 647 829

Our Ref: NTR-ENV-LET-019
16th March 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and greater than two times the trigger value. This notification is to report values recorded on the 1st March 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
16/02/2017	7
22/02/2017	6
01/03/2017	7

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 1st March 2017 was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 16th March 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 16th and 22nd February and the 1st March 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of February.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are currently in the process of implementing changes to the water treatment system to further reduce exceedances.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

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PO Box 37446
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NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-020
22nd March 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and greater than two times the trigger value. This notification is to report values recorded on the 5th March 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
22/02/2017	6
01/03/2017	7
05/03/2017	6

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 5th March 2017 was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 22nd March 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 22nd February and the 1st and 5th March 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the significant dilution from the rain that has fallen in the catchment over the month of February.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR are committed to continual improvement of their water treatment process and are in the process of implementing changes to the water treatment system to further reduce exceedances.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

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PO Box 37446
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-020
4th April March 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Patricia Dumitro
Email: waste@nt.gov.au

Dear Patricia,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5 on three consecutive occasions and greater than two times the trigger value. This notification is to report values recorded on the 12th and the 14th March 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
05/03/2017	6
12/03/2017	9
14/03/2017	31

Licence condition 38.1 Copper values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the12th and the 14th March 2017 was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 4th April 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances were recorded on the 5th, 12th and the 14th March 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5. Data clearly shows a decrease in metal concentrations to below trigger values with the exception of Copper.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the dilution from the rain that has fallen in the catchment over the month of March.

Licence Condition 39.5 NT Resources Pty Ltd (NTR) continually monitor the effectiveness of its' water treatment program through analysis of water quality results. NTR have been making improvement modifications to treatment process and have noted improvements in the water quality of the treatment water. NTR will continue to investigate ways to improve the treatment process to avoid future exceedances.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-026
27th April 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5, at greater than two times the trigger value. This notification is to report values recorded on the 11th April 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
11 April 2017	7

Licence condition 38.1 No values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 11th April 2017 was greater than two times the trigger value on this occasion.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 27th April 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedances was recorded on the 11th April 2017.

Licence condition 39.3 Data indicates that the water treatment process isn't working at its optimum potential and therefore there are residual metals being detected in the Main Sediment Dam. The wetland is functioning as

designed and the water is being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the dilution from the rain that has fallen in the catchment over the month of March.

Licence Condition 39.5 Data indicates that there have been improvements in the water treatment process with the laboratory results from the previous monitoring round recording no exceedances above the trigger values.

NTR will continue to make the necessary adjustments to its process to improve the performance of the treatment process. A transition from sodium carbonate to slaked lime is planned for the upcoming dry season.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-029
15 May 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38 and 38.2, I wish to report Copper exceeded the trigger value at Site 5, at greater than the trigger value. This notification is to report values recorded on the 24th April 2017.

Date	Metals Copper (filtered) ug/L
WDL177-05_Double Trigger Value	5
WDL177-05_SW Trigger Values	2.5
24 April 2017	4

Licence condition 38.1 No values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 24th April 2017 was greater than the trigger value.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 15th May 2017, by Natasha Rodwell.

Licence condition 39.2 Copper exceedance was recorded on the 24th April 2017.

Licence condition 39.3 Elevated copper was in the noted in the Sedimentation Dam however; the wetland is functioning as designed and these metals are being

filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5.

Licence Condition 39.4 The environmental risk of this is exceedance is considered as low, due to the dilution factors and the exceedance being only slightly above trigger values.

Licence Condition 39.5 NTR recently provided detailed information on the improvements that were made to the water treatment process over the season which have resulted in a reduction in exceedance notifications. In addition, NTR have advised NT EPA of the planned upgrade to the water treatment to be implemented over the coming dry season.

Water treatment has ceased on site for the season to allow for these changes to be implemented. In addition, as the river level is dropping and the chance of any further significant rain is unlikely NTR do not anticipate any further discharge events for the season.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Chief Executive Officer

Northern Territories Resources Pty Limited
PO Box 37446
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-031
26 May 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-05 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.2, I wish to report Copper and Cobalt exceeded the trigger value at Site 5, at greater than the trigger value. This notification is to report values recorded on the 16th May 2017.

Date	Metals	
	Copper (filtered) ug/L	**Cobalt** (filtered) ug/L
WDL177-05_Double Trigger Value	5	26
WDL177-05_SW Trigger Values	2.5	13
16 May 2017	7	47

Licence condition 38.1 No values exceeded the trigger value on three consecutive occasions.

Licence condition 38.2 The value recorded on the 16th May 2017 was greater than the trigger value.

Information required under licence condition 39 is given below.

Licence condition 39.1 Exceedances were detected today, the 26th May 2017, by Natasha Rodwell.

Licence condition 39.2 Copper and Cobalt exceedances were recorded on the 16th May 2017.

Licence condition 39.3 Elevated copper levels were detected in the Sedimentation Dam however; the wetland is functioning as designed and these metals are being filtered as it migrates through the wetland and mixes with Middlebrook Creek before leaving the site via compliance Site 5.

Cobalt reading appears to be a bit of an anomaly as no elevated Cobalt was recorded in either the Sedimentation Dam or Site 4. The next monitoring round is in four days and will indicate if these levels have remained elevated or if they were a one off event.

Water flow in this area is very low and areas are expected to dry out over the coming weeks.

Licence Condition 39.4 The environmental risk of this is exceedance is considered low.

Licence Condition 39.5 NTR recently provided detailed information on the improvements that were made to the water treatment process over the season which have resulted in a reduction in exceedance notifications. In addition, NTR have advised NT EPA of the planned upgrade to the water treatment to be implemented over the coming dry season.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

Northern Territories Resources Pty Limited
PO Box 37446
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-032
16 June 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-06 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.2, Northern Territories Resources Pty Ltd (NTR) wish to report that both Copper and Cobalt recorded values that exceeded the trigger value at Site 5. This notification is to report values recorded on the 30th May 2017.

Date	Metals	
	Copper (filtered)	Cobalt (filtered)
	ug/L	ug/L
WDL177-05_Double Trigger Value	*5*	*26*
WDL177-05_SW Trigger Values	*2.5*	*13*
30 May 2016	**5**	**48**
16 May 2017	**7**	**47**
27 April 2017	**4**	4

Licence condition 38.1 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions.***

Copper exceeded the trigger value on three consecutive occasions being the 27th April, 16th May and 30th May 2017.

Licence condition 38.2 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.***

Copper and Cobalt recorded values greater than the trigger value on the 30th May 2017.

Licence condition 39.1 - ***When the exceedance was detected and by whom.***

Exceedances were detected today, the 19th June 2017, by Natasha Rodwell.

Licence condition 39.2 -	***The date and time of the exceedance.***
Copper and Cobalt exceedances were recorded on the 30th May 2017.	
Licence condition 39.3 -	***The actual and potential causes and contributing factors to the exceedance.***
Metal concentrations will increase as the volume of water decreases. The last discharge event into the wetland ceased on the 21st April and the flow at Site 4 ceased not long after this. Since this time the wetland has begun to dry out and flow at Site 5 has almost stopped.	
Licence Condition 39.4 -	***The risk of environmental harm arising from the exceedance.***
The environmental risk of this is exceedance is considered low due to the low volume of water flowing off the site.	
Licence Condition 39.5 -	***The action(s) that have or will be undertaken to address the exceedance and/or environmental harm.***
NTR have provided detailed information on the improvements that were made to the water treatment process over the season which have resulted in a reduction in exceedance notifications. In addition, NTR have advised NT EPA of the planned upgrade to the water treatment to be implemented over the coming dry season.	

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

Northern Territories Resources Pty Limited
PO Box 37446
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Our Ref: NTR-ENV-LET-035
4th July 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-06 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.2, Northern Territories Resources Pty Ltd (NTR) wish to report that Cobalt recorded values that exceeded the trigger value at Site 5. This notification is to report values recorded on the 15th June 2017.

Date	Metals Cobalt (filtered) ug/L
WDL177-05_Double Trigger Value	*26*
WDL177-05_SW Trigger Values	*13*
15th June 2017	**20**
30th May 2016	**48**
16th May 2017	**47**

Licence condition 38.1 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions.***

Cobalt exceeded the trigger value on three consecutive occasions being the 16th and 30th May and 15th June 2017.

Licence condition 38.2 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.***

Cobalt recorded values greater than the trigger value on the 15th June 2017.

Licence condition 39.1 - ***When the exceedance was detected and by whom.***

Exceedances were detected today, the 4th July 2017, by Natasha Rodwell.

Licence condition 39.2 - ***The date and time of the exceedance.***

An exceedance for Cobalt was recorded on the 15th June 2017.

Licence condition 39.3 - ***The actual and potential causes and contributing factors to the exceedance.***

Metal concentrations will increase as the volume of water decreases. At the time the sample was taken, the flow was extremely low and has since stopped. Cobalt concentration has decreased since the 30th May 2017, when the last exceedance was recorded.

Licence Condition 39.4 - ***The risk of environmental harm arising from the exceedance.***

The environmental risk of this is exceedance is considered low due to the low volume of water flowing off the site.

Licence Condition 39.5 - ***The action(s) that have or will be undertaken to address the exceedance and/or environmental harm.***

NTR have provided detailed information on the improvements that were made to the water treatment process over the season which have resulted in a reduction in exceedance notifications. In addition, NTR have advised NT EPA of the planned upgrade to the water treatment to be implemented over the coming dry season.

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

Northern Territories Resources Pty Limited
PO Box 37446
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ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-040
14th Dec 2017

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-06 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.2, Northern Territories Resources Pty Ltd (NTR) wish to report exceedances in some of the trigger values at Site 5. This notification is to report values recorded on the 22nd and the 30th November 2017.

Date	Metals							
	Al	Cd	Co	Cu	Mn	Ni	Pb	Zn
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WDL177-06_ Trigger Values	*80*	*0.4*	*13*	*2.5*	*2,500*	*13*	*5.6*	*15*
Double the Trigger Value	*160*	*0.8*	*26*	*5*	*5,000*	*26*	*11.2*	*30*
22 Nov 2017	90	**1.4**	**340**	**210**	780	**190**	2	**290**
30 Nov 2017	**2,500**	**13**	**2,100**	**2,100**	**11,000**	**2,000**	**380**	**3,100**

Licence condition 38.1 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions.***

No values have exceeded a value on three consecutive occasions.

Licence condition 38.2 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.***

The bold values in the above table indicate where certain parameters have been recorded greater than two times the trigger values.

Licence condition 39.1 - ***When the exceedance was detected and by whom.***

Today being 14th December 2017 by Natasha Rodwell.

Licence condition 39.2 -	***The date and time of the exceedance.***
Exceedances were on 22nd November and the 30th November 2017.	
Licence condition 39.3 -	***The actual and potential causes and contributing factors to the exceedance.***
Both samples were collected after the first significant rain event for the season. The 22nd November sample was taken within the first few hours following a 73mm rain event. Between this event and the 30th November, the site received an additional 42mm of rain. Site4 also began flowing at this time flushing water through the wetland. Recognising this is a limited data set, it may indicate that the drop in the water pH has remobilised the metals within the wetland as a result of a change in the biological activity within the wetland following the rain event. Although there is insufficient data for a comprehensive analysis this site will continue to be monitored fortnightly as per the WDL.	
Licence Condition 39.4 -	***The risk of environmental harm arising from the exceedance.***
The environmental risk of this is exceedance is considered low due to the low volume of water flowing off the site during these rain event.	
Licence Condition 39.5 -	***The action(s) that have or will be undertaken to address the exceedance and/or environmental harm.***
NTR will continue to monitor the water as per the WDL. Site5 has since dried up and there will is a potential for another opportunity to collect additional first flush at this site.	

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

Northern Territories Resources Pty Limited
PO Box 37446
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NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-041
15th January 2018

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-06 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.2, Northern Territories Resources Pty Ltd (NTR) wish to report exceedances in some of the trigger values at Site 5. This notification is to report values recorded on the 29th December 2017.

Date	Metals							
	Al	Cd	Co	Cu	Mn	Ni	Pb	Zn
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WDL177-06_ Trigger Values	*80*	*0.4*	*13*	*2.5*	*2,500*	*13*	*5.6*	*15*
Double the Trigger Value	*160*	*0.8*	*26*	*5*	*5,000*	*26*	*11.2*	*30*
13 Dec 2017	Dry							
29 Dec 2017	**1,900**	**9.5**	**2,900**	**1,800**	**8,100**	**1,800**	**390**	**2,400**

Licence condition 38.1 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions.***

No values have exceeded a value on three consecutive occasions. Exceedances were recorded and reported for November however, Site 5 dried up during this time and was dry during the December sampling round conducted on the 13 December 2017.

Licence condition 38.2 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.***

The parameters in the above table recorded greater than two times the trigger values on a single occasion.

Licence condition 39.1 - ***When the exceedance was detected and by whom.***

12th January 2018 by Natasha Rodwell.

Licence condition 39.2 -	***The date and time of the exceedance.***
These exceedances were recorded on the 29th December 2017.	
Licence condition 39.3 -	***The actual and potential causes and contributing factors to the exceedance.***
This wet season has seen a less than average rainfall across the site and at the time of sampling there was only a very minimal flow across the fence boundary. It should be noted that due to the low rainfall, NTR have not released any water from its containment dam this season. Therefore, any exceedances recorded at Site 5 are not a direct result of current water treatment activities. As discussed in the last correspondence, NTR recognise there is insufficient data for a comprehensive analysis of the water quality at this time. NTR will continue to be monitored fortnightly as per the WDL.	
Licence Condition 39.4 -	***The risk of environmental harm arising from the exceedance.***
The environmental risk of this is exceedance is considered low due to the low volume of water flowing off the site at the time this sample was taken.	
Licence Condition 39.5 -	***The action(s) that have or will be undertaken to address the exceedance and/or environmental harm.***
NTR will continue to monitor the water as per the WDL. At the time of writing, Site 5 is flowing and is schedule for another round of sampling on the 17th January 2018.	

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards
Northern Territories Resources Pty Ltd

Dr Andrew Tong
Director

Northern Territories Resources Pty Limited
PO Box 37446
Winnellie
NT 0821
ACN 124 647 829
ABN 78 124 647 829

Our Ref: NTR-ENV-LET-045
7th February 2018

NT Environmental Protection Authority
Environmental Authorisations
c/-Edel Stoner
Email: waste@nt.gov.au

Dear Edel,

WDL 177-06 – Surface Water Quality Exceedance Notification as per Condition 38

In accordance with licence condition 38.1 and 38.2, Northern Territories Resources Pty Ltd (NTR) wish to report exceedances of Copper and Zinc at Site 5. This notification is to report values recorded on the 18th, 22nd, 29th and 31st January 2018.

Date	Metals	
	Cu	Zn
	ug/L	ug/L
WDL177-06_ Trigger Values	*2.5*	*15*
Double the Trigger Value	***5***	***30***
17 Jan 2018	**33**	**70**
18 Jan 2018	**8**	**23**
22 Jan 2018	**16**	**15**
29 Jan 2018	**8**	6
30 Jan 2018	**5**	7

**Reportable results in bold*

Licence condition 38.1 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on three consecutive occasions.***

Site 5 recorded Zinc on three consecutive occasions including the 17th, 18th and 22nd January. No further exceedances were recorded after this date.

Licence condition 38.2 - ***When a trigger value for Site 5 specified in Table 3 is exceeded on a single occasion where the parameter measures greater than or equal to two times the trigger value.***

Copper was the only analyte to exceed the trigger value equal or greater than two times the trigger value. This notification is to report those exceedances recorded on the 18th, 22nd, 29th and 30th. A previous notification reported the exceedance on the 17th January and has been included in the above table to address Condition 38.1 (i.e. 3 consecutive readings for Zinc.)

Licence condition 39.1 -	***When the exceedance was detected and by whom.***
6th February 2018 by Natasha Rodwell.	
Licence condition 39.2 -	***The date and time of the exceedance.***
These exceedances were recorded on the 18th, 22nd, 29th and 31st January 2018.	
Licence condition 39.3 -	***The actual and potential causes and contributing factors to the exceedance.***
The actual and potential causes of the exceedances are difficult to quantify. The extreme rainfall conditions may have represented a significant 'flush' event, resulting in the transportation of elevated Copper and Zinc from Site 5. As the rain continued the system (wetland) is essentially 'flushed' and transportation of these materials subsides. This is supported by the data. The data demonstrates that both Copper and Zinc significantly reduced over this sample period. Zinc was at or below the trigger value on three consecutive occasions after the 22nd January. Copper levels had reduced almost 85% during the sample period.	
Licence Condition 39.4 -	***The risk of environmental harm arising from the exceedance.***
The environmental risk of this is exceedance is considered low due to the significant amount of rainfall received by the catchment during this time. The site recorded 824.5mm from the 18th to the 31st January 2018.	
Licence Condition 39.5 -	***The action(s) that have or will be undertaken to address the exceedance and/or environmental harm.***
NTR will continue to monitor the water quality as per the WDL. A total of 1107.6mm of rain was recorded for the month of January providing significant fresh water flows to the catchment. In addition, as part of NTR's continual improvement of its management practices, we currently conducting our annual review of potential improvements to water management system. Any such improvement will be presented in the upcoming MMP submission and subsequently forwarded to the NT EPA on approval by the Department of Primary Industry and Resources.	

This noncompliance has been recorded on the new WDL Non-Compliance Register (ref NTR-ENV-REG-001).

Please contact Natasha Rodwell on 0421 541 299 or Natasha.rodwell@NTResources.com.au if you require any further information.

Kind Regards

Northern Territories Resources Pty Ltd

Dr Andrew Tong

Director

APPENDIX H

PHOTO LOG FROM RGC SITE VISIT (JULY 2017)

Photo 1. Monitoring bores BH4A and BH4B and recovery bores BH4F and BH4G

Photo 2. Overhead view of bores BH4A, BH4B, BH4F, and BH4G

Photo 3. Discharge from recovery bore BH4G to the TSF pond

Photo 4. Buckets used for bucket-and-flow measurements of BH4G flow rate

Photo 5: (Left) BH4H and road towards bores BH7A/B (Right) Bores BH3A/B

Photo 6. (Left) BH12A, BH12B, and recovery bore BH12C. (Right) Close-up of BH12C

Photo 7. (Left) Small Sediment Dam. (Right) Bores BH14A and BH14B

Photo 8. Erosion channel on berm and TSF pond

Photo 9. Discharge from recovery bore BH12C to TSF pond

Photo 10. Low grade and Lead ore stockpile and collection pond to right

Photo 11. Vegetated backfill within the TSF

Photo 12. (Left) PAF stockpile. (Right) Low-grade and Lead ore stockpile

Photo 13. Low grade and Lead ore stockpile to right

Photo 14. (Left) Bore 17B. (Right) Bores 15A/B and Intermediate ore stockpile

Photo 15. View of wetland area from Main Sediment Dam

Photo 16: WDL Site 03

Photo 17. WDL Site 03

Photo 18. Browns Pit

Photo 19. Browns Pit

Photo 20. Browns Pit area, looking towards settling pond and drill rig

Photo 21. Browns Pit, looking towards bore TPB4

Photo 22. Browns Pit

Photo 23. Browns Pit near Bore TPB5

Photo 24. View of Site 5 (WDL Monitoring Station)

Photo 25. (Left). View of Bore 22085. (Right) Site 4 (WDL Monitoring Station)

Photo 26. Air photo showing TSF pond extent in 2009

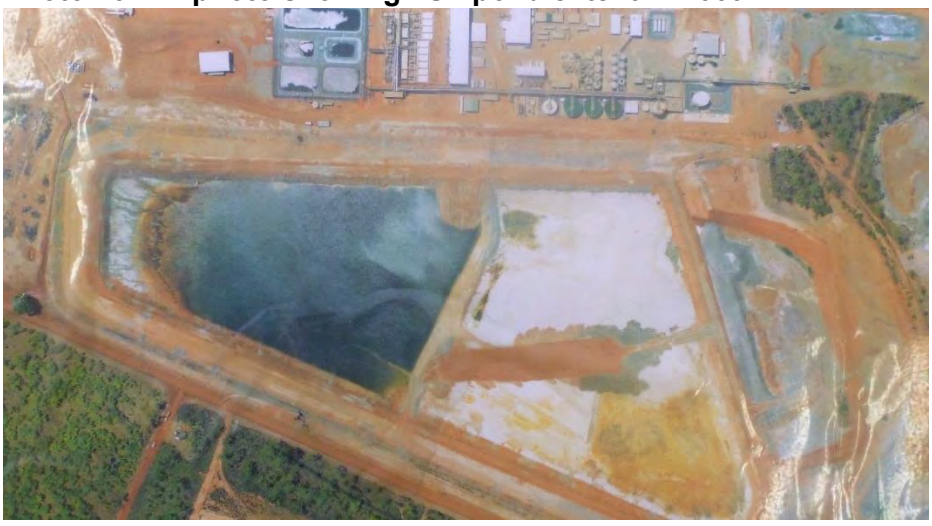


Photo 27. PAF stockpile next to TSF

Photo 28. (Left) Small pond in eastern end of TSF. (Right) Larger, western TSF pond

Photo 29. Western TSF pond

Photo 30. View across the PAF stockpile to station RW02

Photo 31. Residual tailings in the TSF

APPENDIX I

WATER ACCOUNT FOR BROWNS SITE

Water Account for Browns site

The Browns Site is currently managed under a care and maintenance MMP, so there are no active mining operations on site. The Water Account provided here is for the 2016/2017 Wet Season, July 2016 to July 2017. This is the period for which there are reliable estimates of controlled discharge volume from the Main Sediment Dam, as a new electronic sensor was installed in 2016. Further details on the water balance model from which this Water Account is derived is provided in RGC (2018).

A flow sheet for the 2016/2017 Wet Season is provided in Figure 1.

Water Quality Description

The following water categories are identified in Water Accounting Framework (WAF):

- **Category 1.** Close to the drinking water standards, as it only requires minimum treatment (disinfection) to be safe for human consumption. It can be used for all purposes.
- **Category 2.** Suitable for some purposes. Treatment will be required to remove TDS and/or adjust other parameters to be safe for human consumption and more sensitive agricultural and recreational purposes.
- **Category 3.** Water unsuitable for most purposes due to high salinity (> 5000 mg/L TSD) or highly unsuitable pH (<4 or >10). Will require significant treatment to be considered Category 1 or Category 2.

For this report, water that meets ADWGs is considered Category 1 water. Category 2 water meets some of the ADWGs, but some metals exceed guideline concentrations. Category 3 water is acidic and exceeds the ADWGs for SO_4 and most metals.

Surface water at the Browns site is categorized as follows:

- **Category 1.**
  - SITE3. Main Sediment Dam.
  - SITE4. Middlebrook Creek upstream of boundary discharge.
- **Category 2.**
  - TREAT01. Treated effluent to Main Sediment Dam.
  - SITE2. Main Sediment Dam.
  - SITE5. Middlebrook Creek downstream of boundary discharge.
  - RWPOND. Process water storage pond.
  - RSPIT. Browns Pit.
- **Category 3.**
  - SITE1. EBFR Upstream.
  - DAM1. Main Sediment Dam at discharge pipe outlet.
  - RWTSF. TSF Pond.
  - RWSRO. Small Sediment Dam
  - RWBSS. Intermediate ore stockpile pond.
  - RWSP3. Low Grade and Lead ore stockpile pond.
  - RWPAF. PAF ore stockpile pond.

Groundwater recovered by recovery bores BH4G and BH12C is Category 3 water.

Input-Output model

The system boundary for the Browns site is the mine lease boundary. Rainfall runoff on site is collected and treated in the processing plant. Treated effluent is then released to the Main Sediment Dam. Water from the Main Sediment Dam is released to the EBFR as per WDL177-06.

The input-output model is summarized below:

- **Inputs**
  - Surface Water – Rainfall and Runoff
  - Groundwater – Seepage interception by BH4G and BH12C
- **Outputs**
  - Discharge – Controlled discharge from Main Sediment Dam
  - Groundwater – Seepage to groundwater (stockpiles, TSF pond)

Table 1 provides an Input-Output statement for the 2016/2017 Wet Season.

Table 1. Input-Output Statement for Browns site, July 2016 to July 2017

Input-Output	Element	Sub-Element	Water Quality			Note	How were the flows obtained and what is the confidence level of them?
			Cat 1 ML	Cat 2 ML	Cat 3 ML		
Inputs	Surface Water	Rainfall and Runoff	12.8	20.6		1	Simulated, medium
	Groundwater	Aquifer interception			3.8	2	Estimated, low
	TOTAL INPUTS		**12.8**	**20.6**	**3.8**		
Output	Discharge	Controlled discharge		10.4		3	Measured, high
	Groundwater	Seepage			6.1	4	Estimated, low
	Other	Evaporation	17.2			5	Simulated, low
	TOTAL OUTPUTS		**17.2**	**10.4**	**6.1**		

Notes:

1. Rainfall runoff from the site was simulated with a hydrological model (AWBM). Medium confidence in simulation.
2. Flow rates from previous reports assumed because no pumping records are available. Low confidence, field observations suggest lower flows
3. Controlled discharge volume for 2016/2017 Wet Season measured with new electronic senor, high confidene in flows
4. Seepage to groundwater inferred from Darcy flow calculations or calibration of water balance model
5. Estimated with hydrological model (AWBM)

Accuracy Statement

The only flow on site that is measured is controlled discharge from the Main Sediment Dam. Other flows, i.e. rainfall runoff, evaporation, were simulated with a hydrological model that incorporated the Australian Water Balance Model (AWBM). Simulated controlled discharge from July 2016 to July 2017 was within 6% of the observed volume of controlled discharge volume. This suggests the hydrological model can reasonably simulate flows on site. There is medium confidence in these simulated flows because the hydrological model is uncalibrated. Pumping rates for two seepage recovery bores (BH4G and BH12C) from previous reports were assumed here. Recovered groundwater flows are estimated as no flow records

are available. Recent field observations contradict the flows assumed here (from historic records), so there is low confidence in them.

Observed, estimated, and simulated flows are summarized here:

- **Observed flows.**
  - Controlled discharge from the Main Sediment Dam.
- **Estimated flows.**
  - Flows of recovered groundwater from BH4G and BH12C.
  - Surface water losses by direct evaporation from ponds and the Browns Pit.
  - Surface water losses by infiltration to groundwater from ponds and Browns Pit.
- **Simulated flows**
  - Rainfall runoff to water treatment system.

Table 2 provides an accuracy statement for the Browns Site.

Table 2. Accuracy Statement for Browns site, July 2016 to July 2017

Accuracy Statement				
		Confidence (%)		
Flow Types	% of All Flows	High	Medium	Low
Measured	15%	15%	0%	0%
Estimated	14%	0%	0%	14%
Simulated	71%	0%	71%	0%
Total		15%	71%	14%

The Operational model

Raw water is water that is received as an input and has not been used in a task. Worked water is water that has been through a task and treated water is water that has been treated on site.

The site received 328 ML of raw water from July 2016 to July 2017. None of the water on site is considered worked water because there are no operations on site (and hence no tasks). 328 ML of treated water was released from the Main Sediment Dam.

Appendix 2– Water Quality and Load Balance Assessment - Maps

713000 714000 715000 716000 717000 718000 719000 720000 721000 722000

8566000 8565000 8564000 8563000 8562000 8561000

GS8150097

GS8150327

GS8150200

East Branch of Finniss River

West Branch of Finniss River

Old Tailings Creek

East Branch of Finniss River

Rum Jungle Mine Site

GIANT'S REEF FAULT

Upper East Branch of Finniss River

Fitch Creek

Browns Mine Site

West Branch of Finniss River

Lithology

- Whites Formation
- Geolsec Formation
- Coomalie Dolostone
- Crater Formation
- Quartz Vein
- Rum Jungle Complex

- Drainage
- Fault
- Mine Site Boundary
- Gauge

Regional Geology and Flow Gauge Locations near the Browns Mine Site

Geology adapted from Lally (2003) 1:100,000 Scale Geology Map, NT Geological Survey

N W E S

Scale 1:25,000

0 500 1,000 2,000 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 1**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 06, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map1_RegionalGeology_Feb2018.mxd	

715000
716000
717000
8563000
8562000

White's (Main) Pit
Intermediate Pit
TPB4
TPB5
GS200
RUMINTER
Browns Pit (oxide deposit)
RW_PIT
SITE1
SITE5
Intermediate WRD
WAND1
DAMOUT1
RW_BSS
RN023137
Black Shale Stockpile (BSS)
Pre-Settlement Ponds
Main Sediment Dam
White's (Main) WRD
Processing Plant Area
Offices and Car Park
TREAT01
BH17B
BH15A/B
RW_POND
BH18A/B
RW_SRO
Site Run Off (SRO) Pond
BH14A/B
BH2A/B
RWTSF
PAF Ore Stockpile
RW_PAF
DAMOUT2
SITE2
RN022085
Tailings Storage Facility (TSF)
Stockpile 3 (SP3)
BH16B
RW_SP3
BH13A/B
BH12A/B/C
BH3A/B
BH4F
BH4G
BH4A
BH4D
BH4B
BH4E
BH4H
BH5A/B
SITE4
Thompson (RN031479)
Thompson-Mango
BH9A
BH9B
BH7A
BH7B
BH8A/B

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Mine Site Boundary

N
W
E
S

Site Layout and Water Monitoring Networks

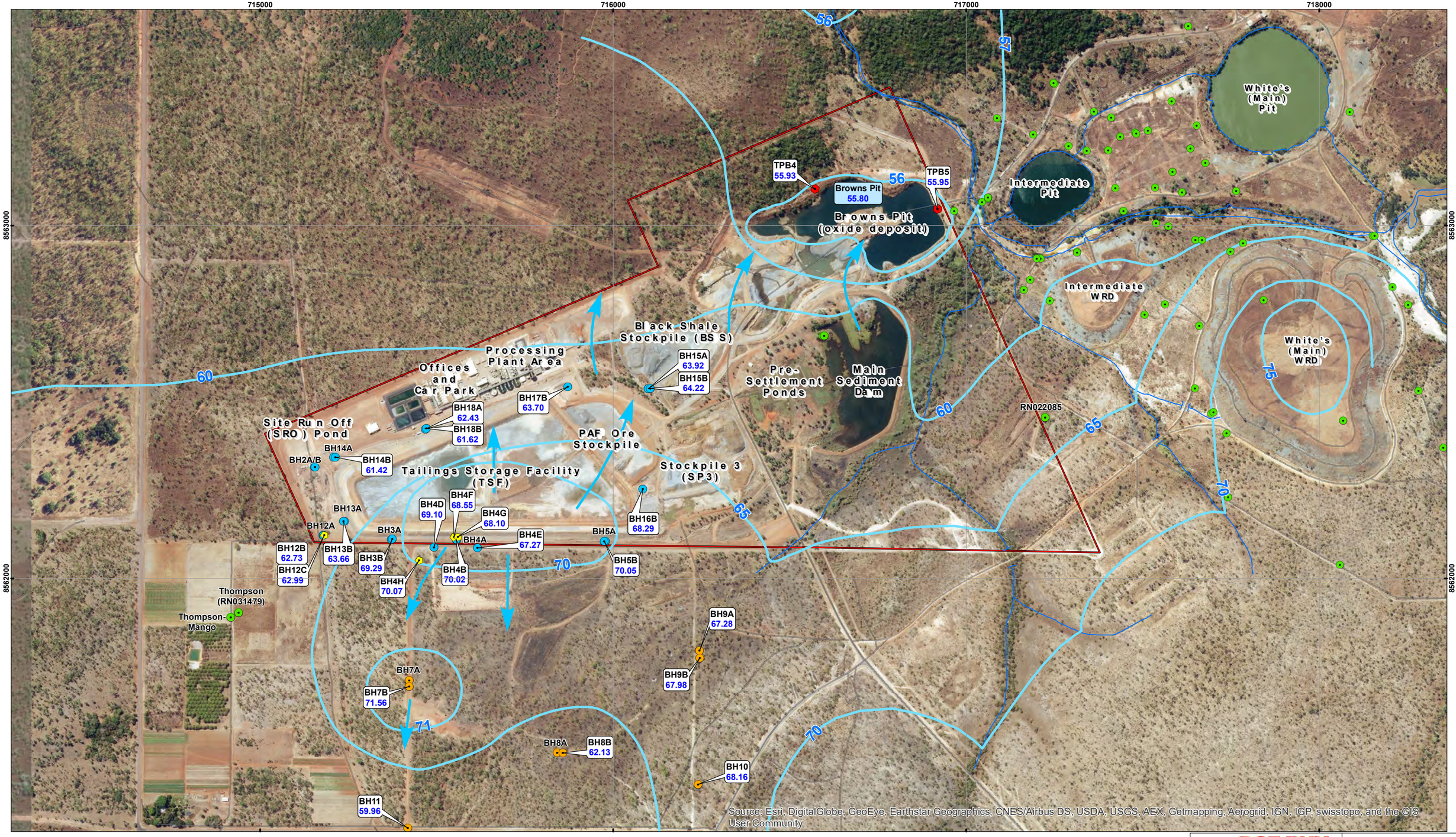
Scale 1:8,000

0 100 200 400 600 800 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 2**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map2_Browns_MonitoringNetwork_Feb2018.mxd	



Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Mine Site Boundary
- Groundwater Level
- 2017 VWP
- 2017 Monitoring Bore
- Flow Direction
- Groundwater Level (m AHD) — BH7A 73.8

N W E S

Geodetic Groundwater Levels and Inferred Contours, November 2017

Scale 1:10,000

0 50 100 200 300 400 500 600 700 800 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 3**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map3_GWL_forNov2017_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

Browns Pit (oxide deposit)

Intermediate Pit

Intermediate WRD

Processing Plant Area

Offices and Car Park

Black Shale Stockpile (BSS)

Pre-Settlement Ponds

Main Sediment Dam

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

PAF Ore Stockpile

Stockpile 3 (SP3)

Fault

Fault

RW_SRO RW_POND RWTSF RW_PAF RW_BSS RW_PIT RW_SP3 TREAT01 DAMOUT1 DAMOUT2 GS200 RUMINTER SITE1 SITE5 WAND1 SITE2 SITE4

B B' A A' C C'

BH2A/B BH7A

BH12A (12.0 m)
10-Jul-17
pH 5.9
EC, µg/L 486
SO_4, mg/L 150
Cu, µg/L 1

BH12B (21.0 m)
2-Aug-17
pH 6.4
EC, µg/L 889
SO_4, mg/L 290
Cu, µg/L 1

BH12C (22.9 m)
9-Jan-18
pH 7.6
EC, µg/L 454
SO_4, mg/L 140
Cu, µg/L 1

Thompson (40 m)
7-Jul-17
pH 6.7
EC, µg/L 336
SO_4, mg/L 2
Cu, µg/L 1

Thompson-Mango
7-Jul-17
pH 6.1
EC, µg/L 140
SO_4, mg/L 4
Cu, µg/L 1

BH13A (40.4 m)
1-Sep-16
pH -
EC, µg/L -
SO_4, mg/L 940
Cu, µg/L 3

BH13B (21.0 m)
9-Jan-18
pH 5.7
EC, µg/L 1,180
SO_4, mg/L 580
Cu, µg/L 380

BH14A (25.4 m)
18-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 790
Cu, µg/L 1

BH14B (21.4 m)
11-Jan-18
pH 6.6
EC, µg/L 474
SO_4, mg/L 230
Cu, µg/L 3

BH18A (15.0 m)
10-Jul-17
pH 5.7
EC, µg/L 332
SO_4, mg/L 76
Cu, µg/L 15

BH18B (27.4 m)
11-Jan-18
pH 5.7
EC, µg/L 1,924
SO_4, mg/L 1,200
Cu, µg/L 74

BH17B (15.3 m)
21-Apr-10
pH 6.8
EC, µg/L 2,056
SO_4, mg/L 187
Cu, µg/L 3

BH15A (24.0 m)
11-Jan-18
pH 5.1
EC, µg/L 55
SO_4, mg/L 5
Cu, µg/L 10

BH15B (50.0 m)
18-Jan-18
pH 6.6
EC, µg/L 196
SO_4, mg/L 10
Cu, µg/L 6

BH4F (50.0 m)
28-Dec-17
pH 7.3
EC, µg/L 147
SO_4, mg/L 5
Cu, µg/L 1

BH4G (24.0 m)
9-Jan-18
pH 3.8
EC, µg/L 877
SO_4, mg/L 370
Cu, µg/L 7,700

BH4A (5.8 m)
8-Jul-17
pH 2.8
EC, µg/L 1,527
SO_4, mg/L 1,400
Cu, µg/L 29,000

BH16B (15.4 m)
29-Apr-17
pH 6.0
EC, µg/L 2,797
SO_4, mg/L 1,600
Cu, µg/L 1

BH3A (5.8 m)
14-Jan-14
pH 4.2
EC, µg/L 102
SO_4, mg/L 3
Cu, µg/L 150

BH3B (20.0 m)
14-Jan-15
pH 3.8
EC, µg/L 137
SO_4, mg/L 11
Cu, µg/L 300

BH4H (23.5 m)
5-Jan-18
pH 7.2
EC, µg/L 103
SO_4, mg/L 2
Cu, µg/L 2

BH4B (20.0 m)
17-Aug-16
pH 3.3
EC, µg/L 1,201
SO_4, mg/L 1,300
Cu, µg/L 27,000

BH4D (38.5 m)
5-Jan-18
pH 3.6
EC, µg/L 381
SO_4, mg/L 120
Cu, µg/L 1,200

BH4E (40.0 m)
5-Jan-18
pH 5.7
EC, µg/L 327
SO_4, mg/L 88
Cu, µg/L 19

BH5A (5.7 m)
8-Jul-17
pH -
EC, µg/L -
SO_4, mg/L 20
Cu, µg/L 17

BH5B (20.0 m)
8-Jul-17
pH 6.3
EC, µg/L 265
SO_4, mg/L 20
Cu, µg/L 17

BH7B (30 m)
5-Jan-18
pH 6.3
EC, µg/L 145
SO_4, mg/L 5
Cu, µg/L 1

BH8A (10 m)
13-May-14
pH 6.6
EC, µg/L 147
SO_4, mg/L 2
Cu, µg/L 1

BH8B (30 m)
4-Jan-18
pH 6.9
EC, µg/L 291
SO_4, mg/L 2
Cu, µg/L 1

BH11 (24.1 m)
5-Jan-18
pH 6.7
EC, µg/L 213
SO_4, mg/L 5
Cu, µg/L 1

TPB4 (71.5 m)
9-Jan-18
pH 7.4
EC, µg/L 455
SO_4, mg/L 5
Cu, µg/L 2

TPB5 (27.0 m)
8-Jul-17
pH 7.6
EC, µg/L 1004
SO_4, mg/L 570
Cu, µg/L 1

RN023137 (40 m)
9-Oct-17
pH 6.5
EC, µg/L 568
SO_4, mg/L 130
Cu, µg/L 1

RN022085 (32 m)
23-Apr-09
pH 7.4
EC, µg/L 508
SO_4, mg/L 1
Cu, µg/L 1

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

BH10 (23.8 m)
4-Jan-18
pH 7.3
EC, µg/L 485
SO_4, mg/L 5
Cu, µg/L 1

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Mine Site Boundary
- Section Line
- Inferred Plume (High Impact)
- Inferred Plume (Moderate Impact)

Bores screened in bedrock

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

Bores screened in laterite/saprolite

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

N W E S

Selected Groundwater Quality and Cross-Section Alignments with Site Features

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 4**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map4_Browns_WQandSectionLines_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

Browns Pit (oxide deposit)

Intermediate Pit

Intermediate WRD

Black Shale Stockpile (BSS)

Processing Plant Area

Offices and Car Park

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

PAF Ore Stockpile

Pre-Settlement Ponds

Main Sediment Dam

Stockpile 3 (SP3)

Fault

RW_SRO RW_POND RWTSF RW_PAF RW_BSS RW_PIT RW_SP3

TREAT01 DAMOUT1 DAMOUT2 SITE1 SITE2 SITE4 SITE5 WAND1 RUMINTER GS200

A A' B B' C C'

BH2A/B

BH12A (12.0 m)
10-Jul-17
pH 5.9
EC, µg/L 486
SO_4, mg/L 150
Cu, µg/L 1

BH12B (21.0 m)
2-Aug-17
pH 6.4
EC, µg/L 889
SO_4, mg/L 290
Cu, µg/L 1

BH12C (22.9 m)
9-Jan-18
pH 7.6
EC, µg/L 454
SO_4, mg/L 140
Cu, µg/L 1

Thompson (40 m)
7-Jul-17
pH 6.7
EC, µg/L 336
SO_4, mg/L 2
Cu, µg/L 1

Thompson-Mango
7-Jul-17
pH 6.1
EC, µg/L 140
SO_4, mg/L 4
Cu, µg/L 1

BH14A (25.4 m)
18-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 790
Cu, µg/L 1

BH14B (21.4 m)
11-Jan-18
pH 6.6
EC, µg/L 474
SO_4, mg/L 230
Cu, µg/L 3

BH13A (40.4 m)
1-Sep-16
pH -
EC, µg/L -
SO_4, mg/L 940
Cu, µg/L 3

BH13B (21.0 m)
9-Jan-18
pH 5.7
EC, µg/L 1,180
SO_4, mg/L 580
Cu, µg/L 380

BH18A (15.0 m)
10-Jul-17
pH 5.7
EC, µg/L 332
SO_4, mg/L 76
Cu, µg/L 15

BH18B (27.4 m)
11-Jan-18
pH 5.7
EC, µg/L 1,924
SO_4, mg/L 1,200
Cu, µg/L 74

BH17B (15.3 m)
21-Apr-10
pH 6.8
EC, µg/L 2,056
SO_4, mg/L 187
Cu, µg/L 3

BH15A (24.0 m)
11-Jan-18
pH 5.1
EC, µg/L 55
SO_4, mg/L 5
Cu, µg/L 10

BH15B (50.0 m)
18-Jan-18
pH 6.6
EC, µg/L 196
SO_4, mg/L 10
Cu, µg/L 6

BH4F (50.0 m)
28-Dec-17
pH 7.3
EC, µg/L 147
SO_4, mg/L 5
Cu, µg/L 1

BH4G (24.0 m)
9-Jan-18
pH 3.8
EC, µg/L 877
SO_4, mg/L 370
Cu, µg/L 7,700

BH4A (5.8 m)
8-Jul-17
pH 2.8
EC, µg/L 1,527
SO_4, mg/L 1,400
Cu, µg/L 29,000

BH16B (15.4 m)
29-Apr-17
pH 6.0
EC, µg/L 2,797
SO_4, mg/L 1,600
Cu, µg/L 1

BH3A (5.8 m)
14-Jan-14
pH 4.2
EC, µg/L 102
SO_4, mg/L 3
Cu, µg/L 150

BH3B (20.0 m)
14-Jan-15
pH 3.8
EC, µg/L 137
SO_4, mg/L 11
Cu, µg/L 300

BH4H (23.5 m)
5-Jan-18
pH 7.2
EC, µg/L 103
SO_4, mg/L 2
Cu, µg/L 2

BH4B (20.0 m)
17-Aug-16
pH 3.3
EC, µg/L 1,201
SO_4, mg/L 1,300
Cu, µg/L 27,000

BH4D (38.5 m)
5-Jan-18
pH 3.6
EC, µg/L 381
SO_4, mg/L 120
Cu, µg/L 1,200

BH4E (40.0 m)
5-Jan-18
pH 5.7
EC, µg/L 327
SO_4, mg/L 88
Cu, µg/L 19

BH5A (5.7 m)
8-Jul-17
pH -
EC, µg/L -
SO_4, mg/L 20
Cu, µg/L 17

BH5B (20.0 m)
8-Jul-17
pH 6.3
EC, µg/L 265
SO_4, mg/L 20
Cu, µg/L 17

BH7A

BH7B (30 m)
5-Jan-18
pH 6.3
EC, µg/L 145
SO_4, mg/L 5
Cu, µg/L 1

BH11 (24.1 m)
5-Jan-18
pH 6.7
EC, µg/L 213
SO_4, mg/L 5
Cu, µg/L 1

BH8A (10 m)
13-May-14
pH 6.6
EC, µg/L 147
SO_4, mg/L 2
Cu, µg/L 1

BH8B (30 m)
4-Jan-18
pH 6.9
EC, µg/L 291
SO_4, mg/L 2
Cu, µg/L 1

TPB4 (71.5 m)
9-Jan-18
pH 7.4
EC, µg/L 455
SO_4, mg/L 5
Cu, µg/L 2

TPB5 (27.0 m)
8-Jul-17
pH 7.6
EC, µg/L 1004
SO_4, mg/L 570
Cu, µg/L 1

RN023137 (40 m)
9-Oct-17
pH 6.5
EC, µg/L 568
SO_4, mg/L 130
Cu, µg/L 1

RN022085 (32 m)
23-Apr-09
pH 7.4
EC, µg/L 508
SO_4, mg/L 1
Cu, µg/L 1

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

BH10 (23.8 m)
4-Jan-18
pH 7.3
EC, µg/L 485
SO_4, mg/L 5
Cu, µg/L 1

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Fault

Lithology

- White's Formation
- Coomalie Dolostone
- Rum Jungle Complex

Bores screened in bedrock

BH9B (30 m)
19-Nov-14
pH 7.0
EC, µg/L 506
SO_4, mg/L 2
Cu, µg/L 1

Bores screened in laterite/saprolite

BH9A (10 m)
16-Jun-14
pH 6.5
EC, µg/L 398
SO_4, mg/L 2
Cu, µg/L 1

N W E S

Selected Groundwater Quality and Cross-Section Alignments with Surficial Geology

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 5**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map5_Browns_WQandSectionLines_Feb2018-2.mxd	

715000 716000 717000

8563000 8562000

White's (Main) Pit

Intermediate Pit

Browns Pit (oxide deposit)

Intermediate WRD

White's (Main) WRD

Processing Plant Area

Offices and Car Park

Black Shale Stockpile (BSS)

Pre-Settlement Ponds

Main Sediment Dam

PAF Ore Stockpile

Stockpile 3 (SP3)

Site Run Off (SRO) Pond

Tailings Storage Facility (TSF)

Thompson (RN031479)

Thompson-Mango

RUMINTER
12-Jan-17
pH 6.3
EC, µg/L 158
SO_4, mg/L 49
Cu, µg/L 55
Zn, µg/L 10

SITE1
29-May-17
pH 4.6
EC, µg/L 2,392
SO_4, mg/L 1,800
Cu, µg/L 2,000
Zn, µg/L 11,000

SITE5
15-Jun-17
pH 6.7
EC, µg/L 643
SO_4, mg/L 75
Cu, µg/L 1
Zn, µg/L 5

RW_PIT
31-Jul-17
pH 7.6
EC, µg/L 644
SO_4, mg/L 240
Cu, µg/L 10
Zn, µg/L 45

RW_BSS
27-Apr-17
pH 4.1
EC, µg/L 545
SO_4, mg/L 110
Cu, µg/L 55,000
Zn, µg/L 990

RW_SRO
27-Apr-17
pH 6.3
EC, µg/L 42
SO_4, mg/L 8
Cu, µg/L 45
Zn, µg/L 22

RW_POND
31-Jul-17
pH 7.2
EC, µg/L 7
SO_4, mg/L 240
Cu, µg/L 19
Zn, µg/L 36

TREAT1
27-Apr-17
pH 9.6
EC, µg/L 810
SO_4, mg/L 140
Cu, µg/L 3
Zn, µg/L 5

RW_PAF
27-Apr-17
pH 3.8
EC, µg/L 670
SO_4, mg/L 330
Cu, µg/L 66,000
Zn, µg/L 7,200

RW_TSF
27-Apr-17
pH 4.6
EC, µg/L 703
SO_4, mg/L 280
Cu, µg/L 13,000
Zn, µg/L 530

RW_SP3
27-Apr-17
pH -
EC, µg/L -
SO_4, mg/L 170
Cu, µg/L 8,600
Zn, µg/L 1,300

DAMOUT1
22-Feb-17
pH 7.1
EC, µg/L 317
SO_4, mg/L 98
Cu, µg/L 11
Zn, µg/L 18

SITE2
22-Feb-17
pH 7.7
EC, µg/L 326
SO_4, mg/L 98
Cu, µg/L 89
Zn, µg/L 38

SITE4
14-Apr-17
pH 7.2
EC, µg/L 41
SO_4, mg/L 2
Cu, µg/L 1
Zn, µg/L 5

RN023137

RN022085

TPB4

TPB5

BH17B

BH15A/B

BH18A/B

BH14A/B

BH2A/B

BH16B

BH13A/B

BH12A/B/C

BH3A/B

BH4F

BH4G

BH4D

BH4A

BH4B

BH4E

BH5A/B

BH4H

BH9A

BH9B

BH7A

BH7B

BH8A/B

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Section Line
- Mine Site Boundary

N W E S

Selected Surface Water Quality Data, 2017

Scale 1:8,000

0 50 100 200 300 400 500 600 700 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 6**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map6_Browns_SWS-WQ_Feb2018.mxd	

715000 715500 716000 716500

8562500 8562000

Processing Plant Area
Offices and Car Park
Black Shale Stockpile (BSS)
Main Sediment Dam
Pre-Settlement Ponds
Site Run Off (SRO) Pond
PAF Ore Stockpile
Stockpile 3 (SP3)
Tailings Storage Facility (TSF)
New Recovery Bore

PMB18-11
PMB18-10
PMB18-9A/B
PMB18-8A/B
PMB18-5
PMB18-6
PMB18-7A/B
PMB18-4A/B
PMB18-1A/B
PMB18-3A/B
PMB18-2A/B

BH17B
BH15A/B
BH18A/B
BH14A/B
BH2A/B
BH16B
BH13A/B
BH12A/B/C
BH3A/B
BH4G
BH4F
BH4B
BH4A
BH4E
BH4D
BH4H
BH5A/B

RN023137
Thompson (RN031479)
Thompson-Mango

Bore ID	Easting GDA 1994 MGA Zone 52	Northing GDA 1994 MGA Zone 52
New Recovery Bore	715556	8562112
PMB18-1A/B	715708	8562013
PMB18-2A/B	715513	8561907
PMB18-3A/B	715531	8561985
PMB18-4A/B	715545	8562051
PMB18-5	715471	8562114
PMB18-6	715623	8562109
PMB18-7A/B	715827	8562100
PMB18-8A/B	715650	8562189
PMB18-9A/B	715656	8562303
PMB18-10	715416	8562567
PMB18-11	715814	8562734

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AE… User Community

Legend

- TSF1 Monitoring Bore
- TSF1 Recovery Bore
- Test Production Bore
- TSF2 Monitoring Bore
- Other Monitoring Bore
- Surface Water Station
- Proposed Recovery Bore
- Proposed Monitoring Bore
- Fault

Lithology

- White's Formation
- Coomalie Dolostone
- Rum Jungle Complex

N W E S

Proposed Drilling Locations

Scale 1:5,000

0 50 100 200 300 400 500 Metres

Projection: GDA 1994 MGA Zone 52 (m)

Robertson GeoConsultants Inc.

Client: DOE RUN AUSTRALIA NL	**Map 7**
Project: MMP Support	Project No: 256003
Report: RGC 256003/1	Last Update: Mar 13, 2018
Browns Mine, NT, Australia	Drawn: L.R.
Original File: Map7_ProposedDrillingLocations_Feb2018.mxd	

Appendix 3– Waste Discharge Licence 177-10

Northern Territory Government

WASTE DISCHARGE LICENCE

(Pursuant to section 74 of the *Water Act 1992)*

Licensee	Northern Territories Resources Pty Ltd
Licence Number:	**WDL 177-10**
Registered Business Address:	42/29 Woods St Darwin NT 0800
ACN:	124 647 829
ABN:	78 124 647 829
Commencement Date:	21 December 2022
Expiry Date:	20 December 2032
Licensed Action:	The controlled discharge of treated water and stormwater run-off from the Sediment Dam into Middlebrook Creek (a tributary of the East Finniss River) via the authorised discharge point and subject to the conditions of this licence.

Contents

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INFORMATION ABOUT THIS LICENCE

This waste discharge licence is granted pursuant to section 74 of the *Water Act 1992* (NT) (Water Act), which empowers the Controller of Water Resources to, in accordance with the Water Act, grant a licence to a person to carry out an action that would otherwise be an offence against this Act.

Responsibilities of Licensee

- In addition to the conditions set out in this licence, general responsibilities of licensees are set out in the *Waste Management and Pollution Control Act 1998* (NT) (WMPC Act), the Water Act and the *Water Regulations 1992* (NT) (Water Regulations).
- It is an offence under the Water Act, if the holder of a waste discharge licence contravene or cause, suffer or permit a person to contravene a term or condition to which the waste discharge licence is subject (s 76 Water Act).
- Except as expressly provided for in this licence or applicable law, it is an offence under section 16 of the Water Act to wilfully cause or cause, directly or indirectly:
    - waste to come into contact with water; or
    - water to be polluted.

Duration of Licence

- This licence will remain in force until its Expiry Date, it is surrendered by the licensee, or until it is suspended or revoked by the Controller of Water Resources.
- A licensee may surrender its licence at any time (s 94 Water Act).
- If the licensee wishes to surrender its licence it should complete the notification form available from the Administering Agency.
- Once a licence is surrendered, the authority to allow waste to come into contact with water or water to be polluted ends, and causing waste to come into contact with water or water to be polluted is an offence pursuant to section 16 of the Water Act.

Amendment, Modification or Revocation of Licence

- As set out in section 93 of the Water Act, the Controller of Water Resources may, by notice served on the holder of the licence:
    - amend or modify the terms and conditions of a licence; or
    - where the Controller of Water Resources is satisfied that the holder of the licence has contravened or failed to comply with a term or condition of the licence or of any other licence previously held by the person for a similar purpose during the 12 months immediately preceding the grant of the first-mentioned licence, the Controller of Water Resources may:
        - revoke a licence; or
        - suspend a licence.

Transfer of Licence

- Where a waste discharge licence is granted to a person in relation to the person's use of land and, during the period of this licence, the person's interest in the land is transferred to another person,

the waste discharge licence shall be deemed to have also been transferred to the other person (s 92 Water Act).

- The licensee must ensure the contact details recorded with the Administering Agency for the licence are correct at all times in accordance with condition 6. Accordingly, it is recommended the transferee complete the notification of transfer of a waste discharge licence form available from the Administering Agency.

Public Register

- A copy of this Licence will be placed on the Register in accordance with section 95 of the Water Act.
- A copy of plans for environmental management, reports, submissions or documents provided at Schedule 1 Item 14 will be placed on the Register.
- The Register is freely available from the Northern Territory Environment Protection Authority (NT EPA) website.

Water Quality Standards

- The Administrator may declare, by notice in the *Gazette*, a beneficial use, quality standard, criteria or objectives which apply in relation to any waste or class of waste, or water or class of water (s 73 Water Act).
- A water or waste beneficial use, quality standard, criteria or objectives declared under s 73 of the Act and in force is an Environment Protection Objective for the purposes of the WMPC Act (s 18 WMPC Act).
- An Environment Protection Objective is a statutory instrument to establish principles on which:
    - Environmental quality is to be maintained, enhanced, managed or protected;
    - Pollution, or environmental harm resulting from pollution, is to be assessed, prevented, reduced, controlled, rectified or cleaned up; or
    - Effective waste management is to be implemented or evaluated.
- Schedule 1 Item 1 specifies the beneficial use, quality standard, criteria or objective relevant to this licence at the date of issue.

Environmental Interests

- Environmentally sensitive or significant areas may be captured by and protected under the *Environment Protection Act 2019* (NT) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). As such, and to best protect and regulate our waterways, waste discharge licences must identify the sensitivity of the environment surrounding the location of the Licensed Action.
- Schedule 1 Item 2 specifies the sites of conservation significance (if any) relevant to this licence at the date of issue.
- Schedule 1 Item 3 specifies the Ramsar wetlands (if any) relevant to this licence at the date of issue.

Cultural Interests

- Under Commonwealth and Northern Territory laws it can be an offence to enter or remain on or damage a sacred site.

- Sites of Aboriginal significance including registered and recorded Aboriginal sacred sites may exist in the vicinity of the Licensed Action.

- It is the licensee's responsibility to contact the Aboriginal Areas Protection Authority, appropriate land council or other governing body and ensure that any authority certificates required as a result of conducting the Licensed Action are obtained and complied with.

- Further specific advice on any cultural requirement or implication of the Licensed Action should be sought from the relevant land council and the Aboriginal Areas Protection Authority.

END NOTES

- WDL177-10 is a renewal and supersedes WDL177-09.

- WDL177-09 was a renewal and amendment and supersedes WDL177-08. It was issued on 21 December 2020 and expired on 20 December 2022.
- WDL177-08 was an amendment and superseded WDL177-07. It was issued on 24 December 2019 and expires on 20 December 2020.
- WDL177-07 was a renewal and superseded WDL177-06. It was issued on 19 December 2018 and expires on 20 December 2020.
- WDL177-06 was a transfer from Compass Operations Pty Ltd to Northern Territories Resources Pty Ltd. It was issued on 5 June 2017 and expired on 21 November 2018.
- WDL177-05 was a renewal and superseded WDL177-04. It was issued on 21 November 2016 to Compass Operations Pty Ltd and expired 21 November 2018.
- WDL177-04 was a renewal and superseded WDL177-03. It was issued on 19 December 2014 to HNC (Australia) Exploration and Mining Pty Ltd and expired on 1 October 2016.
- WDL177-03 was an amendment and superseded WDL177-02. It was issued 6 March 2013 and expired on 31 August 2014.
- WDL177-02 was a renewal and superseded WDL177-01. It was issued on 17 December 2012 and expired on 31 August 2014.
- WDL177-01 was an amendment and superseded WDL177. It was issued on 11 February 2011 and expired on 30 September 2012.
- WDL177 was issued to HNC (Australia) Resources Pty Ltd on 18 February 2010.

SCHEDULE 1 - ITEMS

Item	Detail	
1. **Beneficial uses (condition 19)**	Declaration of Beneficial Uses for Fog Bay -Aquatic Ecosystem Protection (Gazette No. 9, 11/03/1998).	
2. **Sites of conservation significance (condition 19)**	Not applicable.	
3. **Ramsar wetlands (condition 19)**	Not applicable.	
4. **Licence Documents (condition 13)**	(a) Emergency Response Plan; (b) Consultation and Communication Plan; and (c) Water Management Plan.	
5. **Authorised Discharge Point(s) (condition 20)**	SITE 5 as shown on the plan at Appendix 1.	Latitude: -12.992026 Longitude: 131.000723
6. **Source(s) of waste (condition 21)**	Water from the Sediment Dam containing treated water from the wastewater treatment plant and stormwater run-off from the surrounding mine site structures.	
7. **Trigger values (condition 21)**	The trigger values for relevant parameters are listed in Appendix 2.	
8. **Compliance point (condition 21)**	SITE 5 as shown on the plan at Appendix 1.	Latitude: -12.992026 Longitude: 131.000723
9. **Limitations on discharge (condition 21)**	Any authorised discharge must occur only when: (a) the East Branch of the Finniss River is at a flow above 0.5 m^3/s at Gauging Station GS8150200, which equates to a stream height of 1.50 m (56.59 AHD) on the existing gauge board adjacent to GS8150200; and (b) the pH of the discharge water at SITE 2 is between 6.5 – 8.5 prior to commencing and for the duration of each authorised discharge event.	
10. **Notifiable incidents (conditions 23, 25 and 26)**	(a) An exceedance of a trigger value specified in Item 7 at the compliance point in Item 8, on three consecutive sampling occasions; or (b) A measurement outside the range for pH specified in Item 7 at the compliance point in Item 8, on three consecutive sampling occasions; or (c) An exceedance of three or more times a trigger value specified in Item 7 at the compliance point in Item 8; or (d) A discharge at a point not specified in Item 5; or (e) A discharge from a source not specified in Item 6; or (f) Discharges contravening condition 23.	
11. **Monitoring Program (condition 27)**	The Monitoring Program includes: Surface water monitoring in accordance with Appendix 2.	

Item	Detail
12. Annual Return (condition 38)	The Annual Return is due on 1 June each year for the period 1 May to 30 April during the term of the licence (or part thereof).
13. Monitoring Report (condition 39)	The Monitoring Report is due on: (a) 1 June each year for the preceding 12-month period of 1 May to 30 April during the term of the licence (or part thereof); and (b) the Expiry Date of this licence; and (c) in the event the licensee applies to renew the licence, 90 days prior to the Expiry Date.
14. Documents placed on Register (condition 42)	The following documents will be placed on the Register: (a) The Licence Documents specified in Item 4; and (b) The Monitoring Report provided in accordance with condition 39; and (c) The Annual Return.
15. Special conditions (condition 43)	The licensee must: 15.1 submit to the Administering Agency a report for each month that an authorised discharge has occurred via the Authorised Discharge Point (Item 5) ("Monthly Discharge Report"). The Monthly Discharge Report is due within the first 10 business days of the following month and must include: a) water quality data for the authorised discharge point and all monitoring locations specified in Appendix 2; b) flow data and discharge volumes; c) date, time and duration of each discharge event; d) a summary of water inventory and reduction in inventory as a result of authorised discharge; e) a summary of any trigger value exceedances for the month; and f) surface water quality management actions taken in the event of a trigger value exceedance at the compliance point. 15.2 The licensee must review and update the documents listed in Item 5 and provide updated documents to the Administering Agency by 31 March 2023 along with: a) A tabulated summary of any amendments(s) with document references; b) Reasons for the amendment(s); and c) An assessment of environmental risk associated with the amendment(s).

LICENCE CONDITIONS

RULES FOR INTERPRETING THE CONDITIONS OF THIS LICENCE

1. Where there is a discrepancy between the conditions of this licence and any plan, standard, guideline or other document referred to in this licence, the conditions of this licence prevail to the extent of the inconsistency.
2. Any reference to any standard, guideline or code of practice (Australian or international) in this licence means the relevant parts of the current version of that standard, guideline or code of practice.
3. In this licence, unless the contrary intention appears, words that are defined in the Water Act are intended to have the meaning given to them in that Act.
4. In this licence, unless a contrary intention appears, terms are defined in the Definitions at the end of this licence.
5. In this licence a reference to an Item is a reference to an Item specified in Schedule 1.

GENERAL

6. The licensee must ensure the contact details recorded with the Administering Agency for this licence are correct at all times.
7. The licensee must at all times have a 24 hour emergency contact.
8. The licensee must notify the Administering Agency prior to making any operational change that will cause, or is likely to cause, an increase in the potential for environmental harm.
9. The licensee must display clear and legible signage, in English, in a prominent location at each public entrance to the premises of the Licensed Action that includes the following details:
    - 9.1. waste discharge licence number issued under the Water Act; and
    - 9.2. 24 hour emergency contact details.
10. The licensee must cause a hard copy of this licence to be available for inspection, at the premises of the Licensed Action, by any person on request.
11. Unless otherwise specified, within 10 business days of a request, the licensee must provide to the Administering Agency a copy of any record, document, monitoring data or other information in relation to the Licensed Action in electronic form by emailing environmentalregulation@nt.gov.au.
12. All notices, reports, documents or other correspondence required to be provided as a condition of this licence, unless otherwise specified as a condition of this licence, must be provided in electronic form by emailing environmentalregulation@nt.gov.au.
13. The licensee must maintain, implement and comply with the current version of the documents specified in Item 4.
14. Within 10 business days of any amendment being made to a document listed specified in Item 4, the licensee must provide the amended document to the Administering Agency, along with:
    - 14.1. a tabulated summary of the amendment(s) with document references;
    - 14.2. reasons for the amendment(s); and
    - 14.3. an assessment of environmental risk associated with the amendment(s).
15. The Administering Agency may require the licensee to revise or amend and resubmit any document provided in accordance with this licence. Where the Administering Agency requires any document to be revised or amended, the licensee must submit it to the Administering Agency by the date specified by the Administering Agency.
16. *This condition has been removed because it is not applicable*
17. The licensee must maintain a register of complaints that records the details of each complaint received in relation to the Licensed Action and provide a copy to the Administering Agency on

request. Details of the complaints must (as is reasonably practicable) include, the following information:

17.1. the person to whom the complaint was made;

17.2. the person responsible for managing the complaint;

17.3. the date and time the complaint was reported;

17.4. the date and time of the event(s) that led to the complaint;

17.5. the contact details of the complainant if known, or where no details are provided a note to that effect;

17.6. the nature of the complaint;

17.7. the nature of event(s) giving rise to the complaint;

17.8. prevailing weather conditions at the time (where relevant to the complaint);

17.9. the action taken in relation to the complaint, including any follow-up contact with the complainant; and

17.10. if no action was taken, why no action was taken.

18. Without limiting the conditions of this licence, in conducting the Licensed Action, the licensee must do all things reasonable and practicable to:

18.1. minimise the likelihood of waste coming into contact with water or water being polluted as a result of, or in connection with, the Licensed Action;

18.2. prevent and minimise the likelihood of environmental harm occurring as a result, or in connection with, the Licensed Action;

18.3. effectively investigate, monitor and report on water being polluted as a result of, or in connection with, the Licensed Action;

18.4. effectively investigate, monitor and report on environmental harm and the risk of environmental harm occurring as a result of or in connection with the Licensed Action; and

18.5. apply the principles of ecologically sustainable development.

19. The licensee must, without limiting any other condition of this licence, in conducting the Licensed Action do all things reasonable and practicable to minimise adverse effects to any:

19.1. declared beneficial use, quality standard or objective declared under section 73 of the Water Act;

19.2. sites of conservation significance; or

19.3. designated Ramsar wetlands,

including, but not limited to, those specified in Items 1, 2 and 3.

DISCHARGES

20. The licensee must only discharge waste to water from the authorised discharge points specified in Item 5.

21. Discharges from each authorised discharge point must:

21.1. consist only of waste from the source(s) specified in Item 6;

21.2. not exceed the trigger values specified in Item 7 at the compliance point specified in Item 8; and

21.3. comply with the limitations specified in Item 9.

22. The licensee must, for each authorised discharge point, install, operate and maintain a device to measure and record, for each discharge event:

22.1. the time the discharge commenced and the duration of the discharge (this may be recorded manually if automatic recording is not available);

22.2. the discharge rate of flow; and

22.3. the discharge volume.

23. Discharges from each authorised discharge point must not:

23.1. contain any floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter;

23.2. cause or generate odours which would adversely affect the use and amenity of surrounding waters;

23.3. cause algal blooms in the receiving water;

23.4. pollute groundwater;

23.5. cause visible change in the behaviour of fish or other aquatic organisms in the receiving water;

23.6. cause mortality of fish or other aquatic organisms;

23.7. cause erosion or degradation to the beds and banks of a watercourse; or

23.8. cause adverse impacts on plants or animals.

INVESTIGATIONS AND NOTIFICATIONS

24. Following any exceedance of a trigger value specified in Item 7 at the compliance point specified in Item 8, the licensee must:

24.1. investigate the exceedance, including undertaking targeted monitoring, in addition to routine monitoring; and

24.2. take corrective action to mitigate any environmental harm and ensure the exceedance does not reoccur; and

24.3. make a record of:

24.3.1. when the exceedance was detected and by whom;

24.3.2. the date and time of the exceedance;

24.3.3. the actual and potential causes and contributing factors to the exceedance;

24.3.4. the risk of environmental harm arising from the exceedance;

24.3.5. exceedances and details of the investigation and corrective action taken; and

24.3.6. if no action was taken, why no action was taken.

25. If one of the incidents specified in Item 10 occurs, the licensee must notify the Administering Agency by emailing environmentalregulation@nt.gov.au as soon as practicable after (and in any case within 24 hours after) first becoming aware of the incident, including the following information:

25.1. when the incident was detected and by whom;

25.2. the date and time of the incident;

25.3. whether discharge was occurring at the time of the incident and the source of the discharge;

25.4. whether discharge is still occurring; and

25.5. a date (within 10 business days of the incident) when an investigation report will be submitted to the Administering Agency.

26. Within 10 business days of notifying the Administering Agency of an incident specified in Item 10, the licensee must provide the Administering Agency an investigation report that includes:

26.1. when the incident was detected and by whom;

26.2. the date and time of the incident;

26.3. whether discharge was occurring at the time of the incident and the source of the discharge;

26.4. the actual and potential causes and contributing factors to the incident;

26.5. monitoring data of the discharge, and upstream and downstream water of the incident, collected for the date the incident was detected and three sampling rounds prior;

26.6. available flow rates to demonstrate any influence streams and rivers may have had on the incident;

26.7. rainfall recorded at the site prior to the incident;

26.8. the risk of environmental harm arising from the incident;

26.9. the action(s) that have or will be undertaken to mitigate any environmental harm arising from the incident;

26.10. corrective actions that have or will be undertaken to ensure the incident does not reoccur; and

26.11. if no action was taken, why no action was taken.

MONITORING

27. From the Commencement Date of this licence, the licensee must implement and comply with the Monitoring Program specified in Item 11.

28. The licensee must, to the extent practicable, collect samples that are representative of discharge conditions that maximise the ability to detect potential impact from the Licenced Action.

29. In implementing the Monitoring Program the licensee must ensure, to the extent practicable, that samples collected at the sampling points are collected:

29.1. on the same date as discharge event; and

29.2. from the part of the waterway that provides representative (well mixed) samples.

30. If a sample is missed or cannot be collected at a sampling point at a frequency set in the Monitoring Program for any reason, the licensee must revisit the sampling point to collect a sample as soon as possible after the missed collection.

31. The licensee must ensure that all samples and field environmental data are collected in accordance with recognised Australian Standards and guidelines (such as AS/NZS 5667.1 1998, ANZG (2018), as updated from time to time).

32. For the parameters that require analysis at a laboratory, the licensee must ensure that:

32.1. all samples are analysed at a laboratory with current NATA accreditation or equivalent; and

32.2. detection and reporting limits are appropriate to determine compliance with this licence.

33. The licensee must ensure any samples collected in accordance with the Monitoring Program or in connection with the Licensed Action or this licence, are obtained by, or under the supervision of a qualified sampler.

34. The licensee must ensure any plant and equipment used by the licensee in conducting the Monitoring Program:

34.1. is reasonably fit for the purpose and use to which it is put, including that it is properly calibrated;

34.2. is maintained and operational; and

34.3. is operated by a person trained to use the plant and equipment.

35. The licensee must ensure that, for each sample collected in accordance with the Monitoring Program or the Licensed Action, the following information must be recorded and retained:

35.1. the date on which the sample was collected;

35.2. the time at which the sample was collected;

35.3. the location at which the sample was collected;

35.4. the name of the person who collected the sample;

35.5. the chain of custody forms relating to the sample;

35.6. the field measurements (if any) and analytical results (if any) relating to the sample; and

35.7. laboratory quality assurance and quality control documentation.

36. The licensee must for all land based monitoring points specified in the Monitoring Program:

36.1. install and maintain appropriate identification signage so that they are reasonably identifiable at all times; and

36.2. maintain safe access and egress, as is reasonably practicable.

RECORDING AND REPORTING

37. The licensee must keep records of all contraventions with this licence. These records must be adequate to enable the licensee to comply with the notification and reporting conditions of this licence.

38. The licensee must submit a completed Annual Return, by emailing environmentalregulation@nt.gov.au as specified in Item 12.

39. The licensee must complete and provide to the Administering Agency a report of data and information obtained through the implementation and performance of the Monitoring Program (the Monitoring Report), as prescribed by this licence, on the dates specified in Item 13.

40. The licensee must ensure that each Monitoring Report:

40.1. is prepared in accordance with the requirements of the Administering Agency 'Guideline for Reporting on Environmental Monitoring' (or any other guideline as adopted by the Administering Agency from time to time);

40.2. includes a tabulation, in Microsoft ® Excel ® format or another format requested by the Administering Agency, of all monitoring data required to be collected in accordance with this licence for the preceding 12 month period;

40.3. includes a tabulation of monthly and annual contaminant loads discharged from the authorised discharge point specified in Item 5 for the preceding 12 month period. Contaminant loads must be calculated for metals, metalloids, nutrients and other parameters (excluding field parameters) listed in the monitoring program specified in Item 11. The calculations must be based on the discharge volume and the concentration of contaminant present in the discharge. On the days when a sample was not taken the concentration of the contaminant must be estimated using Linear Interpolation methodology;

40.4. includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the Licensed Action over a minimum period of three years (or part thereof);

40.5. includes a summary of any investigations undertaken by the licensee in accordance with this licence for the preceding 12 month period; and

40.6. includes an assessment of environmental impact from the Licensed Action.

41. If the licence expires or is otherwise surrendered, suspended or revoked and the licence contained a condition that the licensee provide a notice, report, record or other information after that date, the licensee must provide any report, record, information or data available to the licensee up to and including the date the licence expired or was surrendered, suspended or revoked.

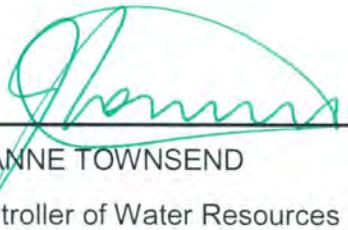
42. A copy of the documents listed specified in Item 14 will be placed on the Register.

SPECIAL CONDITIONS

43. The licensee must comply with the conditions specified in Item 15.

END OF LICENCE CONDITIONS

This licence is not valid unless signed below:



JOANNE TOWNSEND

Controller of Water Resources

Dated the 25 NOVEMBER 2022

DEFINITIONS

In this licence, unless a contrary intention appears:

Term	Definition
24 hour emergency contact	the phone number of a person who can be contacted at any time and be capable of responding to and providing information about any incident associated with the Licensed Action.
Administering Agency	means the NT Government Department with responsibility for administering the Water Act.
Anniversary Date	annual anniversary of the Commencement Date.
Annual Return	an Administering Agency prescribed format for demonstrating and reporting compliance with the conditions of this licence.
ANZG (2018)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at http://www.waterquality.gov.au/anz-guidelines.
business days	a day not Saturday, Sunday or a public holiday, in Darwin, Northern Territory.
Consultation and Communication Plan	a written plan documenting proposed consultation and communications for the Licensed Action before, during and after the Licensed Action which includes a strategy for communicating with members of the public who are likely to have a real interest in, or be affected by, the Licensed Action.
contact details	includes the 24 hour emergency contact, and name, position title and phone number of a representative of the licensee who can be contacted about the licence and Licensed Action.
discharge	releasing or allowing a liquid, gas or other substance to flow out from where it has been confined.
Dry season	means 1 May to 31 October.
Emergency Response Plan	a written plan documenting the licensee's procedures for responding to emergencies caused by, resulting from or associated with the Licensed Action and that may cause environmental harm.
Licensed Action	the Licensed Action as described on the covering page of this licence.
Linear Interpolation	a method to construct new data points within the range of known data points. $y = y1 + ((x - x1) * ((y2 - y1) / (x2 - x1)))$ y is the unknown concentration between known concentrations y1 and y2 y1 is the first known concentration y2 is the second known concentration x is the day of the unknown concentration y x1 is the day of the first known concentration y1 x2 is the day of the second known concentration y2
litter	litter, garbage, rubbish, refuse or waste matter, and includes the body of a dead animal.
NATA	National Association of Testing Authorities, Australia.

Term	Definition
plant and equipment	all material items used in association with the Licensed Action, including (but not limited to) storage vessels and containers, pipe work and hosing, vehicles (including vessels), tools, and measuring equipment.
pollution	has the same meaning as *pollute* as defined in 4 of the Water Act.
public entrance	access to the licensed premises that is utilised by the public.
qualified sampler	a person who has training and experience in obtaining samples from the relevant environmental medium.
Register	the register available at the website of the Northern Territory Environment Protection Authority (NT EPA).
wastewater	water that contains a waste.
Water Act	*Water Act 1992* (NT).
Wet season	means 1 November to 30 April.

APPENDIX 1: Site Plan

FIGURE 1: Surface Water Discharge and Monitoring Locations Source: Google Imagery

Note: DAMOUT1 is the controlled discharge outlet of the Main Sediment Dam and is shown for information purposes. Samples are collected from the Main Sediment Dam at Site 2.

APPENDIX 2: Monitoring Program

Table 1. Monitoring site details

Type	Site Code	Location Description	Latitude	Longitude
Authorised Discharge Point / Compliance Point	**SITE 5**	**Middlebrook Creek at Site Boundary**	**-12.99202°**	**131.00072°**
Environmental monitoring point	SITE 1	East Finniss River upstream of site influence	-12.99167°	131.00299°
Environmental monitoring point	SITE 4	Middlebrook Creek upstream of site influence	-12.99919°	131.00178°
On-site monitoring location	DAMOUT1	Sediment Dam Release Point	-12.993478	130.999281
On-site monitoring location	SITE 2	Main Sediment Dam	-12.993444°	130.998944°
On-site monitoring location	TREAT 01	Treatment Plant CCD2 tank (Treatment plant outlet)	-12.99536°	130.98917°

Table 2. Monitoring Requirements

				Monitoring Locations					Authorised Discharge and Compliance Point	
			Site Code	DAMOUT1	SITE 1	SITE 2	SITE 4	TREAT 01	SITE 5	
Parameter	**Abbr.**	**Units**	**Analysis**	**Monitoring Frequency**						**Trigger Values[1]**
Field Measurements										
Flow	Flow	kL/day	Automatic in situ	C	N/A	N/A	N/A	N/A	N/A	N/A
Water Level	Level	m		N/A	N/A	N/A	N/A	N/A	N/A	N/A
pH	pH	units	In situ	N/A	W	P, W	W	W	D	6.5 – 8.5
Electrical Conductivity	EC	µS/cm								700[2]
Dissolved Oxygen	DO	% sat.								N/A
Turbidity	NTU	NTU								10[5]
Temperature	T	°C								N/A
Metals										
Aluminium	Al	µg/L	Total and Filtered (0.45µm)	N/A	W	P, W	W	W	W	80
Cadmium	Cd									0.4
Chromium	Cr									6[4]
Cobalt	Co									13
Copper	Cu									2.5[3]
Iron	Fe									ND
Lead	Pb									6.6
Manganese	Mn									2500
Nickel	Ni									13[4]
Uranium	U									ND
Zinc	Zn									15[4]
General Chemistry										

				Monitoring Locations					Authorised Discharge and Compliance Point	
			Site Code	DAMOUT1	SITE 1	SITE 2	SITE 4	TREAT 01	SITE 5	
Parameter	**Abbr.**	**Units**	**Analysis**	**Monitoring Frequency**						**Trigger Values[1]**
Total Suspended Solids	TSS	mg/L		N/A	W	P,W	W	W	W	6[5]
Carbonate	CO_3									ND
Hardness as $CaCO_3$	$CaCO_3$									ND
Bicarbonate	HCO_3									ND
Calcium	Ca									ND
Magnesium	Mg									ND
Potassium	K									ND
Sodium	Na									ND
Chloride	Cl									ND
Sulfate	SO_4									ND

KEY:
C = Continuous
D = Daily during discharge and at least once per discharge event.
P = Prior to discharge
W =Weekly during the discharge period, starting within 24 hours of start of discharge and continuing until 14 days after the last discharge event of the season.

[1] Trigger Values are default ANZG (2018) values at 90% species protection level (unless otherwise specified) and are to be applied to dissolved metal concentrations at the Compliance Point (Site 5) only.
[2] Trigger Value for EC is the average concentration of EC at SITE 1, derived using data from the 2016/17 and 2017/18 Wet seasons.
[3] Trigger Value for copper (Cu) is based on the default ANZG (2018) value at 80% species protection level, taking into account background levels of Cu at Site 4.
[4] Concentrations may be modified to account for hardness, on a 'per sample' basis at the frequency specified at Site 5, as measured at GS8150200 and in accordance with the ANZECC 2000 Guidelines.
[5] Trigger values for Turbidity and Total Suspended Solids are based on 80th percentile of data from Site 4 from the 2020/21 and 2021/22 wet seasons. If trigger values are exceeded upstream of the compliance point (Site4) on the date of sampling, exceedances at Site 5 do not count towards notifiable incidents specified at Item 10.

N/A – Not Applicable.

				Monitoring Locations					Authorised Discharge and Compliance Point	
			Site Code	DAMOUT1	SITE 1	SITE 2	SITE 4	TREAT 01	SITE 5	
Parameter	Abbr.	Units	Analysis	Monitoring Frequency						Trigger Values[1]
ND – Not Determined										

Appendix 4 – Surface Water Monitoring Procedures

NTR-ENV-WIN-005
Surface Water Sampling

1. Scope

This work instruction applies to the sampling of all surface water monitoring locations whether man made or natural. This methodology is also applicable to sampling of water storage areas as part of the water treatment process.

2. Purpose

To present a uniform, accurate and reliable set of sampling procedures will foster the collection of comparable data of a known standard. Ultimately, this allows for greater confidence in the interpretation of any field based data.

3. Definitions/Acronyms

Word / Acronym	Description
CoC	Chain of Custody – form used to document the samples being sent to the laboratory and what analysis is required.
Dipper	A long-handled sampler with a claw on the end to hold the sample cup in place while a sample can be safely taken from a distance.
Duplicate	A replicate sample collected in a manner such that the samples are thought to be essentially identical in composition. A field duplicate sample is obtained by dividing a sample collected from a sampling point.
Field sheets	Paper forms used to document field results, later to be converted to digital format.
Sensor	An instrument that plugs into the water quality meters and detects or measures a physical property of a water sample

4. Codes of Practice, Guidelines and Standards

4.1 Australian Standards

AS/NZS 5667.1:1998 (R2016) – Water quality – Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples

AS/NZS 5667.4:1998 (R2016) – Water quality – Sampling – Guidance on sampling from lakes, natural and man-made

AS/NZS 5667.6:1998 (R2016) – Water quality – Sampling – Guidance on sampling of rivers and streams

5. Skills Required

Must have conducted one-on-one training with the Environmental Compliance Manager. A basic level of mathematics is required and a basic understanding of excel software is desirable but not essential.

6. Tools and Equipment

There is an extensive list of equipment required for this task. Refer to the Packing Checklist. In addition, the operator must consider climatic conditions (dust or rain) and ensure that the appropriate vehicle is used to access these areas.

7. Permits, Licences and Other approvals

The monitoring program is presented to the DPIR with the submission of the Mining Management Plan. It is this program that must be adhered to. Any alterations to this program must first be approved by the department. Refer to **Appendix 1** for the current monitoring program.

8. Hazards and Controls

Hazard	Control
Interaction with wild animals (eg crocodiles, pigs, snakes, buffalo)	• Be aware of surroundings. Do not enter areas where unsafe to do so. • Stay on designated tracks/paths. • Do not enter the water. • Use long handled dipper for water sampling • Inform supervisor prior to leaving site. If safe egress to an area is not possible do not sample.

Hazard	Control
Working alone	• Working alone for surface water sampling is not permitted off the site. Ensure you that sampling is done in twos when leaving the Mining Lease. • Radio contact with Control Room when leaving site. • Radio control room when moving from one sample location to the next.
Working at heights	• 3 points of contact when ascending and descending the stairs. • Long handled dipper to be stored permanently on top of the treatment tanks. • Other sampling equipment to be stored in a backpack to keep the sampler's hands free when climbing stairs
Insect bites (spiders, mosquitoes, wasps)	• Insect repellent. • Long pants and Long sleeves.
Slips, trips and falls (uneven terrain)	• Walk carefully, wear lace up ankle boots, and do not walk into areas that are unsafe.
Heat exhaustion, sunburn, dehydration	• Carry extra water, keep fluid intake up, where sunscreen and hat.
Bogging of vehicle	• Assess all roads and creek crossing prior to entry and only proceed where safe to do so. Inform Control Room prior to leaving site and inform of trip itinerary and estimated time expected to return to site.
Lightening	• Implement Lightening Procedure.
Heavy Rain	• Drive to conditions • Consider postponing monitoring till after the storm has passed. • Use the BOM to determine the potential duration and extent of the storm

9. Surface Water Sampling– Obtaining a representative sample

Before beginning your sampling round, ascertain the monitoring locations you plan to visit. In the wet season, you must consider the weather on the day and also accessibility to monitoring locations. It is not recommended to conduct sampling when there is rain or a high chance of rain.

The steps below describe the methodology that must be employed by the sampler to ensure that a representative sample is collected in alignment with Australian Standards.

Step		Detailed instruction	✓
1	Calibrate hand held water quality meter	• Meters should be calibrated weekly during the wet season and fortnightly during the dry season.	
2	Pack Vehicle	• Use the Packing Checklist to ensure you have all the items required to conduct monitoring. • Ensure all items have been stocked up prior to departing	
3	Fill in Field Sheet	• When you arrive at site fill in the details on a field sheet. • A field sheet should be completed for each site regardless of its status. If the site is dry then this should be documented on the field sheet. • Always ensure the details at the top of the field sheet are completed writing N/A if not applicable rather than leaving the section blank. • Write any observations that might assist data interpretation at a later date.	
4	Safe Egress	• Assess the site to ensure that you use the safest method of retrieving a sample without putting your safety at risk.	
5	Label Bottles	• Where bottled samples are required complete the labels prior to filling with sample. • Make sure your writing is neat and clear. Site ID should be exactly as it is written on the Field Data Sheet, no alterations. • The lab bag should be labelled with the Site ID and the date the sample was taken. A separate bag is required for duplicate samples.	

Step		Detailed instruction	✓
6	Duplicate	• Determine is a duplicate sample will be taken at this site. • A duplicate is required for every batch of 20 surface water samples. • If required document on the field sheet that a duplicate has been taken. • The Sample ID for every duplicate is the Site ID with **DP** as a prefix. *Example a duplicate sample at SITE5 will be **DP**SITE5.*	
7	Take sample 	• Attach the plastic 500ml cup to the long-handled dipper. • Extend the arm so that the sampler is a safe distance from the water's edge. • If you require bottled sample you will also need a 2-litre jug to decant the sample into. • Rinse the sample cup and jug in the sample water. Discard this water either to the ground or downstream so as not to have this wash water disturb the area you will be taking your sample from. • Sink the sample cup below the water's surface being careful not to stir up the bottom sediment. • Decan this water into a larger jug until you have the required volume of water. • Take the water back to the car for analysis.	
8	Hand-held Meters 	• Fill the small beaker with ~400ml of water. • Rinse the water quality meter sensor with the sample water prior to placing them in the beaker. • You need to be sampling for pH, EC, Temperature, Redox, Dissolved Oxygen (ppm and % saturation) and turbidity. • Place the sensors in the beaker making sure that the hole on the EC sensor is completely covered in water. • Set the timer for 5 minutes so there is sufficient time for the water to stabilise.	

Step		Detailed instruction	✓
		• Move on to the next step while you wait.	
9	Green Bottle	• *When bottles samples are required for laboratory analysis follow Step 9 and 10. If no bottle samples are required move onto Step 11.* • Take the Green organics bottle and rinse several times with the sample water. • Fill the bottle, replace the lid and put in the plastic bag.	
10	Take Metal samples	*NOTE DO NOT RINSE THE METAL BOTTLES PRIOR TO FILLING AS THEY HAVE BEEN TREATED WITH ACID.* • You require one filtered and one unfiltered sample. • Check the bottle label prior to filling. • Pour the water from the beaker in the bottle marked 'Total' checking the label before filling. • Be careful not to overflow the bottle. • Rinse a single use sterile syringe with the sample water. • Attach a 0.45um filter the syringe. • Decant the sample into the filtered sample bottle marked as 'Dissolved' checking the label before filling. • Be careful not to overflow the bottle. • Sediment laden water may require several filters to retrieve a sample. • When the water is considered too sediment laden the filtering can be done at the laboratory but the bottle must be marked as UNFILTERED and a note written on the CoC.	
11	Record data from hand-held meter	• Water is considered stabilised when the numbers displayed on the meters are no longer moving. • In some instances, this may take 5 minutes or even longer. • Once stabilised, write record the data on the field data sheets.	

Step		Detailed instruction	✓
12	Chill Samples	• Place the bagged sample bottles in an esky with ice brick to keep chilled until monitoring is complete. The esky should be kept inside the cab of the vehicle where possible. • These are to be transferred to a fridge at the earliest convenience.	
13	Clean meters and other sampling equipment	• Decontaminate and rinse all sampling equipment. • Decontaminate and rinse the hand-held meters and the sensors. • Use paper towels to try where necessary. • Remember to put the DO sensor in the travel tube to keep the membrane from drying out. • Pack away in storage box and pelican case.	
14	Pack up	• Pack up and secure equipment on the vehicle. At the end of the day please conduct the following tasks.	
15	Water Quality Meters care and maintenance	• When back at the lab, check which meters need charging and plug in accordingly. • The pH and Redox sensors require a storage solution to be placed in their caps upon storage. Store upright.	
16	Refill	• Refill all the consumables in the boxes in preparation for the next sampling round. • This includes bladders, syringes, filters, jerry cans, paper towel and gloves etc. • If you notice any items getting low, notify the Environmental Compliance Manager.	

10. References

Nil.

11. Associated Documents

Doc #	Document Name
NTR-ENV-MMP-017	Mining Management Plan (includes Water Management Plan)
NTR-ENV-FRM-010	Packing Checklist for Water Sampling Field Work
NTR-ENV-FRM-001	SW Sampling Field Data Sheet - Fortnightly
NTR-ENV-FRM-002	SW Sampling Field Data Sheet - BLANK
NTR-ENV-FRM-003	Rain Water Collection Ponds Field Data Sheet - Quarterly
NTR-ENV-FRM-004	Rain Water Collection Ponds Field Data Sheet - Fortnightly
NTR-ENV-FRM-005	Finniss Rum Jungle SW Field Data Sheet - Monthly
NTR-ENV-FRM-009	WDL 'Upon Discharge' Field Data Sheet
NTR-ENV-FRM-019	WDL 'Daily when Discharging' Field Data Sheet

Appendix 1 - Sampling Schedule

Monitoring Sites		Sampling Frequency			Coordinates	
Site ID	Description	Field Measurements	Metals and Major Chemistry	Radiological	Easting	Northing
Discharge Stream						
SITE1	EFR Upstream	F / U	F / U	-	717262.7	8562947.9
SITE2	Main Sediment Dam	F / U	F / U	-	716810	8562738
SITE4	Middlebrook Creek upstream of discharge	F / U	F / U	-	717108.9	8562079.6
SITE5	Middlebrook Creek ~0.2 km downstream of discharge	D / U	F / U	-	717009.1	8562887.6
DAMOUT1	Main Sediment Dam at the discharge pipe outlet	U	U	-	716855	8562729
DAMOUT2	Main Sediment Dam emergency spillway (when flowing)	U	U	-	716560	8562364
TREAT01	Treatment water - discharging to the Main Sed	F	F / U	-	715751	8562533
WAND01	Wandering Creek upstream of Middlebrook Creek	F / U	F / U	-	717140	8562796
GS200	East Finniss River ~0.4 km downstream of discharge	F / U	F / U	-	717002.7	8563106.6
GS097	East Finniss River ~7 km downstream of discharge	M	M	-	713425.372	8566008.73
RUMWHITE	Rum Jungle Whites Pit	M	B	-	718065	8563345
RUMINTER	Rum Jungle Intermediate Pit	M	B	-	717128	8563036

Monitoring Sites		Sampling Frequency			Coordinates	
Site ID	Description	Field Measurements	Metals and Major Chemistry	Radiological	Easting	Northing
Rainwater Collection Ponds						
RW_TSF	TSF -Stormwater Collection Pond	F	Q	-	715628	8562366
RW_SRO	Small Sediment Dam	F	Q	-	715112	8562411
RW_PAF	PAF Stockpile Pond	F	Q	-	716077	8562383
RW_SP3	Low Grade Ore Pond	F	Q	-	716334	8562245
RW_BSS	Intermediate Stockpile Pond	F	Q	-	716308	8562695
RW_PP	Process water storage pond	F	B	-	715410	8562432
RW_PIT	Oxide pit	F	B	-	716710	8562941

Appendix 5 – Groundwater Monitoring Procedures

NTR-ENV-WIN-001
Low Flow - Groundwater Sampling

1. Scope

This work instruction applies to the sampling of water wells using the micro purge (low flow) method with a bladder pump. This instruction does not include details on purging three well volumes with an electric submersible pump.

2. Purpose

To present a uniform, accurate and reliable set of sampling procedures will foster the collection of comparable data of a known standard. Ultimately, this allows for greater confidence in the interpretation of any field based data.

3. Definitions/Acronyms

Word / Acronym	Description
Aqua Tubing	Double bonded tubing ¼ inch (airline) and $^{3}/_{8}$ inch (discharge line) connected to a bladder pump to the compressor via a control unit. The tubing is left down the well secured with a bull clip.
CoC	Chain of Custody – form used to document the samples being sent to the laboratory and what analysis is required.
Drive cycle	The cycle set on the Control Unit where the line is pressurised forcing water up the discharge line.
Discharge Line	The $^{3}/_{8}$ inch aqua tubing which transports water from the pump to the flow cell.
Duplicate	A replicate sample collected in a manner such that the samples are thought to be essentially identical in composition. A field duplicate sample is obtained by dividing a sample collected from a sampling point.
Control Unit	A unit attached to the compress to regulate the air pressure being delivered to the bladder pump.
Field sheets	Paper forms used to document field results, later to be converted to digital format.
Flow Cell	A purpose-built container, cylindrical in shape which hold the water quality sensor from the top. The aqua tubing (discharge line) from the pump is inserted into the bottom of the container. As water fills the cell water will overflow from the top of the cell into the overflow bucket.

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Word / Acronym	Description
Sensor	An instrument that plugs into the water quality meters and detects or measures a physical property of a water sample
SWL	Standing or Static Water Level – the top of the water column to the top of the casing
Vent Cycle	The part of the cycle where there is no pressure which allows water to re-enter the pump and recharge the bladder.
Water Level Meter	Equipment used to measure the SWL which is essentially a sensor on the end of a tape measure which sounds when the sensor comes into contact with water.

4. Codes of Practice, Guidelines and Standards

4.1 Australian Standards

AS 5667.1:1998 – Water quality – Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.

AS 5667.11.:1998 Water Quality Sampling Part 11: Guidance on sampling of groundwaters.

4.2 Other Resources

Groundwater Sampling and Analysis – A Field Guide – GeoScience Australia

5. Skills Required

Must have conducted one on one training with the Environmental Compliance Manager. A basic level of mathematics is required and a basic understanding of excel software is desirable but not essential.

6. Tools and Equipment

There is an extensive list of equipment required for this task. Refer to the Packing Checklist. In addition, the operator must consider climatic conditions (dust or rain) and ensure that the appropriate vehicle is used to access these areas.

7. Permits, Licences and Other approvals

The monitoring program is presented to the DPIR with the submission of the Mining Management Plan. It is this program that must be adhered to. Any alterations to this program

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must first be approved by the department. Refer to **Appendix 1** for the current monitoring program.

8. Hazards and Controls

Hazard	Control
Interaction with wild animals (eg crocodiles, pigs, snakes, buffalo)	• Be aware of surroundings. Do not enter areas where unsafe to do so. • Stay on designated tracks/paths. • Do not enter the water. • Use long handled dipper for water sampling • Inform supervisor prior to leaving site. If safe egress to an area is not possible do not sample.
Working alone	• Working alone for surface water sampling is not permitted off the site. Ensure you that sampling is done in twos when leaving the Mining Lease. • Radio contact with Control Room when leaving site. • Radio control room when moving from one sample location to the next.
Insect bites (spiders, mosquitoes, wasps)	• Insect repellent
Slips, trips and falls (uneven terrain)	• Walk carefully, wear lace up ankle boots, and do not walk into areas that are unsafe. • Use handrails where available
Heat exhaustion, sunburn, dehydration	• Carry extra water, keep fluid intake up, where sunscreen and hat.
Bogging of vehicle	• Assess all roads and creek crossing prior to entry and only proceed where safe to do so. Inform Control Room prior to leaving site and inform of trip itinerary and estimated time expected to return to site.
Electric shock / use of battery clamps	• Keep the compressor in the off position when not in use. • Only connect and disconnect the battery clamps when vehicle is turned off.
Rolling of Vehicle	• Take the vehicle out of gear. • Engage the hand brake. • Use a chock when parked on a hill.

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Hazard	Control
Lightening	• Implement Lightening Procedure
Heavy Rain	• Drive to conditions • Consider postponing monitoring till after the storm has passed. • Use the BOM to determine the potential duration and extent of the storm

9. Step by Step Instructions

The steps have been broken into 3 sections as the operator may not need to perform all tasks depending on if the well has been previously set up for low flow sampling.

1. The first step required the bore to have the appropriate length of aqua tubing measured up.

2. The second step required the drive and vent times and air pressure to be calculated for each bore.

3. The third step is to conduct the micro purge sampling to retrieve a water sample that is representative of the aquifer.

Below are step by step instructions on how to complete each of these stages**. Figure 8-1** below highlights the basic operational parts of the Control Unit and its functions described in the sections below.

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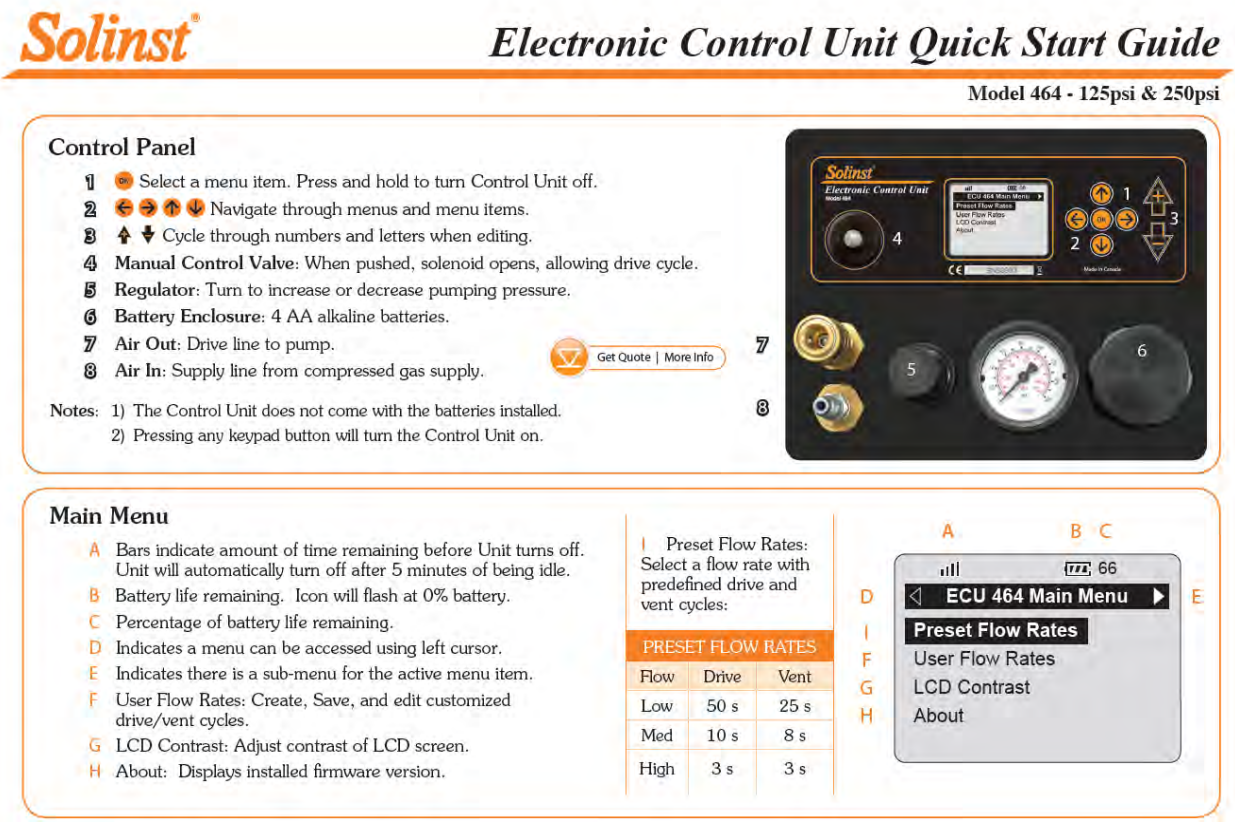

Figure 8-1 – Solinst Control Unit Quick Start Guide

A User Guide for the Control Unit is available on line on via the following link.

https://www.solinst.com/products/groundwater-samplers/464-pneumatic-pump-control-units/operating-instructions/electronic-control-unit-user-guide/

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9.1 Measure and Install the Aqua Tubing

This step is only required if there is no aqua tubing already set up in the well or on those occasions when the aqua tubing is being replaced. If this step is not required move onto Section 8.3 – Obtaining a Representative Sample.

Step		Detailed instruction	✓
1	Set Up	• Place the table adjacent to the well to enable you to feed a roll of tubing from the vehicle (must be kept off the ground). • The first part of the aqua tubing should allow for the 10cm measured from the pump inflow valve to the top the start of the tubing. It is the water inflow valve that must be in the screen interval.	
2	Measurement the tubing	• After the first 90cm, measure the tubing in 1 meter intervals while feeding the aqua tubing down the hole until the required length is reached. • The table should have a 1 metre mark clearly inscribed with the 0m being located at the well end of the table.	
3	Determine the required length	• The tubing should be sufficient length to enable the pump to be placed within the screened interval at all times, throughout the year. • Refer to the Groundwater Field Guide to determine the length of the aqua tubing (ie recommended pump depth). • The aqua tubing should be cut off at approximately 2 – 3m longer than the recommended pump depth.	
4	Labelling	• Label tubing at the recommended pump depth and at 1 meter increments above and below this mark. • No other marking should be required.	

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9.2 Calculating the Drive and Vent Times

This step is required after the aqua tubing has been installed and this is the first time the well has been micro purged. If this has already been completed move onto the next step (**Section 8.3**).

Step		Detailed instruction	✓
1	Set up pump	• Complete steps 1 – 9 as detailed in Section 8.3.	
2	Lower pump down the well	• Gently lower pump into the well. The aqua tubing and the pump wire must be lowered simultaneously being careful not to pull on the aqua tubing which may cause it to loosen the connection on the pump. The pump wire should take the tension while the aqua tubing is fed into the hole at the same time.	
3	Discharge Line	• Place the discharge line (aqua tubing) into a small beaker of DI water (approximately 2cm deep). • Do not connect this to the overflow cell for this process.	
4	Adjust Pressure	• Calculate the pressure required using the formula - Pump Depth **x** 1.5 **+** 15 psi • This can be manually adjusted using the regulator on the Control Unit (refer Figure 8-1).	
5	Timer	• You will need to time both the drive and vent cycles when performing the next couple of steps. As one stops the next timer begins.	
6	Set the Water Level Meter	• Place the Water Level Meter down the well until you reach the top of the water column. • You will hear a beeping from the Meter. You need to keep the Meter at this level and allow the beeping to continue.	

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Step		Detailed instruction	✓
7	Calculate the Drive time	• With the discharge firmly placed in the beaker of water press the Manual Control Valve on the Control Unit (refer **Figure 8-1**). The discharge line must be submerging in the water. • Continue to hold the valve down. • This will pressurise the pump causing bubbles to rise into the beaker water. • Continue to hold down the Manual Control Valve until the bubbles have ceased and immediately release. • Note the number of seconds this step takes while also resetting the timer to time the Vent cycle. *If you don't see a good stream of bubbles increase the pressure by another 10psi and then repeat the steps above. Conversely, if you see a rapid and excessive amount of bubble, reduce the pressure by 10psi.*	
8	Calculate the Vent time	• As soon at the bubbles stop and the Manual Control Valve is released this is the start of the Vent time. • As you release the Manual Control Valve you will hear the beeping of the Water Level Meter stop as the water draws down. • The Vent time is equal to the time it takes for the well to recover. This is indicated when you hear the Water Level Meter begin to beep again. Record the time when you hear the meter begin to beep. *The vent is the time from when you release the Manual Control Valve to the time when you hear the Water Level Meter beep again (ie the well has recovered to pre-pump level).*	
9	Create a User Flow Rate	• Each bore is to have its own individual setting created. • The user will pre-set the Drive, Vent and Pressure and calculated in the steps above. • Do this now (refer **Figure 8-1**).	
11	Obtain a representative sample	• The well is now ready to sample. • Continue from Step 10 in **Section 8.3**.	

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9.3 Micro Purging – Obtaining a representative sample

Before beginning your sampling round, ascertain the monitoring locations you plan to visit. In the wet season, you must consider the weather on the day and also accessibility to monitoring locations. It is not recommended to conduct sampling when there is rain or a high chance of rain.

Step		Detailed instruction	✓
1	Calibrate hand held water quality meter	• Meters should be calibrated weekly during the wet season and fortnightly during the dry season.	
2	Pack vehicle	• Use the Packing Checklist to ensure you have all the items required to conduct monitoring. • Ensure all items have been stocked up prior to departing	
3	Park Vehicle	• Standardise the way you pack the vehicle so it is the same each time. • It is recommended that the compressor be stored on the same side as the battery and that you park the vehicle next to the well on the same side. • Turn off vehicle.	
4	Dip Bore	• Prior to setting up check the SWL to ascertain if there is sufficient water to sample.	
5	Fill in Field Sheet	• A field sheet should be completed for each bore regardless of the SWL. If the bore is dry then this should be documented on the field sheet. • Always ensure the details at the top of the field sheet are completed writing N/A if not applicable rather than leaving the section blank.	
6	Set up work area	• Set up all the equipment that will be required for the sampling. Keep the set up consistent between sites and this will ensure sampling is systematic and efficient.	

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Step		Detailed instruction	✓
7	Connect Compressor	• Connect clamps to the car battery (car is still turned off). • Close air release valve on the compressor. • Connect air hose from the compressor to the control unit and the outlet hose with the air regulator attached. This will later to be connected to the aqua tubing. • Turn on the car followed by the compressor to build up pressure. • Ensure that the water chamber on the compressor outlet seals. You will hear it when it seals but if this takes too long place your finger on the valve on the bottom of the chamber to assist with the seal.	
8	Removing aqua tubing	• If a bore has been set up previously the aqua tubing will be left in-situ. This should be secured with a bull clip and string so the tubing doesn't fall down the well. If there is no tube in the well please follow instructions Section 8.1 and 8.2. • Using gloves remove the tubing being sure not to place the tubing directly on the ground. Use the back of the ute (clean)or a tarp. • From time to time, the aqua tubing may need replacing. See Section 8.1 for more details. • The bottom of the aqua tubing is to be connected to the pump using the 'push' fittings. • The ¼ inch push fitting on the pump is the air inlet and the $^{3}/_{8}$ inch fitting on the pump is the water outlet. • At the other end of the aqua tubing (top end), connect the top of the air line (¼ inch) to the air regulator connected to the control unit. • The water outlet is then connected to the flow cell.	
9	Test the seal	• Sometimes the connections don't well seal initially so these must be checked prior to lowering the pump down the well. • Once all the aqua tubing is connected and before you lower the pump, press the Manual Control Valve (refer **Figure 8-1**) and listen for any leaks. Adjust where necessary.	

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Step		Detailed instruction	✓
10	Place the pump down the hole	• Gently low pump into the well. The aqua tubing and the pump wire must be lowered simultaneously being careful not to pull on the aqua tubing which may cause it to loosen the connection on the pump. The pump wire should take any pressure while the aqua tubing is fed into the hole as the same time. • Once the required pump depth is reached use a clamp to secure the pump reel. • If the labels on the aqua tubing are not clear reapply. Labels 1 meter either side of the pump depth is adequate. *Preferred pump depth is one meter below the top of the screened interval.*	
11	Set up meters	• Place the flow cell in the flow bucket. This is then set up between the well and the table which has the pelican case with the hand-held water quality meters. • Place the decontaminated and rinsed sensors in the flow cell. • Use an empty bucket under the overflow bucket to bring the flow cell up to a suitable height.	
12	Remeasure SWL	• Measure the SWL. • Record on field sheet. • Leave the Water Level Meter in place while pumping is being conducted.	
13	Select settings on the Control Unit	• Select the pre-recorded setting on the Control Unit under the 'User Flow Rates' section of the menu. • If one has been set up previously use arrows to navigate through the menu and set up a new 'User Flow Rate'. • Cross check the settings with the Groundwater Bore Field Guide.	
14	Wait for water to enter flow cell	• Observe the drive and vent cycles. • The drive cycle is the pressurisation of the aqua tubing forcing water up the discharge line. • The Vent cycle allows water to re-enter the pump and	

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Step		Detailed instruction	✓
		recharge the bladder. • Wait for the water to enter the flow cell. If no water enters after 5 minutes refer to the troubleshooting section in Appendix 1.	
15	Start recording	• When water starts to fill the flow cell place the water quality sensor in the cell and turn the meters on. • Start recording values on the field sheet once the upper hole on the EC meter is covered in water. • If the flow rate is less than 100ml/min then record water quality values every 5 minutes. If the flow rate is greater than 100ml/min then record values every 3 minutes. • Set the timer. • The date and time should be set on each of the water quality meters and can be referenced when taking field notes. *If the SWL drops below 10cm of the starting level stop pumping immediately and allow the well to recharge. A drop below 10cm indicates issues with the drive and vent times or with well construction. Refer to **Appendix 1.***	
16	Pump till water is stabilised	• Continue to pump the well until the water has stabilised. • Stabilisation is considered complete when you have 3 consecutive readings for all of the following parameters - pH @ ± 0.05 - EC @ ± 3% - Temp @ ± 0.2°C - Redox @ ± 10mV - DO (ppm) @ 10% or >0.05	
17	Total volume pumped	• Keep an eye on the overflow bucket. It will only hold just over 10 litres and may need emptying if the water is taking a while to stabilise. • Measure the volume of ALL water pumped and record on the field sheet each time you empty the overflow bucket.	

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Step		Detailed instruction	✓
18	Duplicate	• Determine is a duplicate sample will be taken at this site. • A duplicate is required for every batch of 20 groundwater samples. • If required document on the field sheet. • The Sample ID for every duplicate is the Site ID with **DP** as a prefix. *Example a duplicate sample at BH2B will be **DP**BH2B.*	
19	Label Bottles	• In between recording water quality values every 3-5 mins label the sample bottles and back. • Make sure your writing is neat and clear. Site ID should be exactly as it is written on the Groundwater Field Guide and no variations. • The lab bag should be labelled with the Site ID and the date the sample was taken. A separate bag is required for duplicate samples.	
20	Other jobs while waiting	• There are always jobs that can be done while waiting for the water to stabilise. Use this time to; - fill up DI and Decon90 bottles. - Clean equipment or containers if required - Make sure all sampling equipment has been Decontaminated and Rinsed. Hygiene is paramount during sampling. - Make sure that all sections on the field sheet have been completed.	
21	Once stabilised	• Remove the water quality sensors from the flow cell and put to the side for the moment. • Disconnect the aqua tubing from the bottom of the flow cell. • Place the overflow bucket and the cell to the side for the moment. • Place a 1 litre sample bottle in a jug to help keep it balanced. • Remove the lid and insert the tube in to the bottle • Bottle must be rinsed with the sample water prior to filling.	

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Step		Detailed instruction	✓
		• Make sure the jug is secure and not a risk of toppling over. • Leave until full, replace lid and put in labelled sample bag.	
22	Clean meters	• While waiting for the bottle to fill decontaminate and rinse the hand-held meters and the sensors. • Remember to put the DO sensor in the travel tube to keep the membrane from drying out. • Pack away.	
23	Measure overflow water	• Decant the overflow water into a measuring jug and record the volume on the field sheet. • Calculate the flow rate into ml/min and record on the field sheet. • Remember to add any volumes that may have been decanted during Step 18.	
24	Clean flow cell and bucket	• Decontaminate and rinse the flow cell and bucket. • Use paper towels to try where necessary. • Replace lid on bucket and pack away.	
25	Take Metal samples	*NOTE DO NOT RINSE THE METAL BOTTLES PRIOR TO FILLING AS THEY HAVE BEEN TREATED WITH ACID.* • Decontaminate and rinse a small beaker. • Rinse the beaker with the sample water before filling with water. • You require one filtered ('Dissolved') and one unfiltered ('Total') sample. • 60ml is required per bottle. Collect sufficient water for all the bottles (including any duplicates). • Pour the water from the beaker in the bottle marked 'Total' checking the label before filling. • Be careful not to overflow the bottle. • Rinse a single use sterile syringe with the sample water.	

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Step		Detailed instruction	✓
		• Attach a 0.45um filter onto the syringe. • Decant the sample into the filtered sample bottle marked as 'Dissolved' checking the label before filling. • Be careful not to overflow the bottle. • Sediment laden water may require several filters to retrieve a sample. • When the water is considered too sediment laden the filtering can be done at the laboratory but the bottle must be marked as UNFILTERED and a note written on the CoC.	
26	Chill Samples	• Place the bagged sample bottles in an esky with ice brick to keep chilled for the day. The esky should be kept inside the cab of the vehicle where possible. • These are to be transferred to a fridge at the earliest convenience.	
27	Turn off the Control Unit	• When no further water is required turn off the; - Control Unit, - Compressor; and - Vehicle or generator.	
29	Remove the Water Level Meter	• Remove the Water Level Meter from the hole. • Decontaminate and rinse the sensor and tape.	
30	Remove the pump	• Give the pump reel some slack by moving the reel approximately 1 meter from the well. • Remove the pump from the well by lifting the wire and the tubing up vertically at the same time. • Slowly pull the pump up by the wire, placing it next to the reel to be wound up later and the aqua tubing is directed into the tray of the ute. • Once the pump is at the surface, disconnect the aqua tubing.	

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Step		Detailed instruction	✓
		• Place the pump on the table to be cleaned. • Reinsert the aqua tubing back down the well and secured with the bull clip. • Secure the lid back on the casing.	
31	Wind up pump	• Wind up the wire onto the reel. • Use a clamp to secure the reel in place.	
32	Clean Pump	• Separate the pump components and decontaminate and rinse. • Flush the filter to remove any sediment • Remove the bladder. Decontaminate and rinse where possible, otherwise replace with a new one. • Reassemble the pump and pack away.	
33	Disconnect Control Unit	• Disconnect the hoses from the Control Unit and seal the box. • The unit will turn off automatically.	
34	Pack up	• Pack up and secure equipment on the vehicle. At the end of the day please conduct the following tasks.	
35	Drain Air Compressor	• Open the air release valve at the bottom of the compressor and drain. • The valve can remain open until the next occasion to allow any moisture to drain from the machine.	
36	Decontaminate and Rinse	• All equipment should be decontaminated and rinsed at the end of the sampling day. • Use paper towel to dry and remove and dust. • This includes jugs, bottles, buckets, containers etc	

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Step		Detailed instruction	✓
37	Water Quality Meters care and maintenance	• Check which meters need charging and plug in accordingly • The pH and Redox sensors require a storage solution to be placed in their caps upon storage. Store upright.	
38	Refill	• Refill all the consumables in the boxes in preparation for the next sampling round. • This includes bladders, syringes, filters, jerry cans, paper towel and gloves etc.	

10. References

Nil.

11. Associated Documents

Doc #	Document Name
NTR-ENV-FRM-010	Packing Checklist for Water Sampling Field Work
NTR-ENV-FRM-006	Low Flow Sampling Field Sheet
NTR-ENV-FRM-023	Groundwater Sampling Field Guide

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Appendix 1 – Monitoring Schedule

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Monitoring Bore	Sampling Frequency			Co-ordinates		Screen Lithology	Well Type
	Standing Water Level	Field Measure-ments	Metals and Major Chemis try	Easting	Northing		
TPB4	M	Q	Q	716573	8563103	Carbonate	**Production**
TPB5	M	Q	Q	716920	8563046	Carbonate	**Production**
RN023137	M	Q	Q	716598	856288	Amphibolite	Observation
BH2A	M	Q	Q	715154.43	8562316.11	Clayey sand	Observation
~~BH2B~~	M	Q	Q	715155.783	8562314.829	Sandy clay	Abandoned
BH3A	M	Q	Q	715372.046	8562110.323	Shale	Observation
BH3B	M	Q	Q	715374	8562111.696	Shale	Observation
BH4A	M	Q	Q	715557.358	8562109.156	Silt & clay	Observation
BH4B	M	Q	Q	715555.293	8562111.121	Shale	Observation
BH4D	M	Q	Q	715493.305	8562088.046	Shale	Observation
BH4E	M	Q	Q	715615.533	8562086.441	Shale	Observation
BH4F	M	Q	Q	715549.767	8562118.168	Shale	**Production**
BH4G	M	Q	Q	715560.4	8562119	Shale	**Production**
BH4H	M	Q	Q	715451	8562052	Shale	**Production**
BH5A	M	Q	Q	715977.935	8562106.094	Silt	Observation
BH5B	M	Q	Q	715975.242	8562106.284	Silt	Observation
BH12A	M	Q	Q	715178.71	8562123.26	Sandy gravelly clay	Observation
BH12B	M	Q	Q	715179.78	8562122.43	Shale	Observation
BH12C	M	Q	Q	715182.2	8562124	Clay, gravelly sand & quartz dolomite	**Production**
~~BH13A~~	M	Q	Q	715238.7	8562162	Carbonate	Abandoned
BH13B	M	Q	Q	715236.1	8562162	Silt & clay	Observation
~~BH14A~~				715208.5	8562344	Carbonate	Abandoned
BH14B				715213.7	8562344	Sandy clay	Observation
BH15A	M	Q	Q	716099.3	8562538	Shale	Observation
BH15B	M	Q	Q	716105	8562539	Shale	Observation

Monitoring	Sampling Frequency			Co-ordinates		Screen	Well Type
BH16B	M	Q	Q	716084	8562253	Dolerite	Observation
BH17B	M	Q	Q	715871.7	8562543	Carbonate	Observation
BH18A	M	Q	Q	715468.7	8562424	Clay and weathered rock	Observation
BH18B	M	Q	Q	715471.3	8562425	Clayey gravelly sand	Observation
BH7A	M	Q	Q	715422.816	8561710.964	Shale	Observation
BH7B	M	Q	Q	715422.63	8561694.256	Shale	Observation
BH8A	M	Q	Q	715841.654	8561506.191	Clay	Observation
BH8B	M	Q	Q	715857.651	8561505.302	Shale	Observation
BH9A	M	Q	Q	716245.039	8561795.272	Clay	Observation
BH9B	M	Q	Q	716246.203	8561775.22	Shale	Observation
BH10	M	Q	Q	716241.118	8561417	Clayey sand	Observation
BH11	M	Q	Q	715418.049	8561293.334	Clay	Observation
Thompson	Q	Q	Q	714788.54	8561387.25	Shale	Domestic Supply
ThompsonMango	Q	Q	Q	714917	8561890	-	Domestic Supply

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Appendix 2 - Trouble shooting

No water entering the flow cell	Have you waited sufficient time. Are the Drive and Vent times correct? Is the pressure correct? For deeper holes sometimes you need to increase the pressure.
SWL drops below 10cm of starting level.	Recharge well. If it doesn't recharge or if it takes to long this may be indicative of a blockage. Check the Drive and Vent times. Are they set properly? If not recalculate the drive and vent times as per **Section 8.2.**

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NTR-ENV-WIN-002
Groundwater Well Purging

1. Scope

This work instruction applies to the sampling of water wells by purging three well volumes with an electric submersible pump. This instruction does not include details on using the micro purge (low flow) method with a bladder pump.

2. Purpose

To present a uniform, accurate and reliable set of sampling procedures will foster the collection of comparable data of a known standard. Ultimately, this allows for greater confidence in the interpretation of any field based data.

3. Definitions/Acronyms

Word / Acronym	Description
Chain of Custody	A sheet supplied by the laboratory which records the details the information about the samples and gives instruction to the laboratory regarding sampling requirements.
Discharge Line	The $^{3}/_{8}$ inch aqua tubing which transports water from the pump to the surface.
Field sheets	Paper forms used to document field results, later to be converted to digital format.
SWL	Standing or Static Water Level – the top of the water column to the top of the casing
Submersible Pump	An electric pump used to push water to the surface via a discharge line.
Water Level Meter	Equipment used to measure the SWL which is essentially a sensor on the end of a tape measure which sounds when the sensor comes into contact with water.

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4. Codes of Practice, Guidelines and Standards

4.1 Australian Standards

Water Quality Sampling Part 11: Guidance on sampling of groundwaters – AS 5667.11.:1998

4.2 Other Resources

Groundwater Sampling and Analysis – A Field Guide – GeoScience Australia

5. Skills Required

Must have conducted one on one training with the Environmental Compliance Manager. A basic level of mathematics is required and a basic understanding of excel software is desirable but not essential.

6. Tools and Equipment

There is an extensive list of equipment required for this task. Refer to the Packing Checklist. In addition, the operator must consider climatic conditions (dust or rain) and ensure that the appropriate vehicle is used to access these areas.

7. Permits, Licences and Other approvals

The monitoring program is presented to the DPIR with the submission of the Mining Management Plan. It is this program that must be adhered to. Any alterations to this program must first be approved by the department. Refer to the Mining Management Plan for the current monitoring program.

8. Step by Step Instructions

Below are step by step instructions on how to calculate the bore volume and how to purge the bore to obtain representative water sample.

8.1 Purging – Obtaining a representative sample

Before beginning your sampling round, ascertain the monitoring locations you plan to visit. In the wet season, you must consider the weather on the day and also accessibility to monitoring locations. It is not recommended to conduct sampling when there is rain or a high chance of rain.

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Step		Detailed instruction	✓
1	Calibrate hand held water quality meter	• Meters should be calibrated weekly during the wet season and fortnightly during the dry season.	
2	Pack vehicle	• Use the Packing Checklist to ensure you have all the items required to conduct monitoring. • Ensure all items have been stocked up prior to departing	
3	Park Vehicle	• Standardise the way you pack the vehicle so it is the same each time. • Turn off vehicle.	
4	Dip Bore	• Prior to setting up check the SWL to ascertain if there is sufficient water to sample.	
5	Fill in Field Sheet	• A field sheet should be completed for each bore regardless of the SWL. If the bore is dry then this should be documented on the field sheet. • One field data sheet per bore. • Always ensure the details at the top of the field sheet are completed writing N/A if not applicable rather than leaving the section blank.	
6	Set up work area	• Set up all the equipment that will be required for the sampling. Keep the set up consistent between sites and this will ensure sampling is systematic and efficient.	
7	Calculate purge volumes	• To ensure that you obtain a representative sample you must purge 3 well volumes and then make sure the water has stabilised. • The formula for calculating the purge volume is located on the back of the field data sheet. 1. Total Depth minus SWL 2. Work out the bore casing diameter 3. Calculate the volume per metre multiplied by 3. 4. (Volume per metre x 3) multiplied by (Total Depth minus SWL) 5. This is the total volume to be purges (ie 3 well volumes)	

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Step		Detailed instruction	✓
8	Place the pump down the hole	• Gently low pump into the well until it is within the screened interval and secure at the surface.	
9	Connect the booster to the pump	• Connect the booster to the pump. • Connect booster clamps to the car battery (car is still turned off).	
10	Calculate the flow rate	• Turn of the vehicle to start the pump with the discharge line placed in a bucket greater the 15 litres. • Time how much water is pumped over a one minute time period. This is the flow rate. Record this on the field sheet • Use this flow rate to calculate how long it will take to purge the 3 well volumes calculated in Step 7. • Record this on the Field Sheet. • After the flow rate has been calculated move the discharge line away from the work area where it will not create a safety concern for yourself or others working close by.	
11	Sample water	• Collect water from the discharge line every ½ bore volume (ie total purge volume divided by 6). • Collect water in a clean jug and insert water quality meter sensors and wait for the reading so stabilise (approximately 5 minutes). • Record these values on the field sheet.	
12	Pump till water has stabilised	• Continue to pump until 3 bore volumes has been purged. • At this stage confirm that water has stabilised by taking a sample every 3 minutes until the following criteria has been med • Stabilisation is considered complete when you have 3 consecutive readings for all of the following parameters - pH @ ± 0.05 - EC @ ± 3%	

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Step		Detailed instruction	✓
		- Temp @ ± 0.2°C - Redox @ ± 10mV - DO (ppm) @ 10% or >0.05	
13	Duplicate	• Determine is a duplicate sample will be taken at this site. • A duplicate is required for every batch of 20 groundwater samples. • If required document on the field sheet. • The Sample ID for every duplicate is the Site ID with **DP** as a prefix. *Example a duplicate sample at BH2B will be **DP**BH2B.*	
14	Label Bottles	• In between recording water quality values label the sample bottles and back. • Make sure your writing is neat and clear. Site ID should be exactly as it is written on the Groundwater Field Guide and no variations. • The lab bag should be labelled with the Site ID and the date the sample was taken. A separate bag is required for duplicate samples.	
15	Other jobs while waiting	• There are always jobs that can be done while waiting for the purging to finish. Use this time to; - Fill up DI and Decon90 bottles. - Clean equipment or containers if required - Make sure all sampling equipment has been Decontaminated and Rinsed. Hygiene is paramount during sampling. - Make sure there that all sections on the field sheet have been completed.	
16	Once stabilised	• Remove the water quality sensors from the flow cell and put to the side for the moment. • Place the overflow bucket to the side for the moment. • Place a 1 litre sample bottle in a jug to help keep it balanced. • Remove the lid and insert the tube in to the bottle	

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Step		Detailed instruction	✓
		• Bottle must be rinsed with the sample water prior to filling. • Make sure the jug is secure and not a risk of toppling over. • Leave until full, replace lid and put in labelled sample bag.	
17	Clean meters	• While waiting for the bottle to fill decontaminate and rinse the hand-held meters and the sensors. • Remember to put the DO sensor in the travel tube to keep the membrane from drying out. • Pack away.	
18	Clean flow cell and bucket	• Decontaminate and rinse the bucket. • Use paper towels to try where necessary. • Replace lid on bucket and pack away.	
19	Take Metal samples	• Decontaminate and rinse a small beaker. • Rinse the beaker with the sample water before filling with water. • 60ml is required per bottle. Collect sufficient water for all the bottles (including any duplicates). • You require one filtered and one unfiltered sample. • Check the bottle label prior to filling. • Pour the water from the beaker in the unfiltered sample bottle being careful not to overflow the bottle. ***NOTE DO NOT RINSE THE METAL BOTTLES PRIOR TO FILLING AS THEY HAVE BEEN TREATED WITH ACID.*** • Rinse a single use sterile syringe with the sample water. • Using a 0.45um filter attached to the filter decant the sample into the filtered sample bottle checking the label before filling. • Sediment laden water may require several filters to retrieve a sample. • When the water is considered too sediment laden the filtering can be done at the laboratory but the bottle must	

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Step		Detailed instruction	✓
		be marked as **UNFILTERED** and a note written on the CoC.	
20	Chill Samples	• Place the bagged sample bottles in an esky with ice brick to keep chilled for the day. The esky should be kept inside the cab of the vehicle where possible.	
21	Turn off the Control Unit	• When no further water is required turn off the; - Control Unit, - Compressor; and - Vehicle or generator.	
22	Remove the Water Level Meter	• Remove the Water Level Meter from the hole. • Decontaminate and rinse the sensor and tape.	
23	Remove the pump	• Slowly pull the pump up to the surface. • Once the pump is at the surface, place the pump on the table to be cleaned. • Secure the lid back on the bore casing.	
24	Clean Pump	• Decontaminate and rinse the pump being sure to remove any sediment. • Wind the cord and hose back onto the reel and pack away.	
25	Pack up	• Pack up and secure equipment on the vehicle. At the end of the day please conduct the following tasks.	
26	Decontaminate and Rinse	• All equipment should be decontaminated and rinsed at the end of the sampling day. • Use paper towel to dry and remove and dust. • This includes jugs, bottles, buckets, containers etc	

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Step		Detailed instruction	✓
27	Water Quality Meters care and maintenance	• Check which meters need charging and plug in accordingly • The pH and Redox sensors require a storage solution to be placed in their caps upon storage. Store upright.	
28	Refill	• Refill all the consumables in the boxes in preparation for the next sampling round. • This includes bladders, syringes, filters, jerry cans, paper towel and gloves etc.	
29	Sample Storage	• When samples are not being taken to the lab that day they must be placed in the fridge. • If samples are being taken to the lab that day then they must be kept in a esky with frozen ice bricks to keep the samples below 4° C.	
30	Chain of Custody	• Fill in a CoC and deliver this to the lab with the samples.	

9. References

Doc #	Document Name
NTR-ENV-MMP-017	Packing Checklist for Water Sampling Field Work

10. Associated Documents

Doc #	Document Name
NTR-ENV-FRM-010	Packing Checklist for Water Sampling Field Work
NTR-ENV-FRM-007	Groundwater Purging Field Data Sheet
NTR-ENV-FRM-023	Groundwater Sampling Field Guide

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Appendix 6 – Risk Assessment

Environmental Risk Assessment

Releases to Land and Water (Waste Water, Hydrocarbon, Chemicals, Other)	Browns Pit	- No mining excavation planned for the upcoming reporting period. - Extreme rainfall event	- Poor water quality discharged into the East Finniss River - Erosion and sediment control issues impacting surrounding environment. - Spill or leak to the environment with potential to contaminate land resources. - Impact to Threatened Species. - Extreme rainfall event has potential to flood the East Finniss River into the pit.	Minor	Likely	Medium 14	- Safety berm in place between the pit and the East Finniss River. This was successful in keeping the EFR flood waters at bay in the January 2018. - Pit levels monitored with maximum level of 55 AHD. - Daily visual inspections. - Water Management Plan - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m^3)	Minor	Unlikely	Low 5
	Ore Stockpiles	- Existing ore stockpiles with high metal content left insutu.	- Erosion and sedimentation issues impacting surrounding environment. - Spill or leak of low pH water to the environment with potential to contaminate land, surface or groundwater resources.	Minor	Likely	Medium 14	- Stockpile areas bunded to prevent runoff. - Collected water pumped to processing plant for treatment and bund levels kept to minimum. - Emergency spillways to be installed to direct the water to the pit during extreme rain event and prevent discharging to the Sediment Dam. - Standard Operating Procedure for water treatment	Low	Possible	Low 6
	Crushing, agglomeration and conveying	- No production or processing .of ore planned for the reporting period.	- Spill or leak to the environment with potential to contaminate land resources	Low	Likely	Medium 10	n/a - No production or processing .of ore planned for the reporting period.	n/a	n/a	#N/A
	Processing Plant - Water Treatment	- Large holding tanks eg diesel - Propose to construct a Diversion Drain to direct away from the Sediment Dam and to the Pit. - Maintenance of plant and equipment	- Spill or leak to the environment with potential to contaminate land, surface or groundwater resources	Moderate	Possible	Medium 13	- Diversion Drain to be constructed to divert water from the plant to the pit. -Use, store and handle chemicals in accordance with legislation and Australian Standard AS1940 - Hazardous and bulk storage tanks contained within bunded areas. - Regular service and maintenance. - Spill kits and SDS when chemicals being stored or used. - Spill Response Procedure - NTR-ENV-PRO-004	Moderate	Rare	Low 4
	TSF	- Groundwater contamination from existing tailings stored in the unlined TSF - Recovery bores - Groundwater and surface water monitoring.	- Seepage into groundwater for unlined facility. - Low pH water generated from the PAF in the TSF wall. - Inappropriate erosion and sedimentation management impacting surrounding environment	Major	Frequent	Extreme 24	- Install a new recovery bore and 6 new observation bores with data to inform a remediation plan. - Continue recovery of groundwater seepage - Continue to conduct water qualtiy monitoring to inform future management decisions - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m^3) - Capacity to hold a 1 in 100 year rain event (96,000kL) - TSF Operations and Maintenance Manual	Major	Possible	High 17
	Chemical Storage and usage	- Diesel, sulfuric acid, hydrated lime, flocculent, glyphosphate, soda ash. - Waste products awaiting disposal paint, old reagents, waste oils	- Spill or leak to the environment with potential to contaminate land, surface and groundwater resources	Minor	Likely	Medium 14	- Use, store and handle chemicals in accordance with legislation and Australian Standard AS1940 - Hazardous and bulk storage tanks contained within bunded areas. - Ensure sufficient capacity of the bunding and oily water separator for any new oil filled assets being commissioned as part of this project. - Spill kits and SDS when chemicals being stored or used. - Locate chemical storage 50 metres from waterways or drainage lines. - Hazardous Goods and Waste Management Plan. - Spill Response Procedure - NTR-ENV-PRO-004	Minor	Unlikely	Low 5
	Environmental Monitoring	- Water Quality monitoring of Ground and surface waters to an approved schedule. - Dust Monitoring. - Handling of contaminated products.	- Inappropriate disposal with potential to contaminate land resources. - Inappropriate sampling procedures resulting in non-representative samples.	Low	Possible	Low 6	- Dispose of in accordance with *Waste Management and Pollution Control Act* - Hazardous Materials and Waste Management Plan - Water Monitoring Procedure - NTR-ENV-PRO-001 - Water Sampling Work Instruction - NTR-ENV-WIN-001 - Spill Response Procedure - NTR-ENV-PRO-004	Low	Unlikely	Low 3
	Transport Activities	- Transportation of dangerous goods and hazardous materials.	- Spill or leak to the environment with potential to contaminate land resources	Minor	Possible	Medium 9	- Use of licenced transport operators for the transportation of dangerous or hazardous goods. - Spill Response Procedure - NTR-ENV-PRO-004 - Spill response Kits and Emergency Trailer	Minor	Unlikely	Low 5
	Utilities	- The use of diesel run pumps and generators	- Spill or leak to the environment with potential to contaminate land resources	Low	Possible	Low 6	- Regular service and maintenance of equipment. - Standard operating procedures for refuelling. - Employee training and awareness of these procedures. - Spill Response Procedure - NTR-ENV-PRO-004. - Spill Response Kits.	Low	Unlikely	Low 3

	General site activities	- Use of chemicals and fire for weed management	- Inappropriate use of chemicals causing contamination to the land. - Inappropriate erosion and sedimentation management impacting surrounding environment - Spill or leak to the environment with potential to contaminate land resources	Low	Possible	Low 6	- Standard operating procedures. - Employee training and awareness of these procedures. - SDS (Safety Data Sheet) guidelines for storage and handling of chemicals - Spill Response Procedure - NTR-ENV-PRO-004 - Invasive Species Management Plan - Good housekeeping	Low	Unlikely	Low 3
	Water Discharge from Sedimentation Dam	- Water discharge from the main sediment dam - Extreme rainfall event	- Unauthorised discharge to the East Finniss River - Discharge of water exceeding WDL licence trigger values - Poor water quality discharged into the East Finniss River - Impact to threatened species	Moderate	Likely	High 18	- An approved Waste Discharge Licence WDL177-06 - Water Monitoring program (refer to WMP). - Daily monitoing during the wet season. - Standard operating procedures. - Employee training and awareness of these procedures. - Prepare standby storage capabilities (nominated emergency circuit capacity is 7440 m3) - Engineered emergency spillway constructed to protect the dam wall integrity during high rainfall events. - Maintenance programs to protect the integrity of the dam wall. - Construction of a Diversion Drain to direct contact water away from the Sediment Dam to the Pit	Moderate	Rare	Low 4
	Rehab /Closure	- Land rehabilitation of previously disturbed areas - Extreme rainfall event	- Unsuccessful rehabilitation techniques causing erosion and sedimentation issues impacting surrounding environment - Failure of rehabilitation efforts - Erosion removing soil and preventing establishment of vegetation.	Low	Likely	Medium 10	- Investigation into rehabilitation techniques, rehab trials and appropriate ongoing monitoring to measure rehab success. - Control erosion in accordance with IECA Australia Best Practice Erosion and Sediment Control - Biological and Land Management Plan - Annual maintenance to fix any areas of erosion or slumping. - Weed management program	Low	Possible	Low 6
Biological and Land Management **Biosecurity** (Weeds and Pest Animals)	General site activities	- Land disturbance activities - Standing water left unattended in drains - Vehicle Movement	- Direct fauna mortality from clearing activity - Invasion of pest/invasive species - Erosion and sedimentation issues - Fragmentation - Impact to Threatened Species - Increase in biting insect populations - Direct fauna mortality from vehicle collision	Low	Likely	Medium 10	- No clearing permitted without an approved 'Land Disturbance Permit' - Clearing of pre-disturbed area as a first option - Weed infested soil to be disposed of so as not to spread weeds or seeds. - Biological and Land Management Plan - Daily visual inspections of water bodies and drainage - Hazard and incident reporting - Application of control measures were necessary. - Biological and Land Management Plan	Low	Possible	Low 6
	Rehab /Closure	- Weed management of rehabilitated areas.	- Weeds and feral animals destroying / damaging rehabilitation - Introduction of pest species causing a decrease in biodiversity	Minor	Likely	Medium 14	- Weed hygiene and vehicle inspections of earthmoving equipment. - Seed application to consist of local plant species to assist with revegetation resilience. - Site induction for training and awareness - Develop closure criteria - Invasive Species Management Plan	Minor	Unlikely	Low 5
Fire Management	Processing Plant - Water Treatment	- Hot work activities - Fire risk from machinery	- Biodiversity loss - Direct mortality of native vegetation and terrestrial fauna.	Minor	Possible	Medium 9	- Fire suppression systems throughout the plant. - Regular service and maintenance of equipment - Dedicated fire water - Emergency Response Management Plan - Fire Management Plan	Minor	Unlikely	Low 5
	Chemical Storage	- Hot work activities - Incorrect storage of flammable goods	- Biodiversity loss - Direct mortality of native vegetation and terrestrial fauna.	Minor	Possible	Medium 9	- No hot works permitted - Fire suppression systems and spill containment. - Maintain good house keeping. - Site Induction for training and awareness - Maintain containment areas - Spill Response Procedures - Emergency Response Management Plan - Fire Management Plan	Minor	Unlikely	Low 5
	Transport Activities	- Transportation of dangerous goods and hazardous materials.	- Biodiversity loss - Direct mortality of native vegetation and terrestrial fauna.	Minor	Possible	Medium 9	- Only use licenced contractors for the transportation of dangerous goods and hazardous materials. - Emergency Response Management Plan - Fire Management Plan	Minor	Unlikely	Low 5
	Utilities	- Hot work activities - Fire risk from machinery	- Biodiversity loss - Direct mortality of native vegetation and terrestrial fauna.	Minor	Possible	Medium 9	- No hot work activities without a permit - Regular service and maintenance of equipment - Fire suppression systems - Emergency Response Management Plan - Fire Management Plan	Minor	Unlikely	Low 5

Resource Consumption (Surface Water, Groundwater)	Browns Pit	- Limited water demand during care and maintenance - Water treatment to continue on occasion over the dry season	- Depletion in Natural Resources	Minor	Possible	Medium 9	- Water balance will require water to be discharged off site during care and maintenance operations. - Water Management Plan - Waste Balance Report	Minor	Unlikely	Low 5
	Utilities	- Potable water will be sourced from either the pit or sed dam	- Depletion in Natural Resources	Low	Possible	Low 6	- Investigate alternative means to discharging - Regular maintenance of water devices	Low	Unlikely	Low 3
	Water Discharge from Sedimentation Dam	- Water to be used as the source fo process water	- Reduction in water discharge events	Low	Likely	Medium 10	- Maintain an approved WDL - Continue to monitor as per WDL 177-06	Low	Unlikely	Low 3
	Rehab /Closure	- Land rehabilitation of previously disturbed areas	- Unsuccessful rehabilitation techniques causing erosion and sedimentation issues impacting surrounding environment - Failure of rehab - Erosion removing soil and preventing establishment of vegetation.	Low	Likely	Medium 10	- Investigation into rehabilitation techniques, rehab trials and appropriate ongoing monitoring to measure rehab success. - Use local plant species that are resilient to local climatic conditions - Biological and Land Plan	Low	Possible	Low 6
Resource Consumption Fuel Use	Utilities	- Increase in energy consumption as the plant moves from care and maintenance into a operations.	- Depletion of natural resources -Increased contribution to Global warming	Minor	Likely	Medium 14	- Regular service and maintenance of plant and equipment	Minor	Unlikely	Low 5
Waste Management	Processing Plant - Water Treatment	- Maintenance of plant and equipment generating waste oils and other listed wastes	- Incorrect disposal of hazardous waste resulting in contamination of land, surface or groundwater resources.	Low	Likely	Medium 10	- If oil filled assets are to be removed off site they must be drained of oil (listed waste) and then removed off site. - Comply with the *WMPC Act* - Removal by a licenced contractor - Hazardous Materials and Waste Management Plan	Low	Unlikely	Low 3
	Utilities	- Maintenance of plant and equipment generating waste oils and other listed wastes	- Incorrect disposal of hazardous waste resulting in contamination of land, surface or groundwater resources.	Low	Likely	Medium 10	- If oil filled assets are to be removed off site they must be drained of oil (listed waste) and then removed off site. - Comply with the *WMPC Act* - Removal by a licenced contractor - Hazardous Materials and Waste Management Plan	Low	Unlikely	Low 3
	General site activities	- Day to day operations	- Incorrect disposal of waste resulting in contamination of land, surface waters or groundwater resources.	Low	Likely	Medium 10	- Removal by a licenced contractor - Comply with the requirements of the *WMPC Act* - Recycle waste materials where appropriate. - Remove from the site and dispose of at a licenced facility. - Implement measures to reduce, re-use and recycle waste products/materials - Correct segregation and collection of recyclables. - Hazardous Materials and Waste Management Plan	Low	Unlikely	Low 3
Project Approvals	Future Mining of Browns Pit	EPBC Referral expired	- Non-compliance under the EBPC Act	Minor	Possible	Medium 9	- Discussion with the Department of Environment. - DoE have advised that if NTR is to consider recommence mining then a Referral must be submitted to the DoE for their consideration to ascertain if it is considered to be a controlled action. - Should NTR plan to resume operations discussions are to be had with the NT EPA to acertain if formal assessment may be required	Minor	Unlikely	Low 5
	Water Discharge from Sedimentation Dam	Non-compliance with WDL	- Non-compliance - Unauthorised Discharge to the East Finniss River - Surface water contamination	Minor	Likely	Medium 14	- A valid Waste Discharge Licence WDL177-06 - Water Monitoring program as per licence conditions - Standard operating procedures. - Employee training and awareness of these procedures. - Regular contact with the NT EPA.	Minor	Unlikely	Low 5