2019-2020 Annual Groundwater Monitoring Report

Dunmore Quarry

Prepared for Boral Resources (NSW) Pty Ltd
August 2020

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2019-2020 Annual Groundwater Monitoring Report

Dunmore Quarry

Report Number

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Client

Boral Resources (NSW) Pty Ltd

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31 August 2020

Approved by

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31 August 2020

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1 Introduction

Dunmore Hard Rock Quarry (the quarry) is located at the end of Tabbita Road, in the Shellharbour local government area (LGA). The quarry is owned and operated by Boral Resources (NSW) Pty Ltd (Boral).

The quarry supplies construction materials to markets in the Illawarra, Southern Highlands and Sydney regions.

Hard rock extraction from the Bumbo Latite of the Shoalhaven Group commenced at the quarry in the early 20th century. The quarry comprises one elongated open cut pit with an approved disturbance area of about 100 hectares (ha) (Figure 1.1). Site infrastructure includes a crushing and screening plant, product stockpiles, workshop and site offices located east of the pit.

Boral received approvals for a pit modification to extend the quarry to the west to enable the continued delivery of aggregate until approximately 2034, with the additional area referred to as the Croome West pit (Figure 1.1). Staged extraction began in the 2017−2018 monitoring year with the construction of acoustic and visual bunding. During the 2018−2019 monitoring year extraction continued in the Croome West pit moving slowly north, with overburden placement in the northern section of the formerly mined Croome pit. Throughout the 2019−2020 monitoring year, extraction has continued in the Croome West pit towards the west. The final pit will be extended both laterally and vertically with a maximum proposed pit depth of 60 metres (m) Australian Height Datum (AHD).

Water management at the quarry comprises routine surface water and groundwater monitoring and the capture of intercepted surface runoff. Captured runoff is directed into dedicated water management dams for treatment and storage. Stored water is utilised for site operations (dust suppression). Excess water within the excavated quarry pits is pumped to the Middle Dam, which has a holding capacity of 120 to 150 megalitres (ML) (EMM 2020).

EMM Consulting Pty Limited (EMM) was engaged by Boral to characterise the hydrogeological environment and conduct groundwater monitoring and interpretation in relation to the Croome West extension.

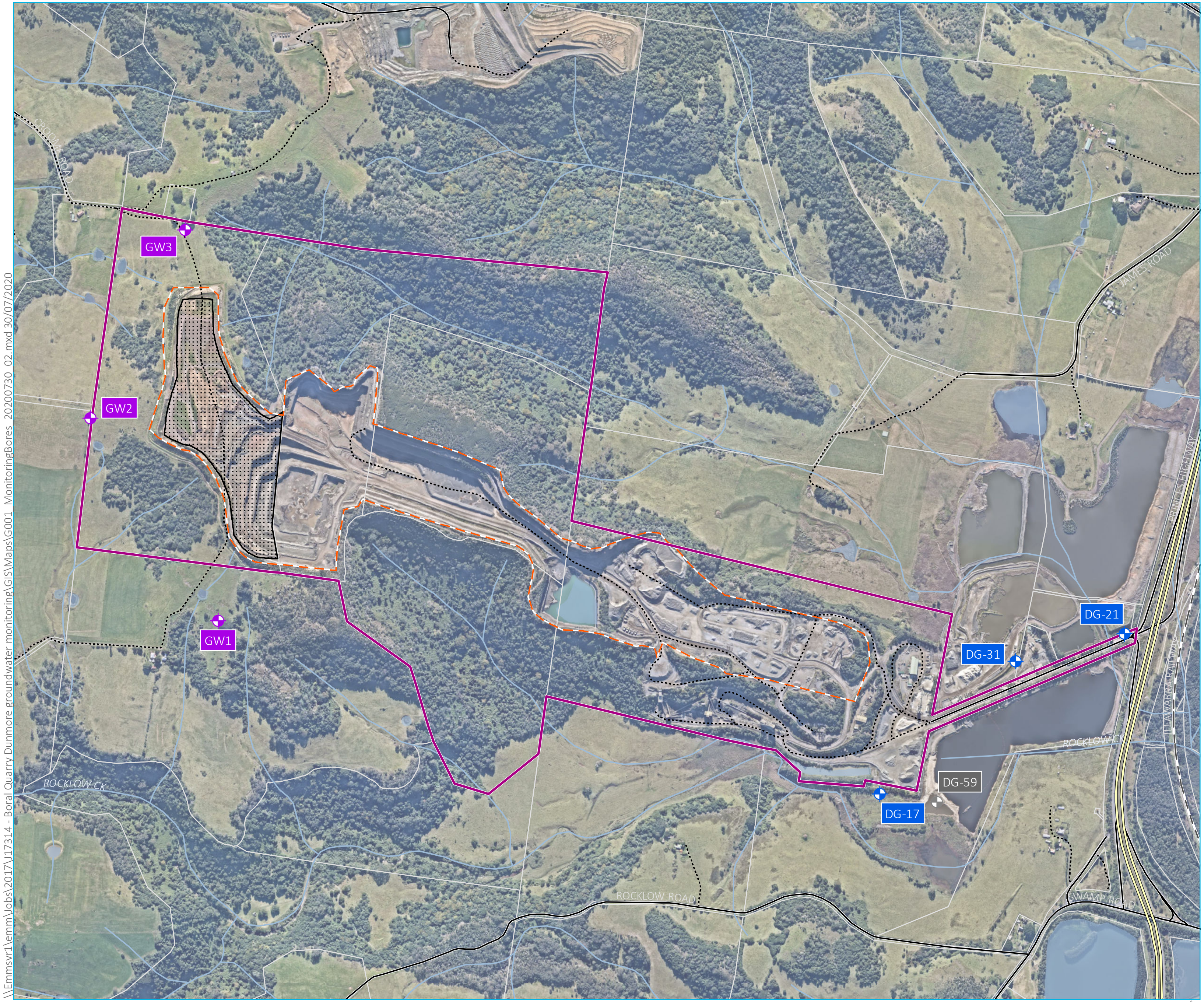
1.1 Scope of works

This annual groundwater monitoring report has been prepared as a requirement of the groundwater monitoring program (GMP) (EMM 2016) in compliance with condition 44 (c) of the quarry's current approval (DA 470-11-2003). The monitoring program includes analysis and interpretation of groundwater quality and groundwater level data collected from the groundwater monitoring network consisting of three bores screened up gradient in the Bumbo Latite and three down gradient in the alluvium, with emphasis on the data obtained during the 12 months from 1 July 2019 to 30 June 2020 (the monitoring year).

The scope of works as defined in the GMP was to:

- conduct groundwater monitoring, including six-hourly groundwater level measurements and six-monthly groundwater sampling events at the Bumbo Latite monitoring bores located up hydraulic gradient from the quarry (Figure 1.1);
- analyse and interpret water level and water quality data obtained from the Bumbo Latite monitoring bores with reference to the conceptual model where relevant; and
- analyse and interpret water level and water quality data obtained from the Dunmore Sand & Soil (DSS) quarry monitoring bores located in the alluvium down hydraulic gradient from the quarry (Figure 1.1, data collected by Environmental Earth Sciences).

This report also includes a review of the current monitoring network design and provides recommendations for ongoing monitoring.



KEY

- Dunmore Quarry site boundary
- Approved extraction area
- Croome West pit extension
- Rail line
- Main road
- Local road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary
- Croome West monitoring bore

Dunmore Sand and Soil monitoring bores

- Active
- Decomissioned

Site location and monitoring bores

Boral Dunmore Quarry
Annual groundwater monitoring report
Figure 1.1

EMM
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Source: EMM (2020); Nearmap (2020); DFSI (2017); GA (2011); ASGC (2006)

0 250 500 m
GDA 1994 MGA Zone 56
N

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2 Environmental setting

2.1 Site setting and topography

The regional topography rises from coastal flats in the east to a ridge which then descends to a shallow and broad valley at the foot of a larger rise to the Southern Highlands region of the Great Dividing Range in the west.

The quarry is set on a north south-west trending range. The peak is named Locking Hill and is partially incised by the existing pit. The ridge extends along the current western quarry highwall and has an elevation of approximately 164 mAHD. The elevation of the south-east processing area is 10 mAHD.

The project area is surrounded by small agricultural plots, with cattle and horse grazing, and rural residential properties. Historically the area has been used for dairy farming. Remnant native vegetation lines the top of the prominent ridge line and exists in isolated pockets in the lower lying areas.

The DSS quarry and the Dunmore Concrete Batching Plant (CBP) are generally east of the quarry. Quaternary alluvium sediments associated with the Minnamurra River system are extracted and processed at the DSS quarry.

Approximately 1.5 kilometres (km) to the north is the Cleary Bros Bombo Pty Ltd (Cleary Bros) Albion Park Quarry. The Cleary Bros quarry is approved to produce 900,000 tonnes per annum (tpa) and has extracted and processed hard rock from the Bumbo Latite since the 1950s (MMJ 2013). Holcim Australia Pty Ltd (Holcim) operates the Readymix Albion Park Quarry immediately west of the Cleary Bros Albion Park Quarry. This quarry also extracts a hard rock resource from the Bumbo Latite.

2.2 Climate

The project area is part of the Illawarra region, which is characterised by a mild/temperate climate described as warm and humid. Rainfall and climate data were obtained from the Bureau of Meteorology, Albion Park weather station (BoM 068241), which is approximately 10 km north of the quarry. Temperature and rainfall data have been collected at this monitoring station since 1999.

Temperature fluctuates throughout the year. January is the warmest month and July the coldest month. The mean, maximum, and minimum temperatures are shown in Table 2.1. The average annual rainfall is 914 millimetres (mm) (BoM 068241) with the most significant rainfall events generally experienced in late summer (February and March) and the lowest rainfall in late winter (July-September).

No site-specific evaporation data is available for the quarry. Mean daily evaporation for the BoM Goulburn Tafe station (070263) and the BoM Sydney Observatory station (066062) is presented in Table 2.2. This shows that throughout most of the year regional evaporation exceeds rainfall, except in June and July.

Table 2.1 Temperature and rainfall statistics

	Temperature (^{o}C)			Rainfall (mm)		
	Min	**Mean**	**Max**	**Min**	**Mean**	**Max**
January	25.1	27.1	29.8	2.6	74.3	178.4
February	24.3	26.4	28	9.8	145.5	356
March	23.6	25.3	26.5	4.2	120.7	422.2
April	21.5	23.3	25.2	8	71.5	261.2
May	19.4	20.7	22.4	4.8	53.1	398.6
June	16.6	18.1	19.6	0	90.6	340.4
July	16.6	17.8	19.3	1.4	47.6	185.6
August	17	18.8	20.8	1.2	52.7	281.8
September	19.8	21.3	23.4	0	42.7	112
October	20.7	23.1	25	0.2	65.7	218.8
November	22.3	24.1	26.4	9.6	80.2	222
December	22.3	25.7	28.1	1.6	63	171.8

Source: Data from BoM station 068241 (Albion Park – Shellharbour Airport)

Table 2.2 Regional evaporation statistics

	Goulburn Tafe (070263)		Sydney Observatory (066062)	
	Mean daily evaporation (mm)	**Mean monthly evaporation (mm)**	**Mean daily evaporation (mm)**	**Mean monthly evaporation (mm)**
January	6.3	195.3	4.6	142.6
February	5.2	145.6	3.9	109.2
March	3.9	120.9	3.1	96.1
April	2.5	75	2.6	78
May	1.6	49.6	1.9	58.9
June	1.1	33	1.2	36
July	1.2	37.2	1.5	46.5
August	1.9	58.9	1.9	58.9
September	2.8	84	2.5	75
October	3.9	120.9	3.3	102.3
November	5	150	4.3	129
December	6.1	189.1	4.4	136.4

The cumulative deviation of monthly rainfall from the mean (CDFM) (from 1999 to mid-2020, Albion Park) is plotted in Figure 2.1. The long-term CDFM is generated by subtracting the long-term average monthly rainfall for the recorded period from the actual monthly rainfall and then accumulating these residuals over the assessment period. Periods of below average rainfall are represented as downward trending slopes while periods of above average rainfall are represented as upward trending slopes.

The cumulative deviation plot for Albion Park shows a period of predominantly below average or average rainfall from 1999 until 2010, followed by some years of above average rainfall. From the start of 2017 rainfall was generally below average, with the notable exception of February 2020.

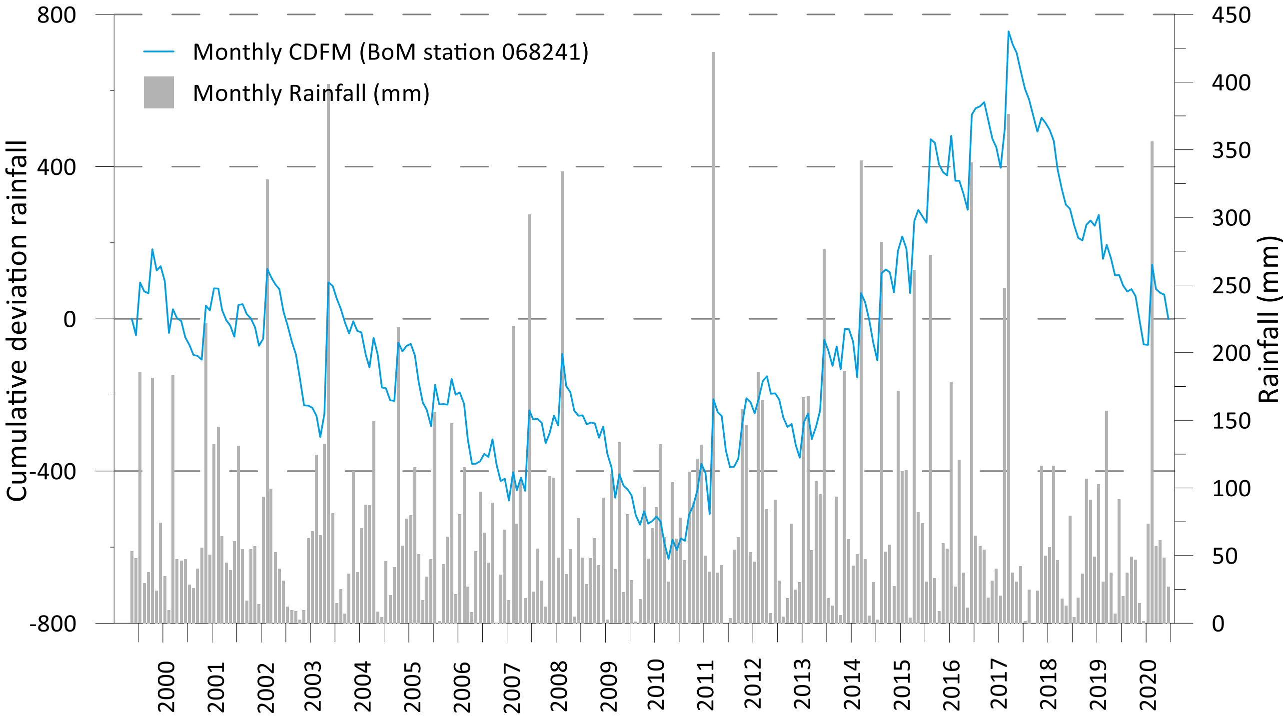


Figure 2.1 Cumulative deviation from long term monthly mean rainfall

Over the 2019-2020 monitoring year, rainfall was below the average recorded from 1999 to 2020, with 792.8 mm of rain recorded, compared to the annual average of 908 mm. Rainfall totals for most months over the monitoring year are comparable to the long-term monthly averages, with notable exceptions being November and December 2019, which recorded significantly below-average rainfall, and February 2020 which recorded significantly above-average rainfall (Figure 2.2).

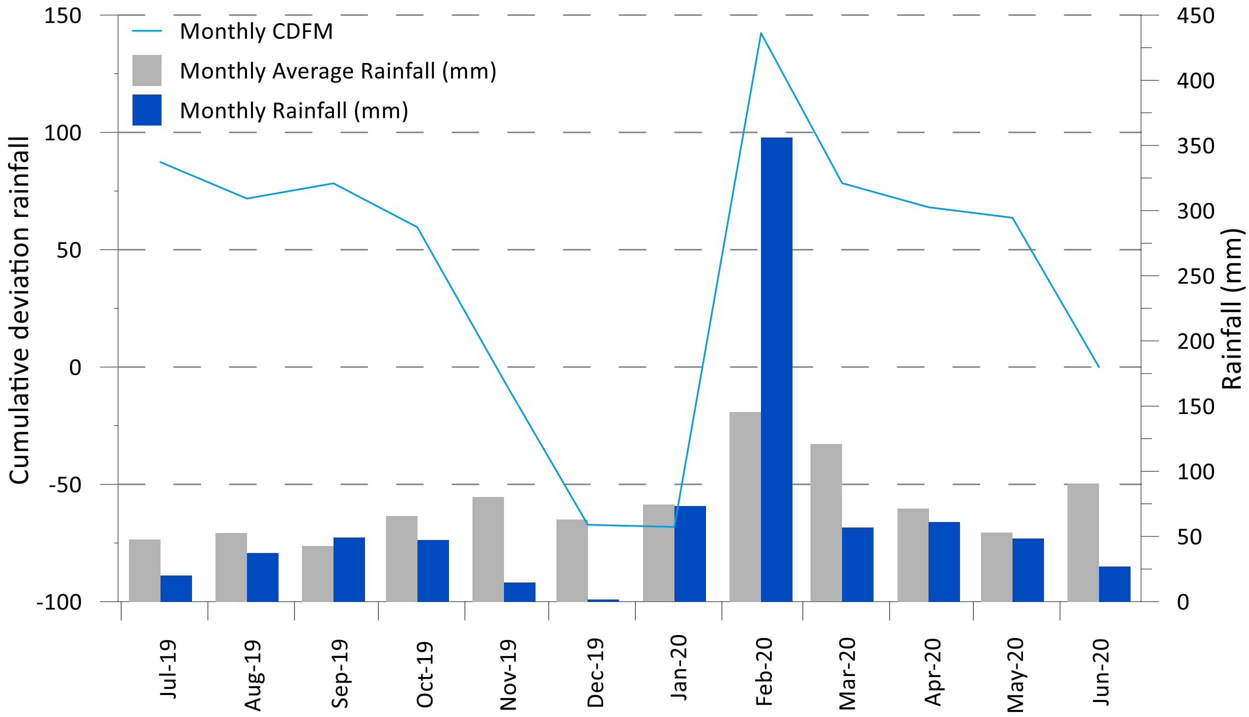


Figure 2.2 Monthly rainfall for June 2019 to June 2020 compared to average

2.3 Surface water

The quarry is in the Rocklow Creek catchment area, which forms part of the Minnamurra River Catchment. The Minnamurra River discharges into the Pacific Ocean approximately 8 km south-east of the project area.

Rocklow creek is south of the quarry, flowing to the east and draining to the Minnamurra River. The Rocklow Creek catchment (21 km^2) originates in the Illawarra Range, 3 km west of the project area (Arcadis 2016). All clean water runoff from the project area flows into Rocklow Creek. Boral have a current surface water extraction licence (WAL 25152 under Section 12 of the *Water Act*) to extract 227 ML of surface water from Rocklow Creek.

To the north of the project area is the Frasers Creek catchment area which drains to Lake Illawarra. Frasers Creek is an ephemeral system and forms disconnected pools during dry periods.

2.4 Geology

The project area is situated in the south-eastern corner of the Permo-Triassic Sydney Basin. The Sydney Basin predominantly comprises Permian and Triassic aged sedimentary rocks. In the vicinity of the quarry the Triassic and Late Permian sedimentary rocks have been eroded and the early Permian Gerringong Volcanics of the Shoalhaven Group dominate (*Geology of the Wollongong, Kiama and Robertson 1:50,000 Sheet,* Department of Mines 1974).

Volcanic activity in the area has produced a series of flat lying lava flows interspersed with volcaniclastic sandstone members and breccias. The thickness of each successive flow decreases with distance from the volcanic origin, assumed to be off the current coastline to the south (Cohen 2006). At the quarry all geological units exhibit a gentle dip in an easterly direction at approximately 2 to 3° (Evans and Peck 2006; MMJ 2013).

The Gerringong Volcanics facies comprise nine latite members, and three volcanic sandstones or tuff members. Latite is a term used to describe the type of basalts along the south coast of NSW, they are also referred to as trachybasalts (Cohen 2006). The Gerringong Volcanics were deposited in a shallow marine environment, which was then uplifted above sea level. The area has since been eroded via river action to form the present landscape (Cohen 2006). Geological outcrop for the project area is shown in Figure 2.3.

The Bumbo Latite is the areas greatest and most persistent lava flow and is the predominant geological unit at the quarry. The latite has a maximum thickness of 150 m. The Bumbo Latite Member is divided into three flows: upper, middle, and lower. The Bumbo Latite is a grey to dark grey, very hard dense rock with light coloured phenocrysts of feldspar (Cohen 2006). Weathered latite is generally softer with a brownish, yellow colour. The latite can be jointed and fractured, with the dominant jointing close to vertical, however jointing is not widespread (MMJ 2013).

A breccia layer was deposited between the middle and lower Bumbo Latite Member flows. This breccia layer, also comprising volcanic material, ranges in thickness between 5 to 22 m (Cohen 2006). It comprises a softer layer of fragmental, angular materials cemented in a fine grained matrix (Department of Mines 1974).

The Bumbo Latite Member overlies the Kiama Sandstone Member at the quarry, although to the west of the quarry the Kiama Sandstone outcrops. The Kiama Sandstone has a maximum thickness of 90 m (Evans and Peck 2006). The Kiama Sandstone Member comprises tuff, and interbedded volcanic and lithic sandstones and shales. The sandstones are typically moderately sorted and the lithic material comprises mainly andesitic to basaltic material (Department of Mines 1974). This sandstone is easily weathered and therefore not extracted for quarrying activities.

Further east is Quaternary Alluvium associated with the floodplain areas of the Minnamurra River and its tributaries. This alluvium comprises unconsolidated to loosely consolidated gravels, sands, silts and clays.

2.5 Hydrogeology

2.5.1 Overview

The regional groundwater system, within the Kiama Sandstone aquifer, flows south-east, governed by the dip of the strata and topography (Cohen 2006). Recharge to the Kiama Sandstone is via infiltration at outcrop and from overlying sedimentary units to the west of the project area. Regional groundwater in the Kiama Sandstone discharges to the Pacific Ocean (Cohen 2006).

Local groundwater flow systems (horizontal scale of less than 5 km) are present within the Bumbo Latite along the elevated ridgeline (Walker *et al* 2003). These systems are isolated and have limited connection to the regional flow system. The Bumbo Latite is tight with a low primary and low secondary porosity (Cohen 2006) restricting groundwater flow. Groundwater flow is minimal and predominantly occurs along fractures and contacts between volcanic rock and the underlying sandstone (MMJ 2013).

Information from Boral suggests that the breccia layer is partially saturated and more permeable than the surrounding Bumbo Latite. Breccia generally exhibits a variable porosity with areas of higher permeability common however they are generally limited in their extent. There is no visual evidence of groundwater seepages to the pit with the rockface remaining dry throughout the year. Cohen (2006) reports that there is no active mine dewatering at the two Albion Park quarries which also intersect the Bumbo Latite. Water use at these quarries constitutes only collected rainwater runoff.

The local groundwater systems are recharged by rainfall with infiltration higher in areas where the Bumbo Latite outcrops on the ridgelines and hilltops of the landscape (ie areas with limited soil profile). Cohen (2006) identified the Locking Hill peak, within the project area, as a recharge area for the Bumbo Latite. Discharge from the local groundwater system occurs in the valleys and includes ephemeral springs.

The Quaternary alluvial sediments associated with the surface water courses form unconfined groundwater systems of varying storage. These systems are recharged by leakage from surface water courses during wet periods. The alluvial systems are depleted during dry periods and are not recharged by underlying porous and fractured rocks (Cohen 2006).

2.5.2 Conceptual hydrogeological model

i Groundwater flow

Groundwater within the Bumbo Latite flows from areas of high relief towards the valleys and low lying plains where it discharges to the alluvium and surface watercourses. The bulk rock mass has a low primary permeability with groundwater flow primarily through fractures and along the contacts between the latite flows and breccia.

In the vicinity of the quarry, groundwater flow is generally towards the south-east discharging to Rocklow Creek and the Minnamurra estuary system. To the north of the quarry the landscape gives way to steep valleys that shed surface water and provide limited potential for groundwater recharge.

The deep groundwater systems within the Kiama Sandstone typically flow sub-horizontally towards the east and are coincident with the dip of the strata.

ii Recharge and discharge

The regional groundwater system is recharged by rainfall and losses from surface watercourses. The steep relief increases runoff with a smaller percentage of rainfall infiltration in this steeper terrain.

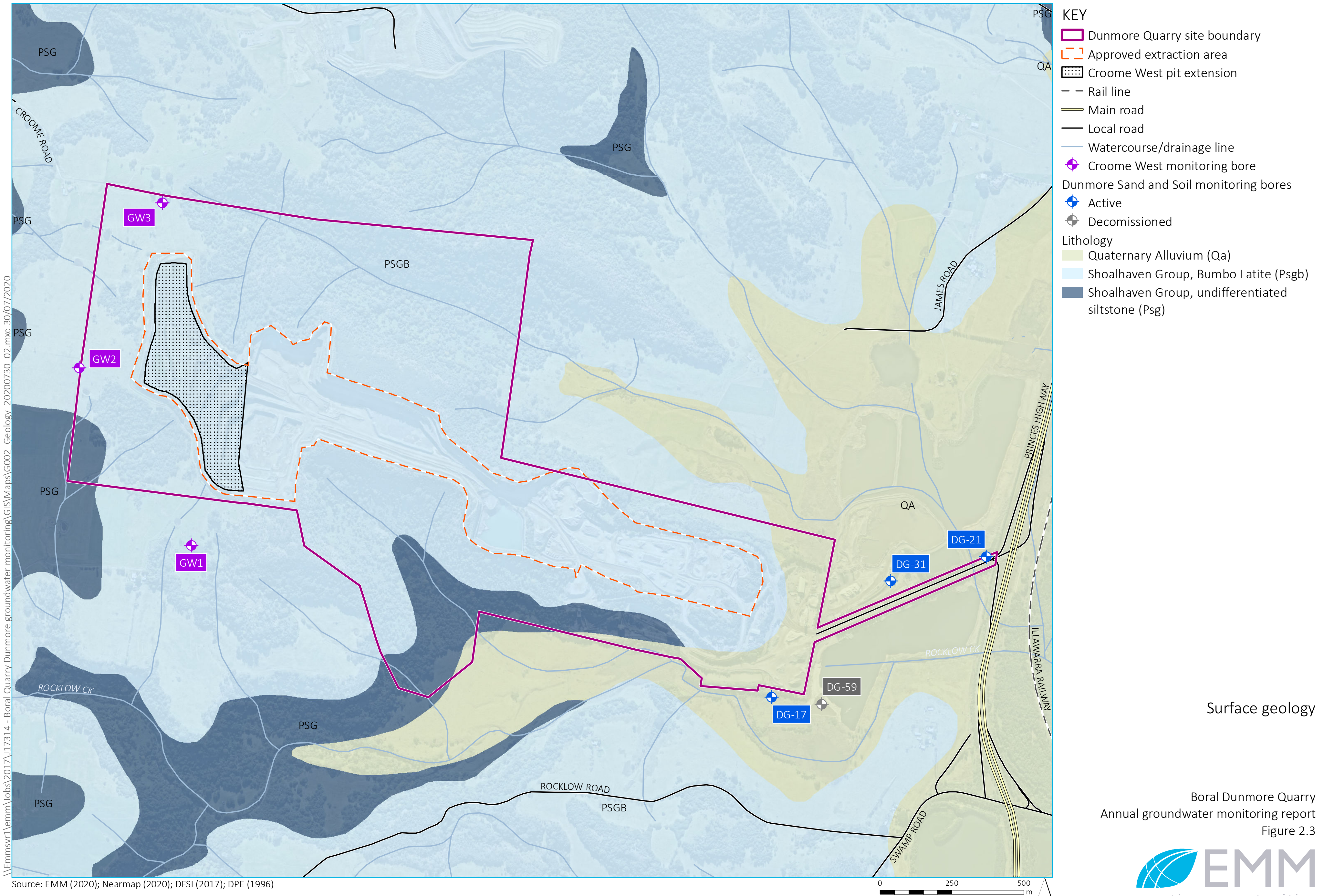
Groundwater from the shallow latite is largely thought to discharge to the Minumurra River and Rocklow Creek, which form the main drainage systems in the vicinity of the quarry.

iii Groundwater-surface water connectivity

The surface water courses in the elevated parts of the landscape are ephemeral in nature with the upper reaches drying out during periods of low rainfall. This ephemeral nature indicates that the surface water courses are hydraulically disconnected from the underlying fractured rock groundwater systems.

The surface water systems to the east of the quarry in the lower parts of the landscape (Illawarra River, Minnamurra River and Rocklow Creek) are connected to shallow, marginal groundwater systems within surficial alluvial systems. Direct rainfall and surface runoff recharges these shallow systems during wet periods which rapidly deplete during the drier periods providing an important source of baseflow for the surface watercourses.

Although groundwater within the shallow latite flows through to the alluvium in the east, the volume of this flux is likely to be insignificant in comparison to the recharge from the overlying rivers.



Source: EMM (2020); Nearmap (2020); DFSI (2017); DPE (1996)

Surface geology

Boral Dunmore Quarry
Annual groundwater monitoring report
Figure 2.3

EMM creating opportunities

3 Groundwater monitoring program

3.1 Monitoring network design

The monitoring network designed in accordance with the GMP consists of a total of six monitoring bores (Figure 1.1 and Table 3.1). In summary:

- three deep monitoring bores (GW1, GW2 and GW3) were completed within the Bumbo Latite in July 2014. GW1 is screened across the latite and the top of the underlying sandstone, GW2 is screened across the latite, and GW3 is screened across the latite and the breccia. These bores are located up hydraulic gradient from current quarrying activities; and

- DSS installed and monitored several bores as part of their operations. Of these, three shallow monitoring bores (DG-17, DG-31 and DG-21), screened in the alluvium and located down hydraulic gradient from current quarrying activities were selected to be part of the monitoring network. The following changes to the shallow monitoring network have occurred during the monitoring year:

  - DG-59 was included in the 2018/2019 monitoring report. DG-59 was demolished in August 2019 due to further expansion of the DSS dredge pond. DG-21 has been added to the network and will be monitored and assess as a replacement to DG-59.

Table 3.1 provides an overview of the completion details for the monitoring network.

Table 3.1 Groundwater monitoring bore construction details

Monitoring bore	Total depth (mbgl)	Ground level (mAHD)	Total depth (mAHD)	Screened interval (mbgl)	Screened interval (mAHD)	Lithology	Formation	Duration of monitoring
GW1	78.0	131.44	53.44	72.0–78.0	59.44–53.44	Latite/ sandstone	Bumbo Latite and Kiama Sandstone	July 2014 - present
GW2	86.0	135.69	49.69	79.0–85.0	56.69–48.69	Latite	Bumbo Latite	July 2014 - present
GW3	80.0	147.25	67.25	68.0–80.0	79.25–67.25	Latite/ breccia	Bumbo Latite and Breccia	July 2014 - present
DG-17	6.0	3.49	-2.51	2.8–6.0	0.69--2.51	Sand	Alluvium	November 2018 - present
DG-31	5.5	3.05	-2.45	2.5–5.5	0.55--2.45	Sand	Alluvium	May 2016 - present
DG-59 (decommissioned)	8.69	1.763	-6.927	tbc	tbc	Sand	Alluvium	February 2017 - August 2019
DG-21	5.0	2.12	-2.88	2.0–5.0	0.12--2.88	Sand	Alluvium	November 2018 - present

Notes: mbgl = metres below ground level
mAHD = metre Australian Height Datum
tbc = to be confirmed by Boral

3.2 Groundwater quality

In accordance with the GMP, groundwater quality sampling was undertaken as detailed in Table 3.2.

Table 3.2 Water quality monitoring program

Monitoring bores	Monitoring events (during the 2019/20 monitoring year)	Monitored by
GW1, GW2, GW3	December 2019 and June 2020	EMM
DG-17, DG-31, DG-21	August and November 2019, February and May 2020	Environmental Earth Sciences (EES)

3.2.1 Sampling technique

Due to the low permeability of the Bumbo Latite, a low-flow sampling technique (stainless steel double-check bailer) was used to obtain groundwater quality samples from the Croome West monitoring bores. A submersible pump or a bailer was used to obtain groundwater quality samples from the higher permeability shallow alluvial monitoring bores.

Physicochemical parameters (pH, EC, temperature, total dissolved solids (TDS), dissolved oxygen (DO) and oxidation reduction potential (ORP)) were measured during and following purging using a calibrated hand-held water quality meter.

3.2.2 Chemical analysis

Water quality samples collected from the monitoring network were analysed for a broad chemical suite designed specifically to assess the chemical characteristics of the different water bearing zones at the monitoring sites. Table 3.3 details the analytical suite.

Table 3.3 Water quality suite of analysis

Grouping	Parameters	
Physicochemical parameters (field)	EC	Temperature
	pH	TDS
	DO	ORP
Major ions	Calcium[1] Magnesium Sodium Potassium	Chloride Total alkalinity Sulphate Silica[1]
Dissolved metals	Aluminium[1] Arsenic[1] Cadmium[1] Chromium[1] Copper[1]	Iron Manganese[1] Nickel[1] Zinc[1]
Nutrients	Ammonia	Total nitrogen
	Nitrate	Total phosphorus
	Nitrite	

Note: 1. Not analysed in the shallow monitoring bores (DG-17, DG-31 and DG-21).

The samples collected from the Bumbo Latite bores by EMM were analysed by Australian Laboratory Services (ALS) in Smithfield. The samples collected from the alluvial bores by Environmental Earth Sciences (EES) were analysed by Sydney Analytical Laboratories in Seven Hills. All laboratories used for analysis are NATA accredited.

Water samples for laboratory analysis were collected in sample bottles specified by the laboratory, with appropriate preservation where required. Samples undergoing dissolved metal analysis were filtered through 0.45 µm filters in the field prior to collection.

3.2.3 Quality assurance and quality control (QA/QC)

Field sampling procedures at the Croome West monitoring locations conformed to EMM's QA/QC protocols to prevent cross-contamination and preserve sample integrity. The following QA/QC procedures were applied:

- samples were collected in clearly labelled bottles with appropriate preservation solutions;
- samples were delivered to the laboratories within the specified holding times; and
- unstable parameters were analysed in the field (physiochemical parameters).

i Laboratory QA/QC

The laboratories conduct their own internal QA/QC program to assess the repeatability of the analytical procedures and instrument accuracy. These programs include analysis of laboratory sample duplicates, spike samples, certified reference standards, surrogate standards/spikes and laboratory blanks. In addition, a duplicate sample is collected in the field for every ten samples collected to assess sampling and laboratory analysis accuracy. A duplicate sample was collected during the December 2019 and June 2020 sampling rounds. The duplicate sample results were within acceptable range.

3.3 Groundwater levels

Following completion of the Croome West monitoring bores in July 2014, Solinst™ pressure transducers (dataloggers) were installed in the water column and programmed to record a groundwater level every six hours. To verify the level recorded by the dataloggers, manual measurements were recorded during each six-monthly monitoring event (December 2019 and June 2020) using an electronic dip meter.

Dataloggers were installed by EES in monitoring bore DG-31 in May 2016, in DG-21 in December 2018 and in DG-17 in May 2019. These dataloggers were programmed to record a groundwater level every hour. Manual measurements have been recorded periodically since installation.

4 Groundwater levels and spatial trends

Hydrographs showing groundwater levels and rainfall from the start of monitoring until June 2020 are presented in Figure 4.1 and Figure 4.2 . Individual hydrographs for each monitoring bore are included in Appendix A.

4.1 Alluvium

Groundwater levels in the alluvium (DG-17, DG-31 and DG-21) are shallow, with observed levels generally less than 3 metres below ground level (mbgl), and show a direct response to rainfall and minor tidal influence (EES 2017) (Figure 4.1).

During the monitoring year, alluvial bores continued to show direct responses to rainfall, which is expected. An increase in groundwater levels in the alluvial system in February 2020 reflects the observed above-average rainfall conditions, with levels otherwise in decline during the drier months.

Groundwater level data for the alluvial bores was supplied to EMM by Boral.

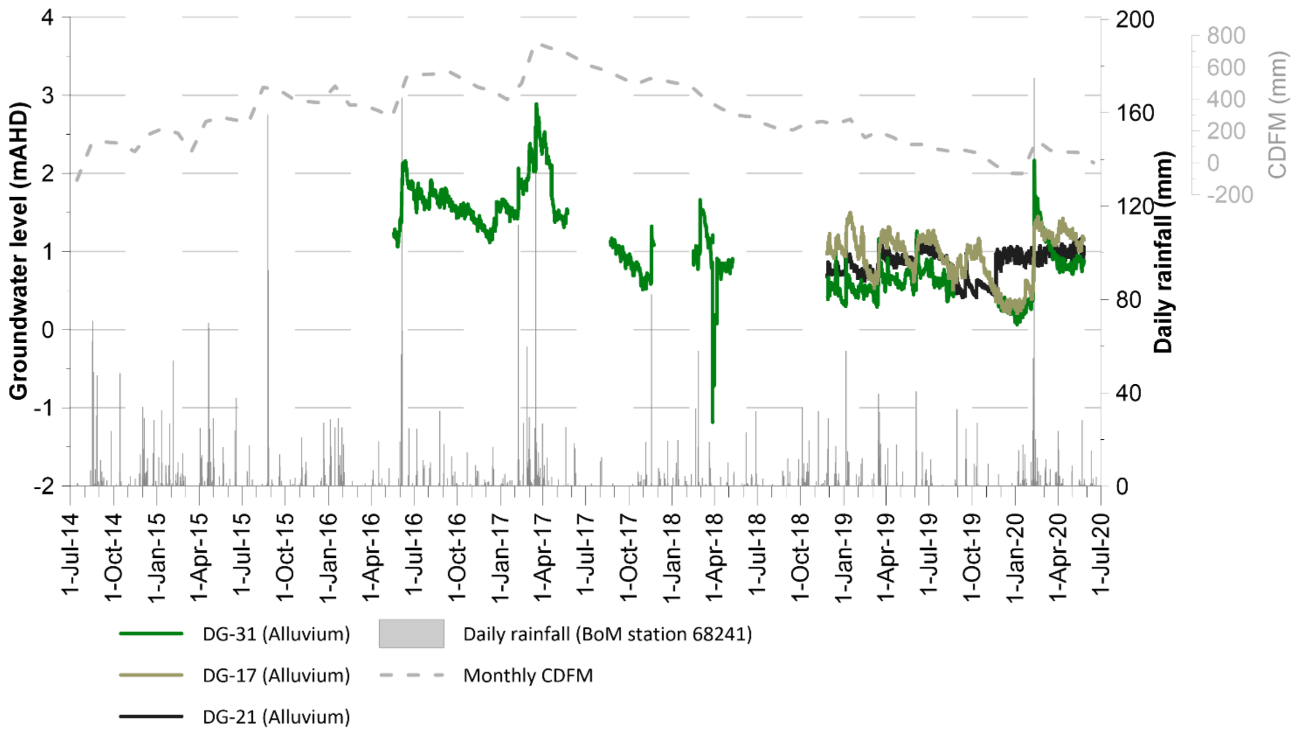


Figure 4.1 Groundwater levels in the alluvium

4.2 Bumbo Latite

Groundwater levels in the Bumbo Latite monitoring bores vary spatially between the three monitoring bores (Figure 4.2). The groundwater level elevation is highest at monitoring bore GW2 (128 mAHD) and lower at monitoring bores GW1 (generally between 100 mAHD and 110 mAHD) and GW3 (105 mAHD). This suggests that there is a potential downward hydraulic gradient from the Bumbo Latite to the underlying Kiama Sandstone.

The groundwater levels at GW1 (partially screened in the Bumbo Latite and the underlying Kiama Sandstone) and GW2 (screened entirely in the Bumbo Latite) show a slow recovery (longer than 1 year) after installation. This slow recovery is due to the very low permeability of the Bumbo Latite formation at these locations (between 1.93×10^{-8} metres per day (m/d) and 6.39×10^{-8} m/d (EMM 2014)).

The groundwater level at monitoring bore GW3 (partially screened in the Breccia) recovered immediately after installation. This is consistent with the slightly higher hydraulic conductivity measured at this location (8.93×10^{-7} m/d (EMM 2014)) and information from Boral which suggests that the Breccia is more permeable than the surrounding Bumbo Latite (Section 2.5).

GW1 has historically shown a clear response to rainfall during periods of above and below average rainfall. Comparatively, GW2 and GW3 show little to no response to rainfall. Although GW1 is deeper, it is screened within the Kiama Sandstone and responds to regional groundwater flows.

Logger data was unavailable at GW3 for the monitoring year due to logger malfunction, however manual dips show groundwater levels are similar to previous monitoring years (refer to Appendix A). The logger was replaced during the June 2020 monitoring event.

GW1 shows a clear response to the wet conditions in early 2020 as regional groundwater sources recharged. No response to rainfall was observed at GW2.

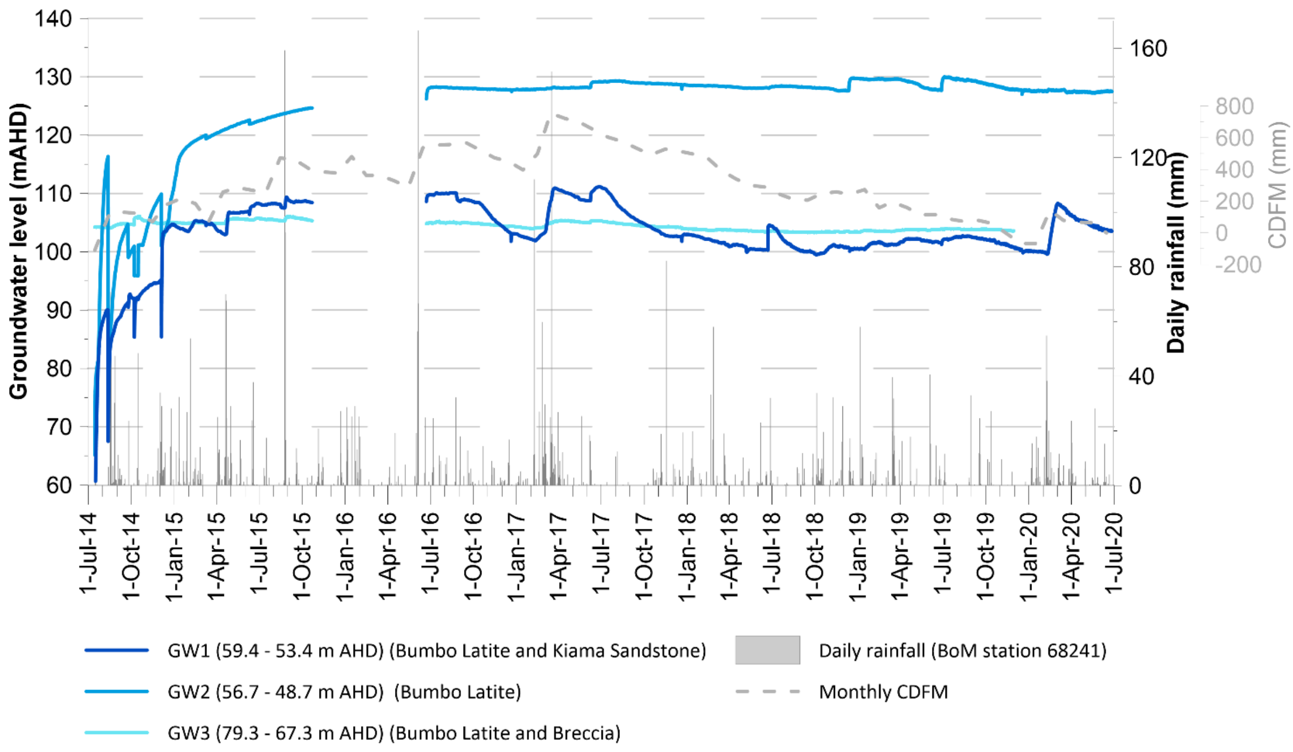


Figure 4.2 Groundwater levels in the Bumbo Latite

4.3 Summary

Croome West pit operations (which began in January 2018) have had no observable effect on groundwater levels in the Bumbo Latite or the Kiama Sandstone Formation underlying the site.

5 Groundwater quality

Water quality results for the 2019/2020 monitoring year are summarised in this chapter and are compared to previous monitoring years. The 2019/2020 monitoring year full water quality results for the Croome West sites are presented in Appendix B and laboratory results in Appendix C.

5.1 Field parameters

Time series of field EC and pH are presented in Figure 5.1 and Figure 5.2.

Groundwater sampled from the alluvium is brackish, with a neutral to slightly acidic pH. EC at DG-31 appears to be variable and potentially dependent on rainfall, showing a freshening following significant rainfall in February 2020.

Groundwater sampled from the Bumbo Latite monitoring bores is similar to previous years: marginal (GW3) to brackish (GW1 and GW2) with neutral to slightly alkaline pH. EC at GW1 appears to have freshened over this monitoring year compared to the 2018−2019 monitoring year, but remains within the observed range.

Groundwater EC and pH at the Croome West sites were overall comparable to previous monitoring years.

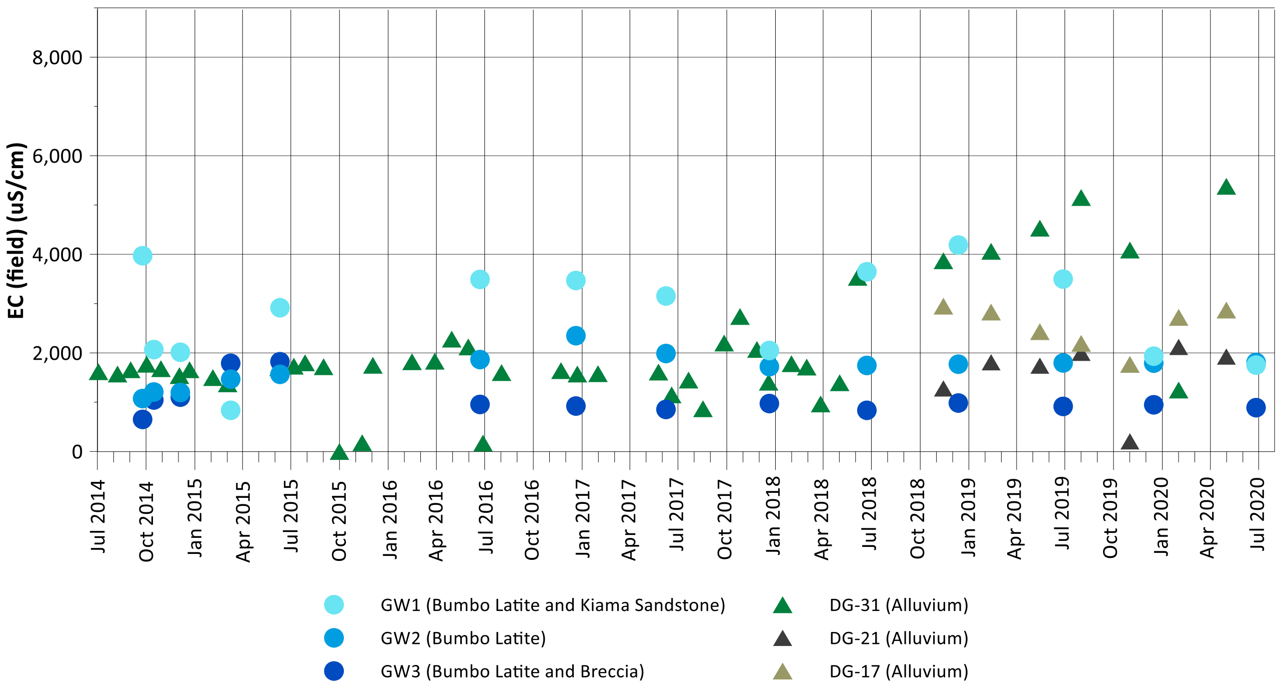


Figure 5.1 EC timeseries for all monitoring bores

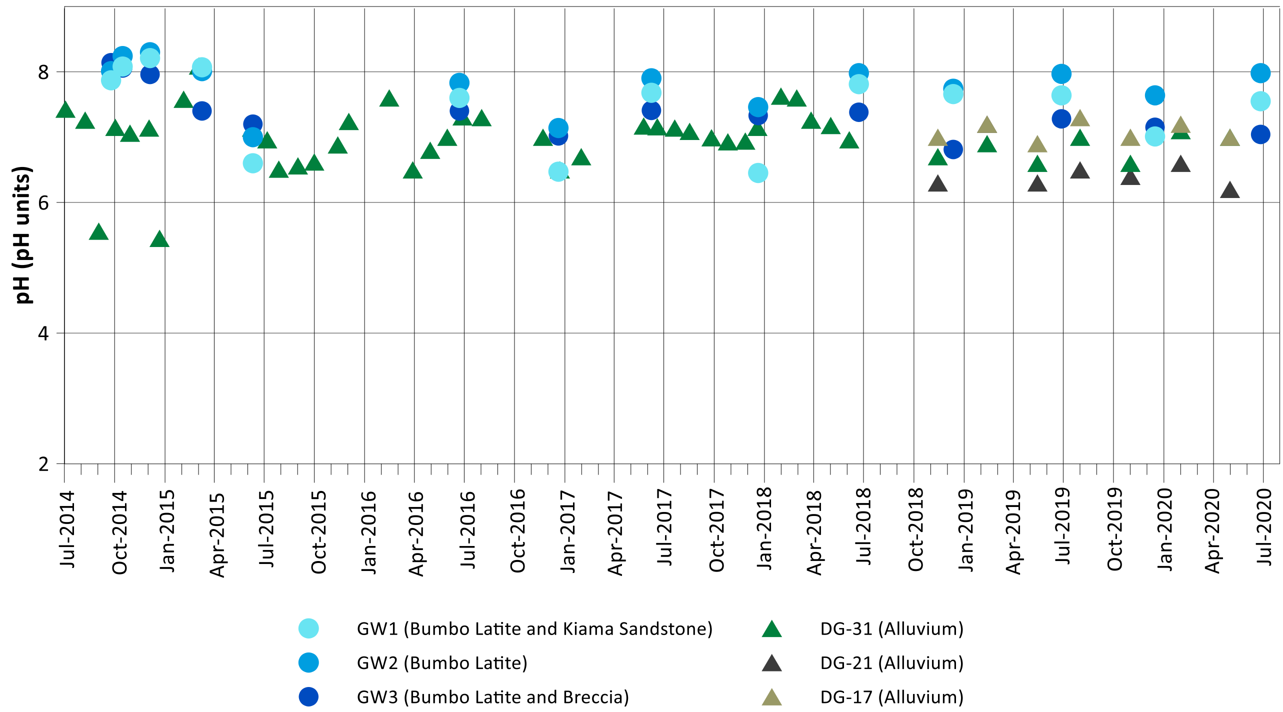


Figure 5.2 pH timeseries for all monitoring bores

5.2 Major ions

The major ion characteristics of groundwater samples for the Croome West and alluvial monitoring bores for this monitoring year are shown in a piper diagram (Figure 5.3). A piper diagram is a graphical representation of the relative concentrations of major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-}, CO_3^{2-} and SO_4^{2-}).

The Croome West sites have some variation in water type when compared with each other. GW1 and GW2 are marginally bicarbonate dominant mixed type. Groundwater at GW3 has a magnesium-bicarbonate water type. Major ion concentrations at the Croome West sites are comparable to previous monitoring years.

Groundwater at the alluvial sites is also high in sodium and magnesium. DG-17 has a similar marginally bicarbonate dominant mixed water type, to GW1 and GW2 which is consitent with the conceptual model suggesting groundwater flow from the latite discharging to the alluvial river systems to the east. DG-21 and DG-31 are sodium chloride dominated indicating a surface water and possible tidal influence. Trends at the DSS sites are regularly monitored by EES and will be further assessed in the DSS annual report.

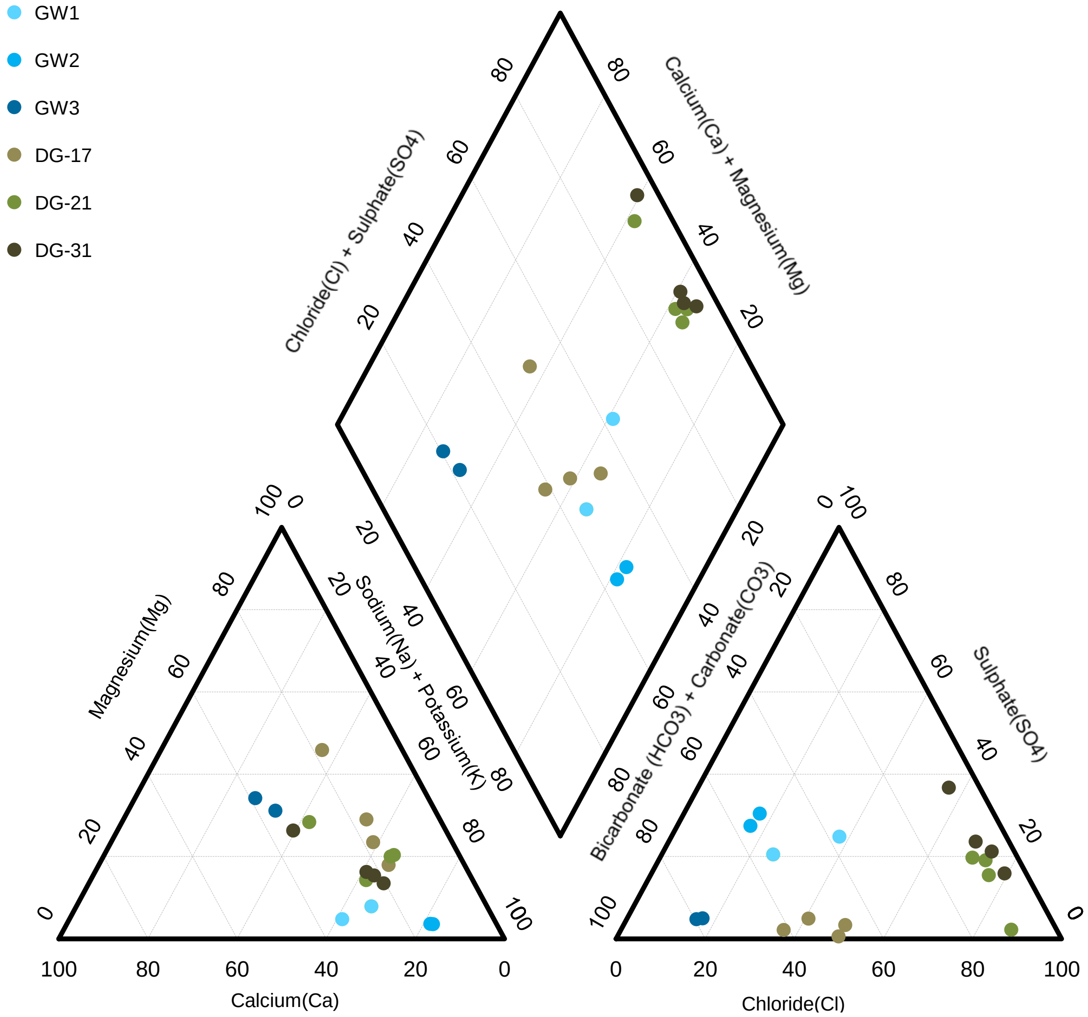


Figure 5.3 Piper plot for all monitoring bores (2019/2020 monitoring year)

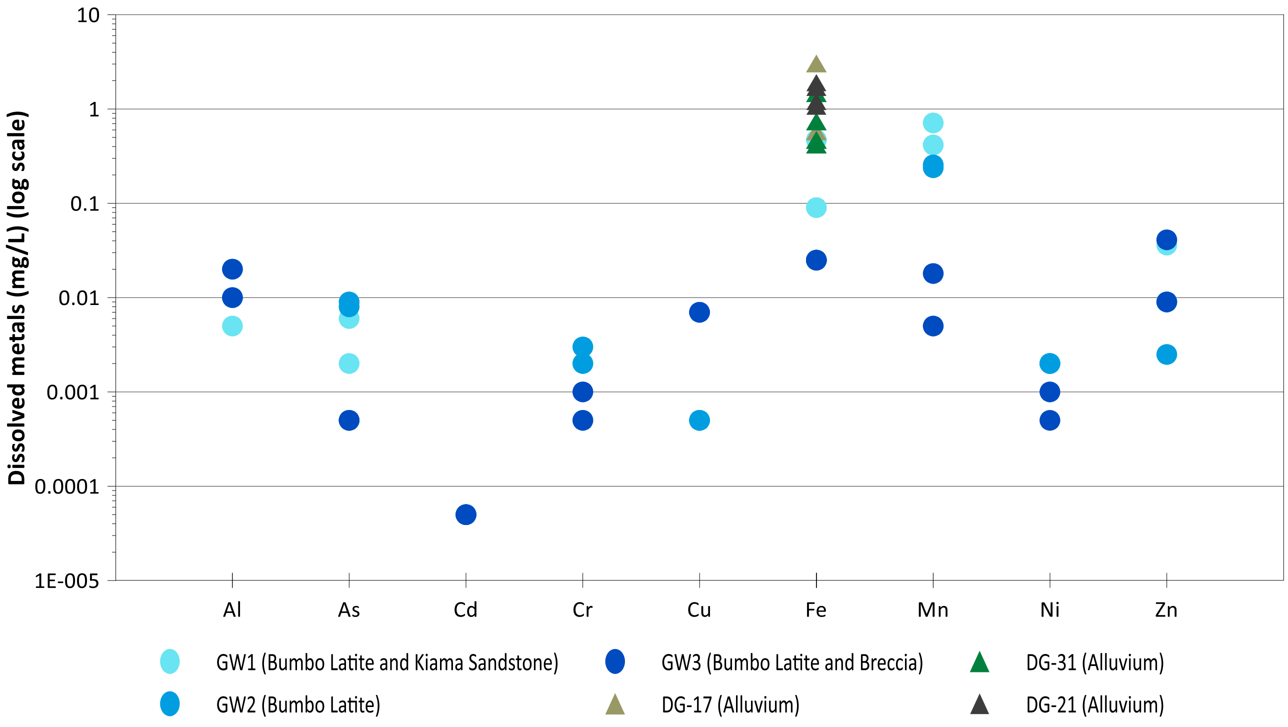
5.3 Dissolved metals

Concentrations of dissolved metals in groundwater in the 2019/2020 monitoring year are presented in Figure 5.4. A full suite of metals was analysed for the Bumbo Latite and timeseries of results is shown in Appendix D. In the Alluvium, only dissolved iron was analysed during the monitoring year.

The major findings at the Croome West sites for dissolved metals for this monitoring year are as follows:

- aluminium, cadmium, copper, nickel and zinc concentrations were consistent with previous monitoring years;
- arsenic concentrations continue to decrease at all sites;
- chromium concentrations increased in the 2018/2019 monitoring period, and has since decreased during the current monitoring year; and

- iron and manganese concentrations at GW1 showed an increase in the December 2019 monitoring round, although the concentration was within the observed range. Iron concentrations at GW1 reduced during the June 2020 monitoring round.



Note: Concentrations below the Estimated Quantitation Limit (EQL) are presented as half the EQL

Figure 5.4 Dissolved metal concentrations for all monitoring bores (2019/2020 monitoring year)

5.4 Nutrients

Time series of nitrate, total phosphorus and ammonia concentrations are presented in Figure 5.5, Figure 5.6 and Figure 5.7 respectively.

The major findings for nutrients are as follows:

- nitrate concentrations at the Bumbo Latite monitoring bores were comparable to previous monitoring years, with the highest concentrations detected at GW3. Nitrate as DG-21 was high relative to the other alluvial bores;
- total phosphorus concentrations were comparable to previous monitoring years at the Bumbo Latite sites. Phosphorus concentrations in the alluvial bores are generally within range of historic values; and
- ammonia concentrations at the Croome West sites and the alluvial sites were comparable to previous monitoring years.

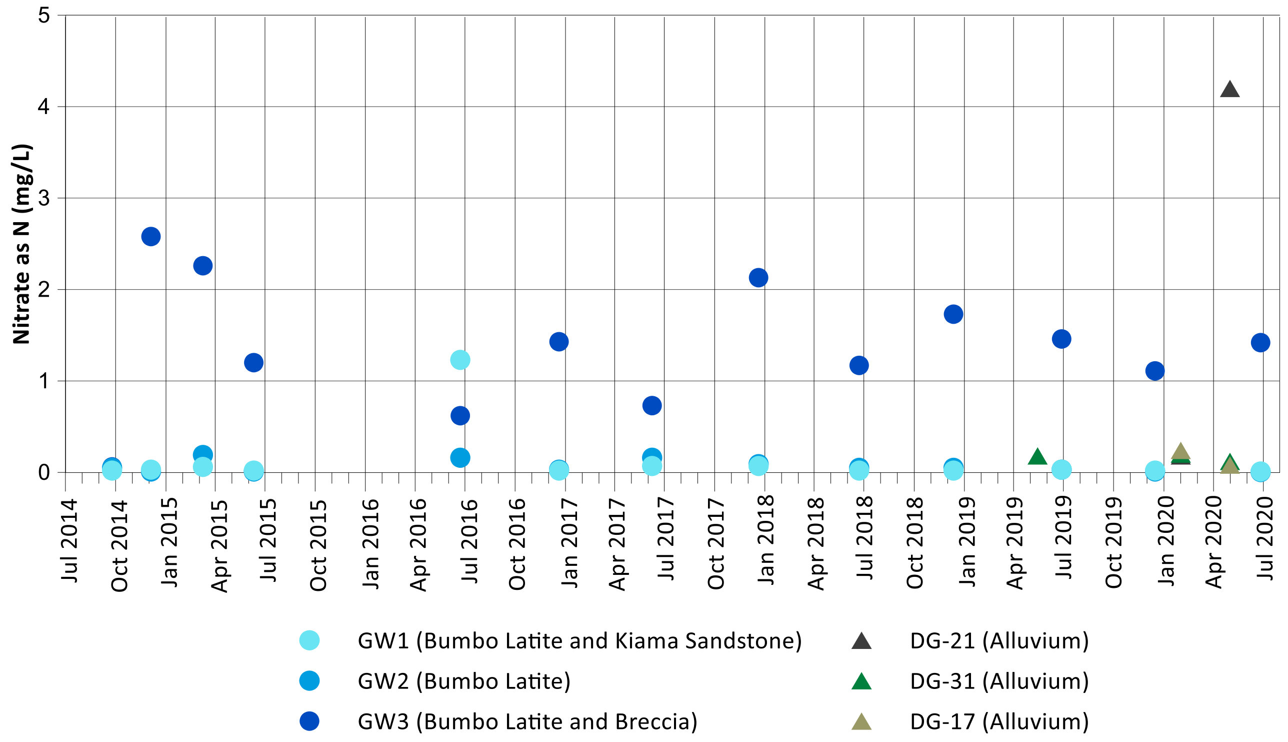


Figure 5.5 Nitrate timeseries for all monitoring bores

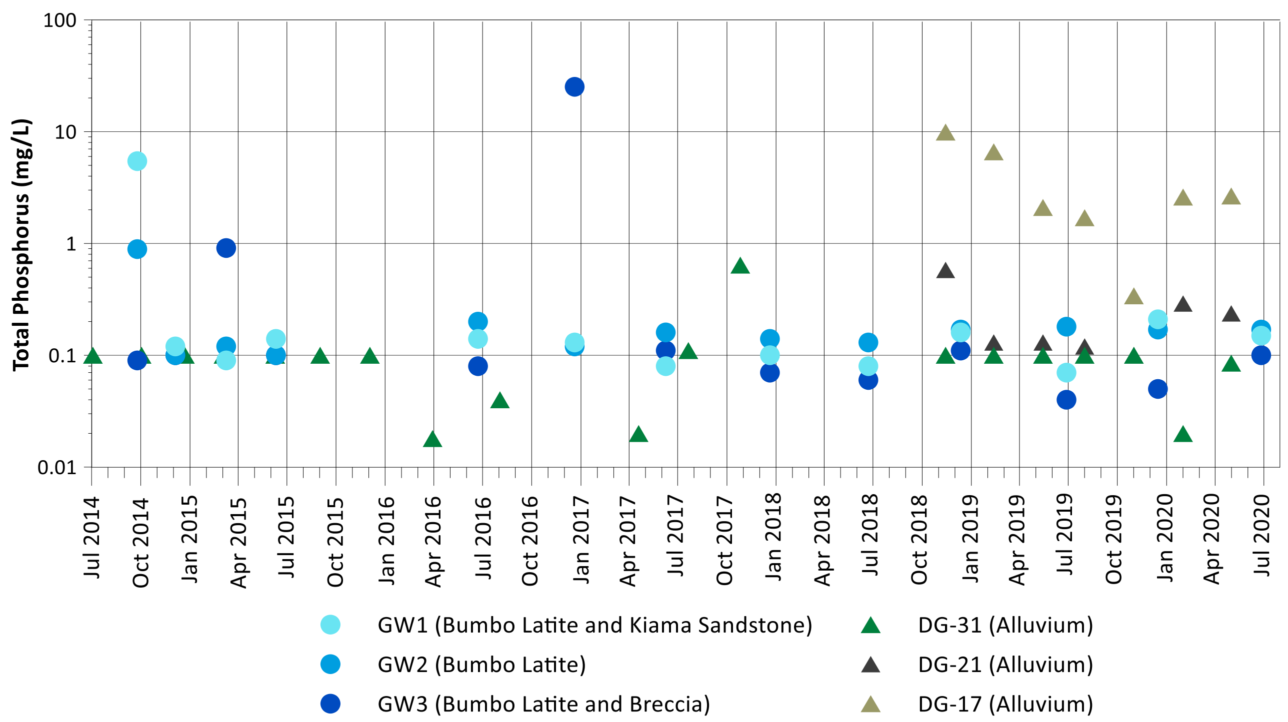


Figure 5.6 Total phosphorus timeseries for all monitoring bores

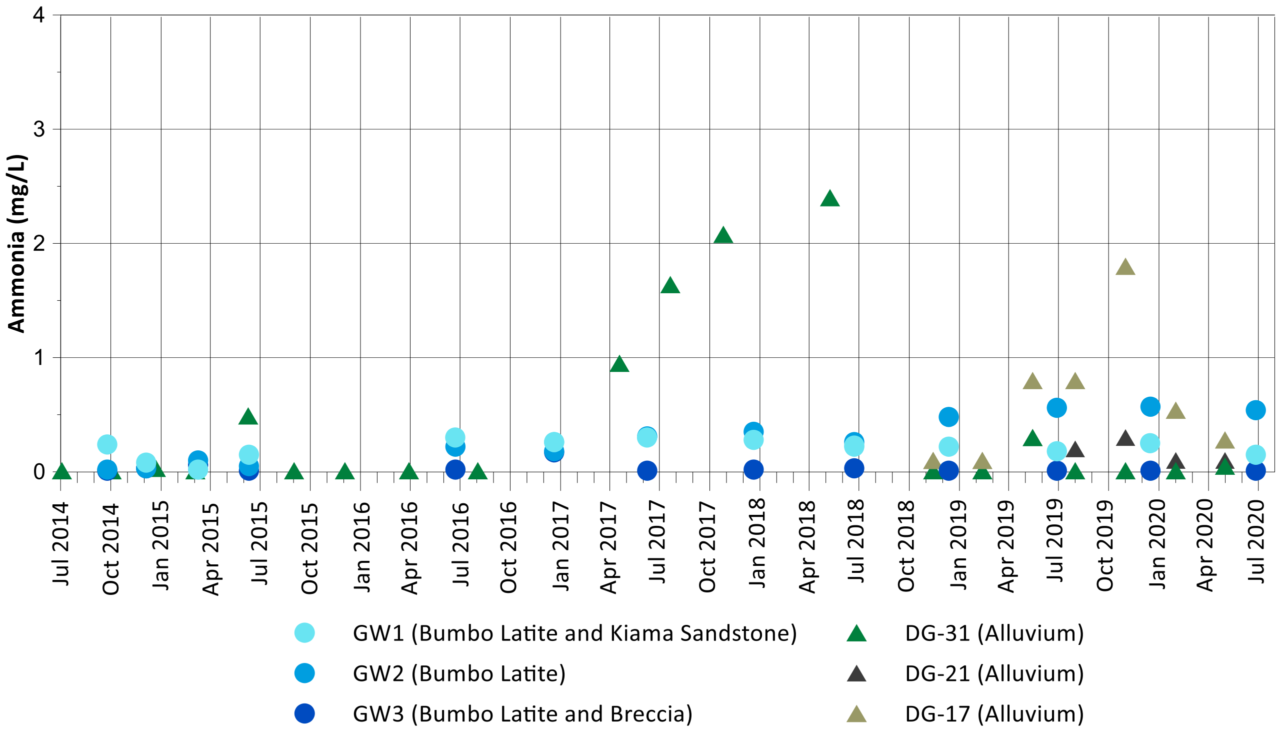


Figure 5.7 Ammonia timeseries for all monitoring bores

5.5 Summary

Water quality data collected during the monitoring year is generally consistent with previous years. The Croome West expansion has not impacted water quality at the Croome West sites.

6 Conclusions and recommendations

Groundwater levels are recorded every six-hours allowing water level trends to be identified in the alluvium and the Bumbo Latite. Continued six monthly sampling of water quality at the Croome West sites and quarterly sampling at the DSS sites also established useful trends.

The main findings for the 2019/2020 monitoring year regarding water levels are:

- groundwater levels in the alluvium at the DSS sites continue to show a direct response to rainfall, showing a decline during the dry conditions up to January 2020, and a recovery due to wet conditions in February 2020; and

- groundwater levels in the Bumbo Latite monitoring bores are steady at GW2 and GW3, and show some fluctuation associated with rainfall at GW1, particularly following rainfall in February 2020.

The main findings for this monitoring year regarding water quality are:

- groundwater quality at the alluvial monitoring sites was generally consistent with historical data, except for major ions showing a chloride influence at DG21 and DG31.

- Groundwater quality at the Croome West sites is consistent with previous monitoring years. Some metals concentrations were elevated in the December 2019 results, but returned to the typical range in the June 2020 results.

The results for the 2018/19 monitoring year are consistent with the conceptual model for the project.

It is recommended that groundwater level monitoring via dataloggers continues at six-hourly intervals and that groundwater quality monitoring continues at the six-monthly frequency at the Bumbo Latite monitoring bores, and at approximately quarterly intervals at the DSS sites in accordance with the GMP.

There does not appear to be any impact on groundwater levels or quality in the Bumbo Latite or Kiama Sandstone associated with the Croome West pit extension activities.

7 References

Cohen 2006, *Shellharbour/Kiama regional hard rock resource review groundwater assessment study*, NSW Government – Department of Planning.

Department of Mine 1974, *Geology of the Wollongong, Kiama and Robertson 1:50,000 Sheets*.

EES 2017, *Annual report on groundwater level monitoring at the Swamp Road Quarry, Dunmore NSW – May 2016 to May 2017*. Prepared for Boral Dunmore Sand and Soils Pty Ltd, dated 16 June 2017.

EMM 2016, *Groundwater Monitoring Program for Dunmore Hard Rock* Quarry, prepared for Boral Dunmore Quarry, dated 18 November 2016.

EMM 2020, *Dunmore Hard Rock Quarry: Water Management Plan*, prepared for Boral Dunmore Quarry, dated 29 April 2020.mmj.

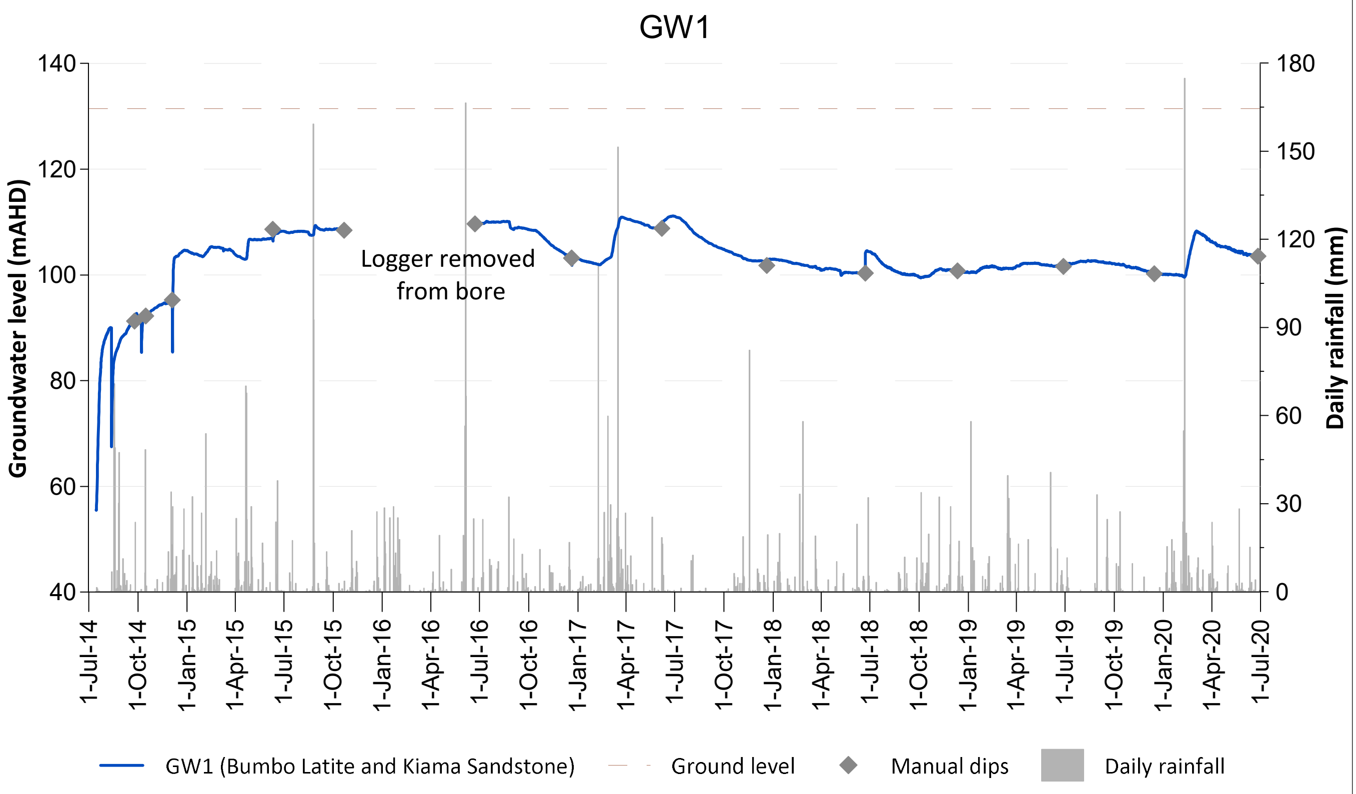
Evans and Peck 2006, *Statement of Environmental Effects, Section 4 Water Management, Dunmore Hardrock Quarry extension*.

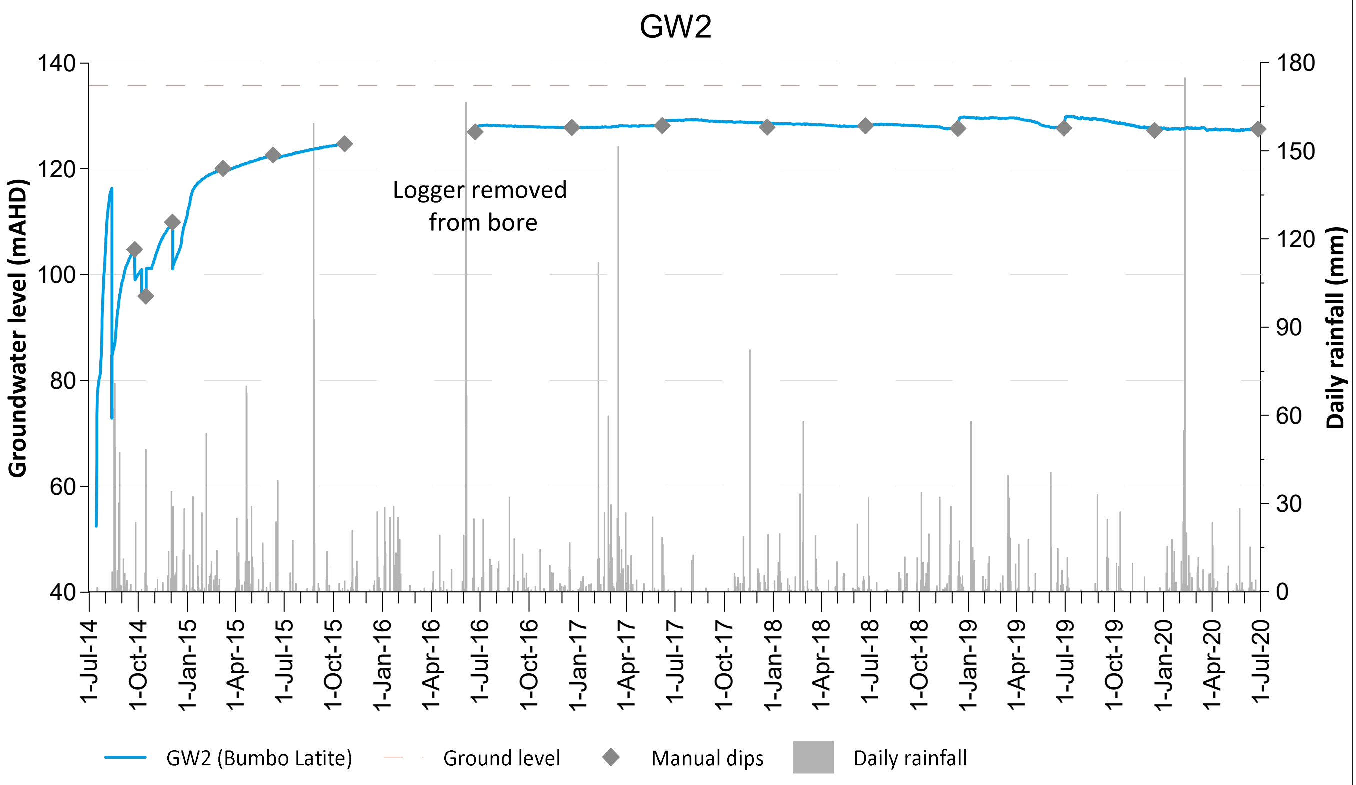
MMJ Wollongong (MMJ) 2013, *Environmental Assessment, Modification of Development Consent 10639 of 2005 Albion Park Quarry*.

Walker G., Gilfedder M., Evans R., Dyson P., Stauffacher M. 2003, *Groundwater Flow Systems Framework – Essential Tools for Planning Salinity Management*, Murray Darling Basin Commission and CSIRO Land and Water.

Appendix A

Groundwater hydrographs



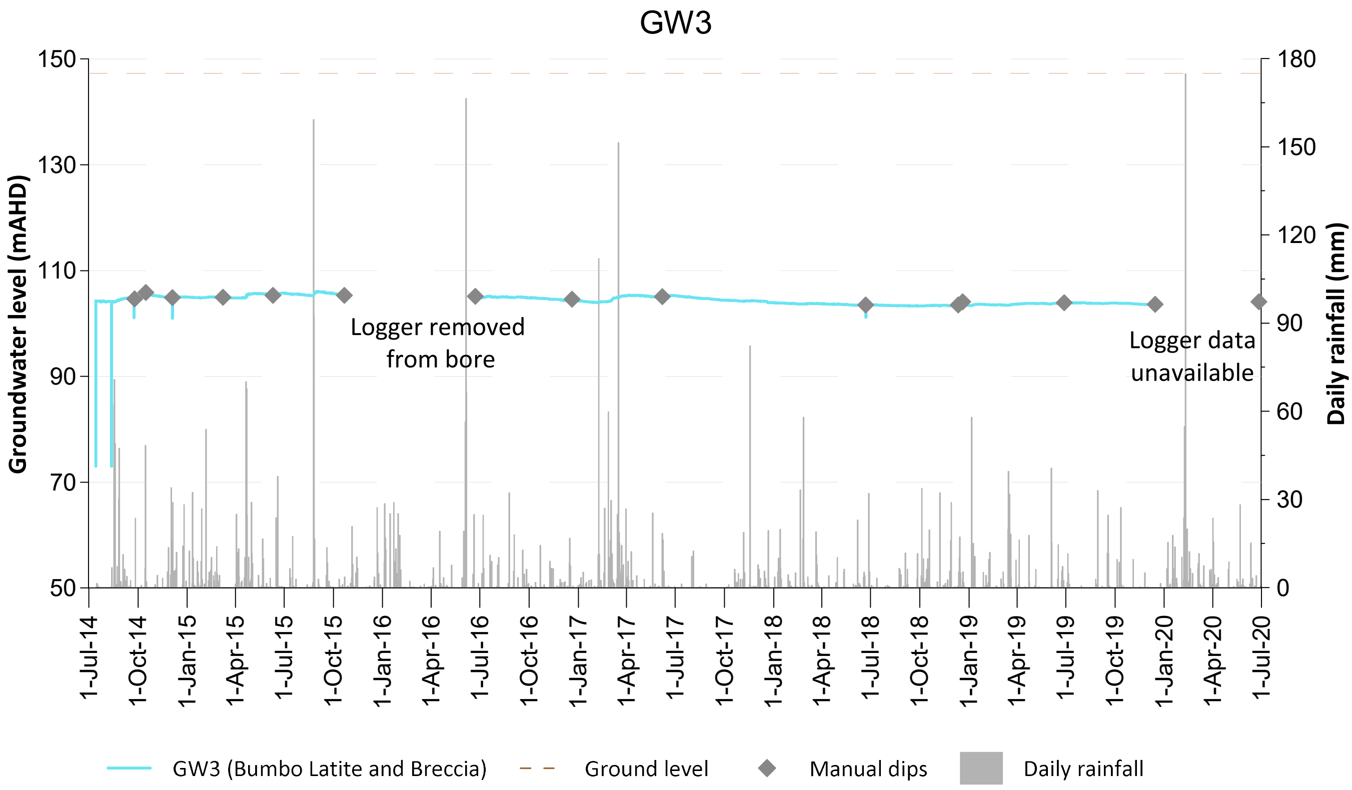


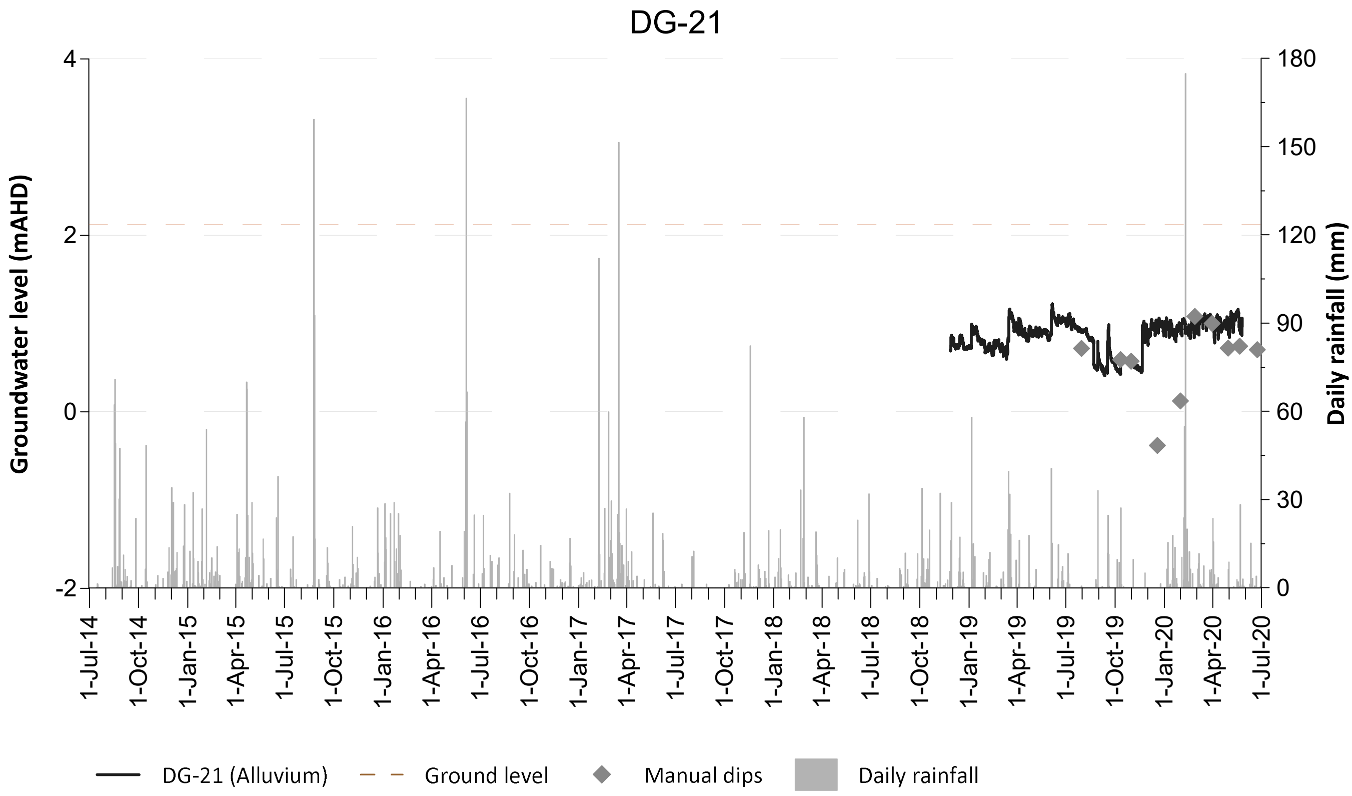
GW1 and GW2 hydrographs

Boral Dunmore Quarry

2019-2020 Annual Groundwater Monitoring Report

Figure A.1



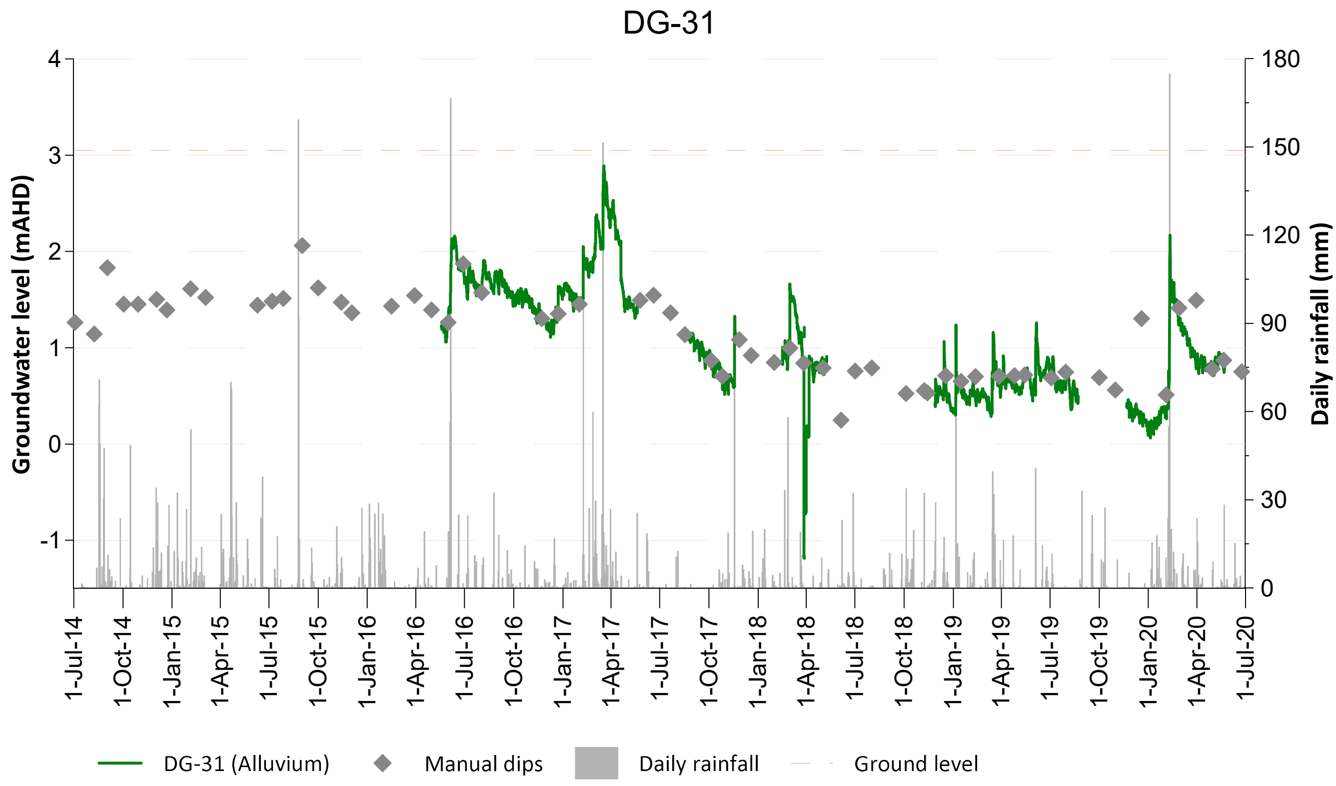


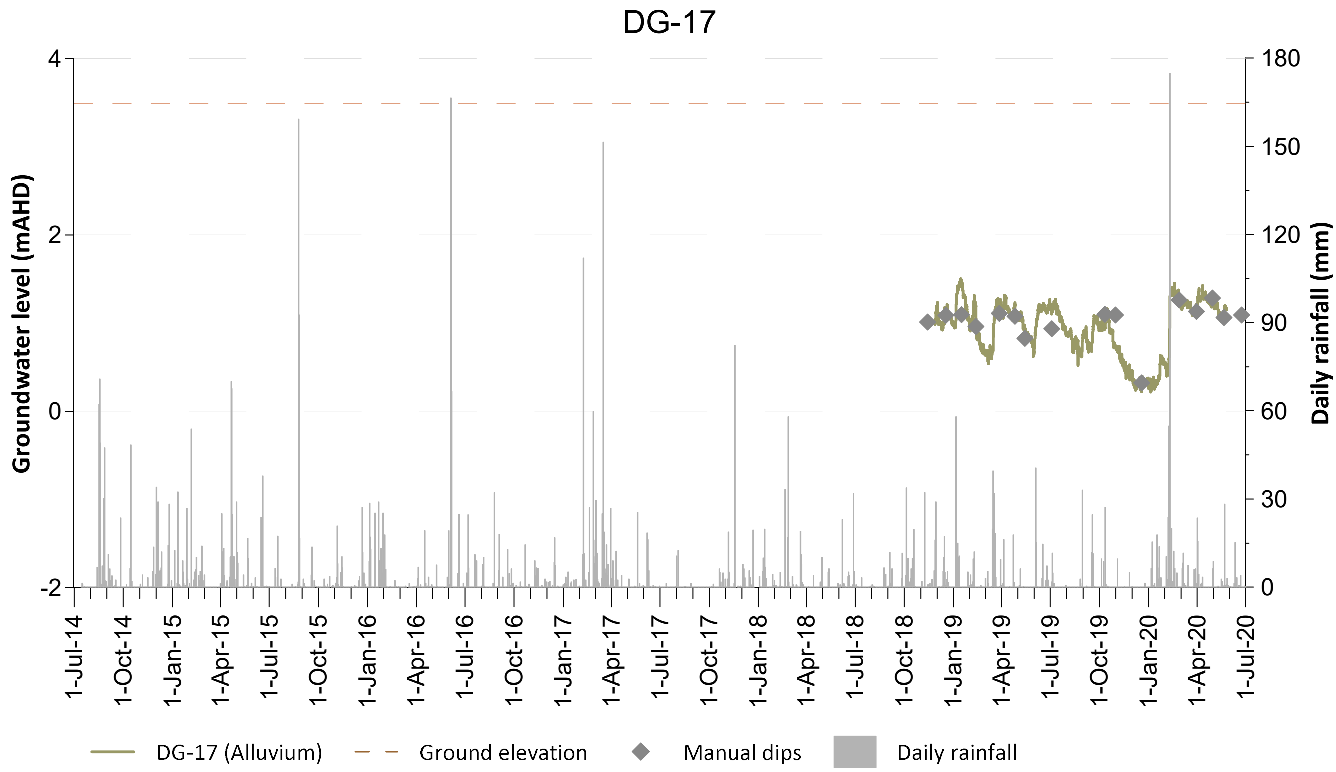
GW3 and DG-21 hydrographs

Boral Dunmore Quarry

2019-2020 Annual Groundwater Monitoring Report

Figure A.2





DG-31 and DG-17 hydrographs

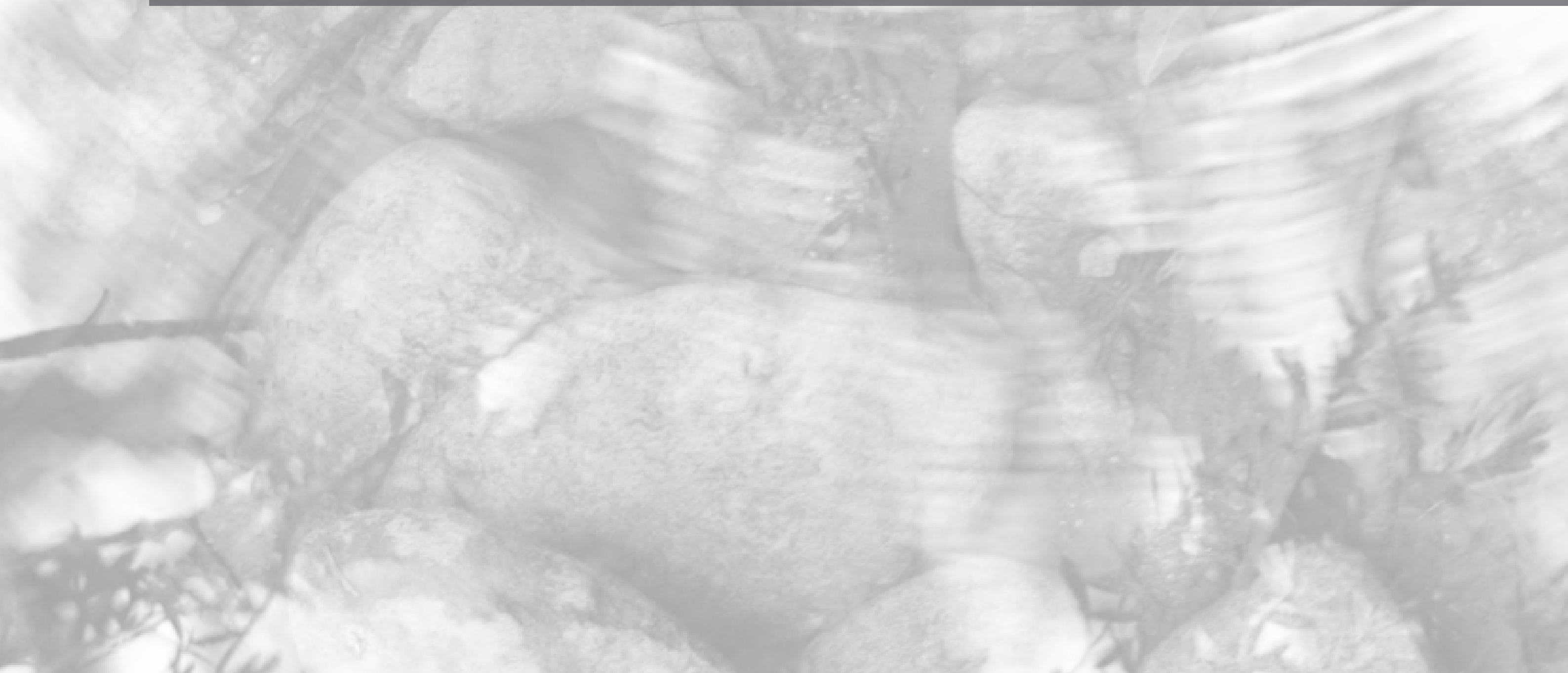
Boral Dunmore Quarry

2019-2020 Annual Groundwater Monitoring Report

Figure A.3

Appendix B

Water quality summary tables

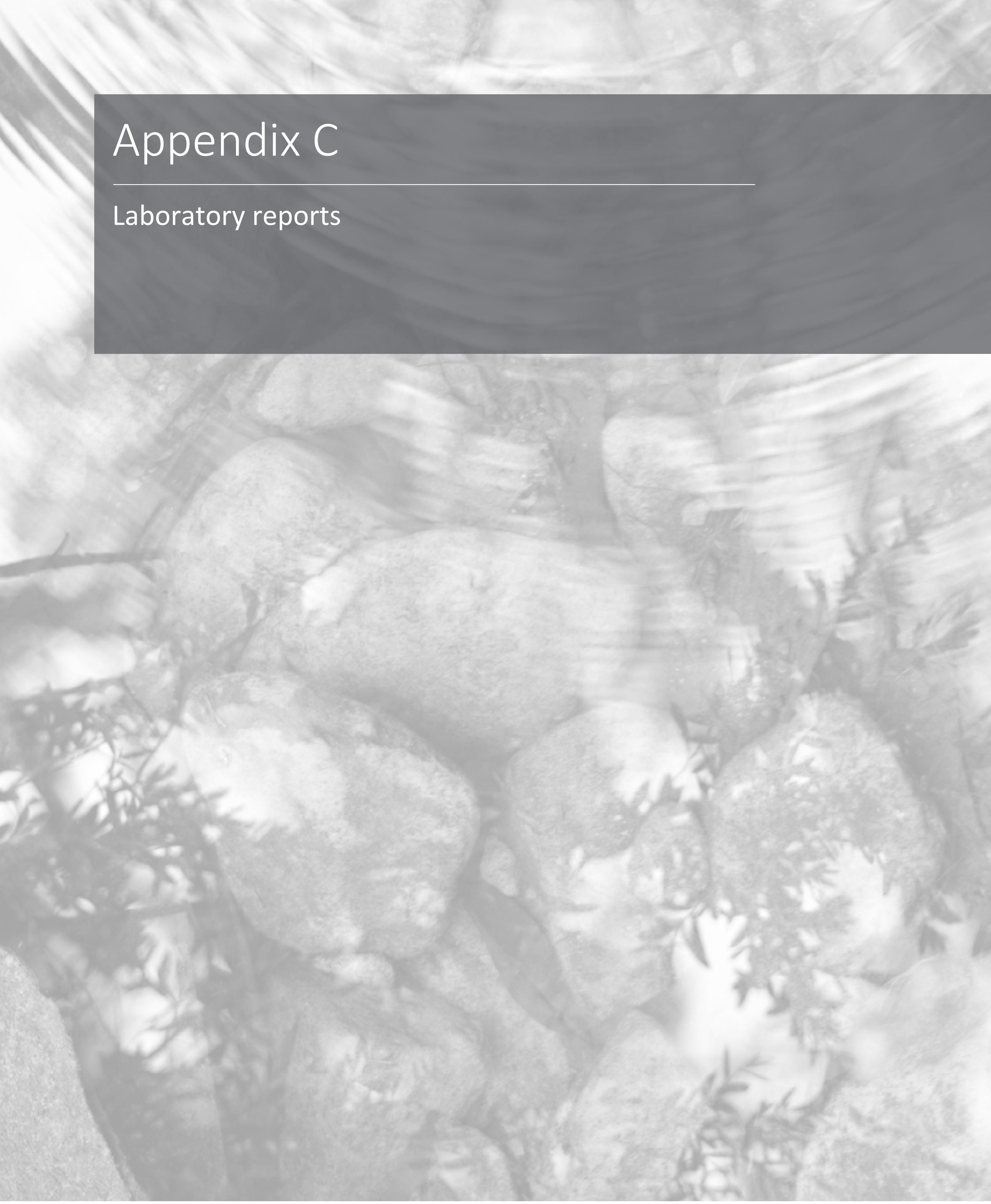


Parameter		Units	EQL	GW1	GW1	GW2	GW2	GW3	GW3
			Date	16/12/2019	26/06/2020	16/12/2019	26/06/2020	16/12/2019	26/06/2020
Field	pH	pH units		7.01	7.55	7.64	7.98	7.15	7.04
	Electrical conductivity	uS/cm		1933	1751	1793	1805	947	890
	Temperature	°C		19	19.9	19.6	18.2	19.5	18
	Dissolved oxygen	%		44.6	60.5	33.8	51.9	36	33.7
	Dissolved oxygen	mg/L		4.11	5.51	3.09	4.8	3.28	3.18
	Total dissolved solids	mg/L		1255	1138	1164	1176	617.5	578.5
	Oxidation reduction potential	mV		2.1	-229.5	-93.6	-221.1	89.8	24.3
Major ions	Alkalinity (Hydroxide) as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1
	Alkalinity (total) as CaCO3	mg/L	1	406	437	332	383	302	314
	Bicarbonate Alkalinity-mg CaCO3/L	mg/L	1	406	437	316	383	302	314
	Calcium (Filtered)	mg/L	1	103	236	53	54	72	73
	Carbonate Alkalinity-mg CaCO3/L	mg/L	1	<1	<1	16	<1	<1	<1
	Chloride	mg/L	1	265	624	153	159	93	88
	Magnesium (Filtered)	mg/L	1	19	20	8	8	38	39
	Potassium (Filtered)	mg/L	1	3	2	3	3	<1	<1
	Silicon as SiO2 (Filtered)	mg/L	0.1	34.2	21.6	25.1	21.3	40.1	33.6
	Sodium (Filtered)	mg/L	1	300	486	349	340	76	58
	Sulfate as SO4 - Turbidimetric (Filtered)	mg/L	1	293	555	368	358	37	36
Dissolved metals	Aluminium	mg/L	0.01	<0.01	0.01	0.01	0.02	0.01	0.02
	Arsenic	mg/L	0.001	0.006	0.002	0.009	0.008	<0.001	<0.001
	Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium	mg/L	0.001	0.002	<0.001	0.003	0.002	0.001	<0.001
	Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.007
	Iron	mg/L	0.05	0.47	0.09	<0.05	<0.05	<0.05	<0.05
	Manganese	mg/L	0.001	0.713	0.416	0.255	0.238	0.018	0.005
	Nickel	mg/L	0.001	0.002	0.002	0.002	0.002	<0.001	0.001
	Zinc	mg/L	0.005	0.036	0.009	0.009	<0.005	0.041	0.009
Nutrients	Ammonia (as N)	mg/L	0.01	0.25	0.15	0.57	0.54	<0.01	<0.01
	Nitrite (as N)	mg/L	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	Nitrate (as N)	mg/L	0.01	0.02	0.01	0.01	<0.01	1.11	1.42
	Nitrate + Nitrite (as N)	mg/L	0.01	0.02	0.03	0.01	<0.01	1.11	1.42
	Nitrogen (Total)	mg/L	0.1	0.6	0.6	0.8	0.8	1.2	1.7
	Kjeldahl Nitrogen Total	µg/L	100	600	600	800	800	100	300
	Total phosphorus	mg/L	0.01	0.21	0.15	0.17	0.17	0.05	0.1

Note: EQL = Estimated Quantitation Limit

Appendix C

Laboratory reports



ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1941705**	Page	: 1 of 4
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: IMOGEN FRAWLEY	Contact	: Shane Colley
Address	: Ground Floor Suite 1 20 Chandos Street St Leonards NSW NSW 2065	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: Dunmore	Date Samples Received	: 16-Dec-2019 15:00
Order number	: J17314	Date Analysis Commenced	: 16-Dec-2019
C-O-C number	: ----	Issue Date	: 24-Dec-2019 15:23
Sampler	: IF		
Site	: ----		
Quote number	: EN/112/18 - Primary work only		
No. of samples received	: 4		
No. of samples analysed	: 4		

ilac-MRA NATA

Accreditation No. 825
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ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

			Client sample ID	GW1	GW2	GW3	QA	----
			Client sampling date / time	16-Dec-2019 01:00	16-Dec-2019 12:00	16-Dec-2019 11:15	16-Dec-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1941705-001	ES1941705-002	ES1941705-003	ES1941705-004	--------
				Result	Result	Result	Result	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	**16**	<1	**5**	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**406**	**316**	**302**	**400**	----
Total Alkalinity as CaCO3	----	1	mg/L	**406**	**332**	**302**	**405**	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**34.2**	**25.1**	**40.1**	**34.0**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**293**	**368**	**37**	**254**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**265**	**153**	**93**	**268**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**103**	**53**	**72**	**103**	----
Magnesium	7439-95-4	1	mg/L	**19**	**8**	**38**	**19**	----
Sodium	7440-23-5	1	mg/L	**300**	**349**	**76**	**301**	----
Potassium	7440-09-7	1	mg/L	**3**	**3**	<1	**3**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.01**	**0.01**	**0.01**	----
Arsenic	7440-38-2	0.001	mg/L	**0.006**	**0.009**	<0.001	**0.006**	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	**0.002**	**0.003**	**0.001**	**0.003**	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.007**	<0.001	----
Manganese	7439-96-5	0.001	mg/L	**0.713**	**0.255**	**0.018**	**0.715**	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.002**	<0.001	**0.002**	----
Zinc	7440-66-6	0.005	mg/L	**0.036**	**0.009**	**0.041**	**0.045**	----
Iron	7439-89-6	0.05	mg/L	**0.47**	<0.05	<0.05	**0.51**	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.25**	**0.57**	<0.01	**0.26**	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	**0.01**	**1.11**	**0.01**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	**0.01**	**1.11**	**0.01**	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GW1	GW2	GW3	QA	----
			Client sampling date / time	16-Dec-2019 01:00	16-Dec-2019 12:00	16-Dec-2019 11:15	16-Dec-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1941705-001	ES1941705-002	ES1941705-003	ES1941705-004	--------
				Result	Result	Result	Result	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.6**	**0.8**	**0.1**	**0.7**	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.6**	**0.8**	**1.2**	**0.7**	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.21**	**0.17**	**0.05**	**0.22**	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	**0.8**	<0.1	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**21.7**	**18.6**	**9.43**	**20.9**	----
ø Total Cations	----	0.01	meq/L	**19.8**	**18.6**	**10.0**	**19.9**	----
ø Ionic Balance	----	0.01	%	**4.48**	**0.14**	**3.08**	**2.62**	----

CERTIFICATE OF ANALYSIS

Work Order	: **ES2022254**	Page	: 1 of 4
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: IMOGEN FRAWLEY	Contact	: Customer Services ES
Address	: Ground Floor Suite 1 20 Chandos Street St Leonards NSW NSW 2065	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: DUNMORE	Date Samples Received	: 26-Jun-2020 15:10
Order number	: J17314	Date Analysis Commenced	: 27-Jun-2020
C-O-C number	: ----	Issue Date	: 03-Jul-2020 10:49
Sampler	: IF		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

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Signatories

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Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

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- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

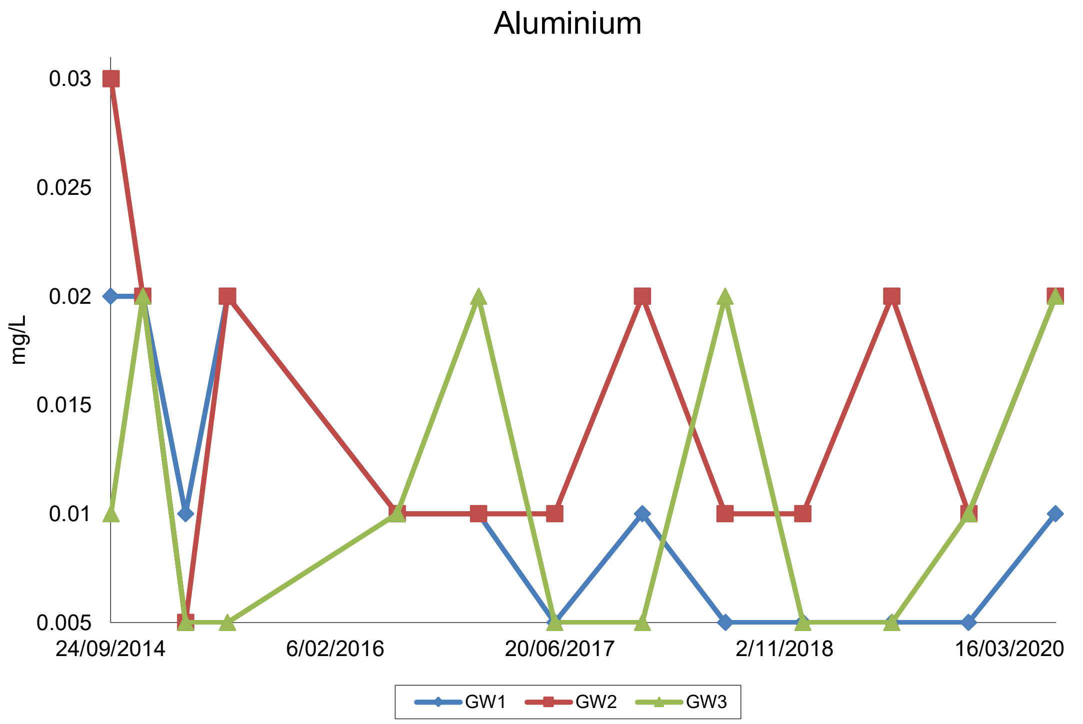
Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GW1	GW2	GW3	QA	----
			Client sampling date / time	26-Jun-2020 10:20	26-Jun-2020 12:20	26-Jun-2020 11:30	26-Jun-2020 00:00	----
Compound	CAS Number	LOR	Unit	ES2022254-001	ES2022254-002	ES2022254-003	ES2022254-004	--------
				Result	Result	Result	Result	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**437**	**383**	**314**	**333**	----
Total Alkalinity as CaCO3	----	1	mg/L	**437**	**383**	**314**	**333**	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**21.6**	**21.3**	**33.6**	**33.0**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**555**	**358**	**36**	**35**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**624**	**159**	**88**	**89**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**236**	**54**	**73**	**73**	----
Magnesium	7439-95-4	1	mg/L	**20**	**8**	**39**	**38**	----
Sodium	7440-23-5	1	mg/L	**486**	**340**	**58**	**57**	----
Potassium	7440-09-7	1	mg/L	**2**	**3**	<1	<1	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	**0.02**	**0.02**	**0.02**	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.008**	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.002**	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.007**	**0.007**	----
Manganese	7439-96-5	0.001	mg/L	**0.416**	**0.238**	**0.005**	**0.004**	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.002**	**0.001**	<0.001	----
Zinc	7440-66-6	0.005	mg/L	**0.009**	<0.005	**0.009**	**0.008**	----
Iron	7439-89-6	0.05	mg/L	**0.09**	<0.05	<0.05	<0.05	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.15**	**0.54**	<0.01	<0.01	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	**0.02**	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	<0.01	**1.42**	**1.43**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.03**	<0.01	**1.42**	**1.43**	----

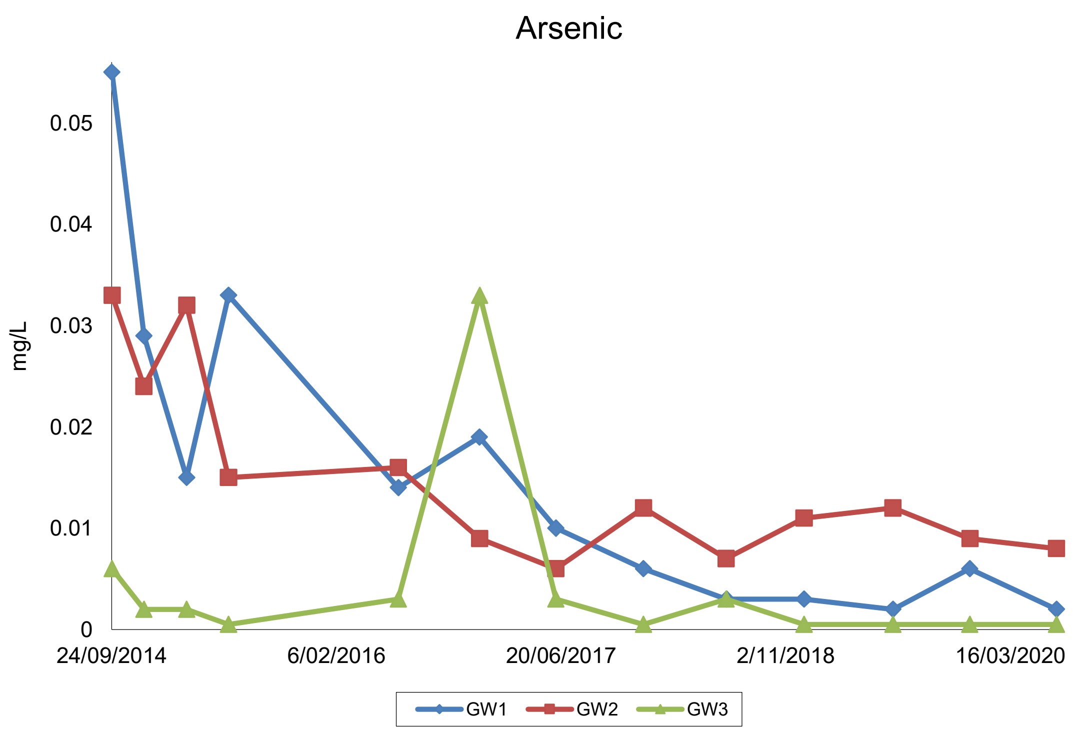
Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GW1	GW2	GW3	QA	----
			Client sampling date / time	26-Jun-2020 10:20	26-Jun-2020 12:20	26-Jun-2020 11:30	26-Jun-2020 00:00	----
Compound	CAS Number	LOR	Unit	ES2022254-001	ES2022254-002	ES2022254-003	ES2022254-004	--------
				Result	Result	Result	Result	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.6	0.8	0.3	0.3	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	0.6	0.8	1.7	1.7	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.15	0.17	0.10	0.10	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	37.9	19.6	9.50	9.89	----
ø Total Cations	----	0.01	meq/L	34.6	18.2	9.38	9.25	----
ø Ionic Balance	----	0.01	%	4.52	3.63	0.69	3.36	----

Appendix D

Croome West sites - metals timeseries charts





Note: Concentrations below the EQL are presented as half the EQL

Figure D.1

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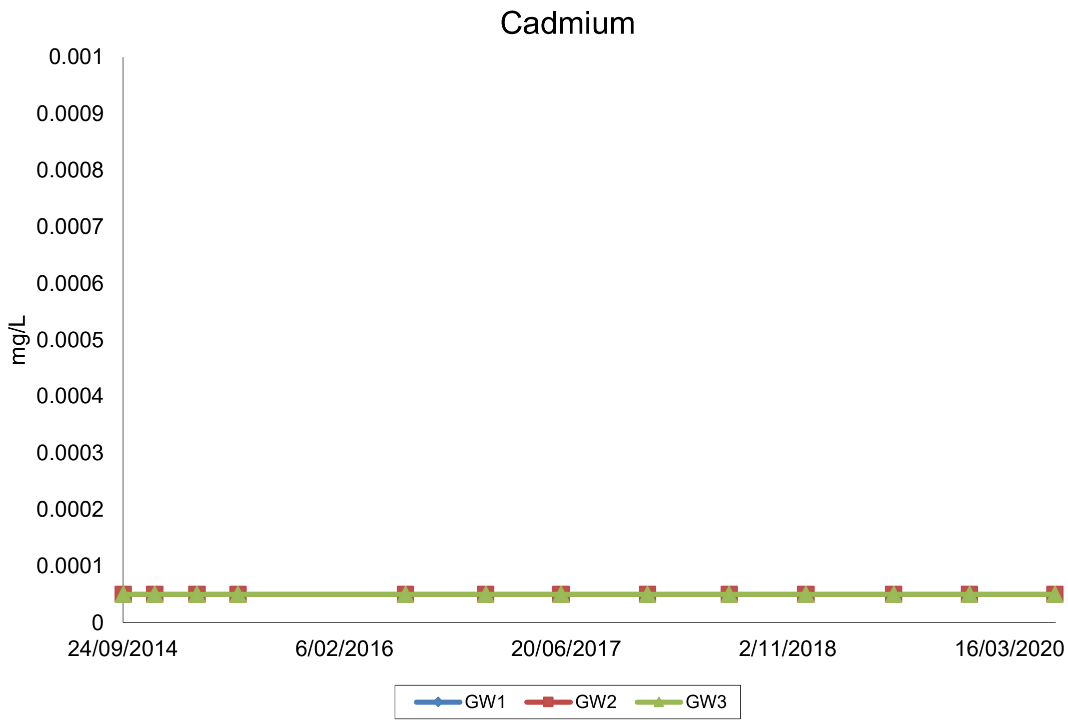

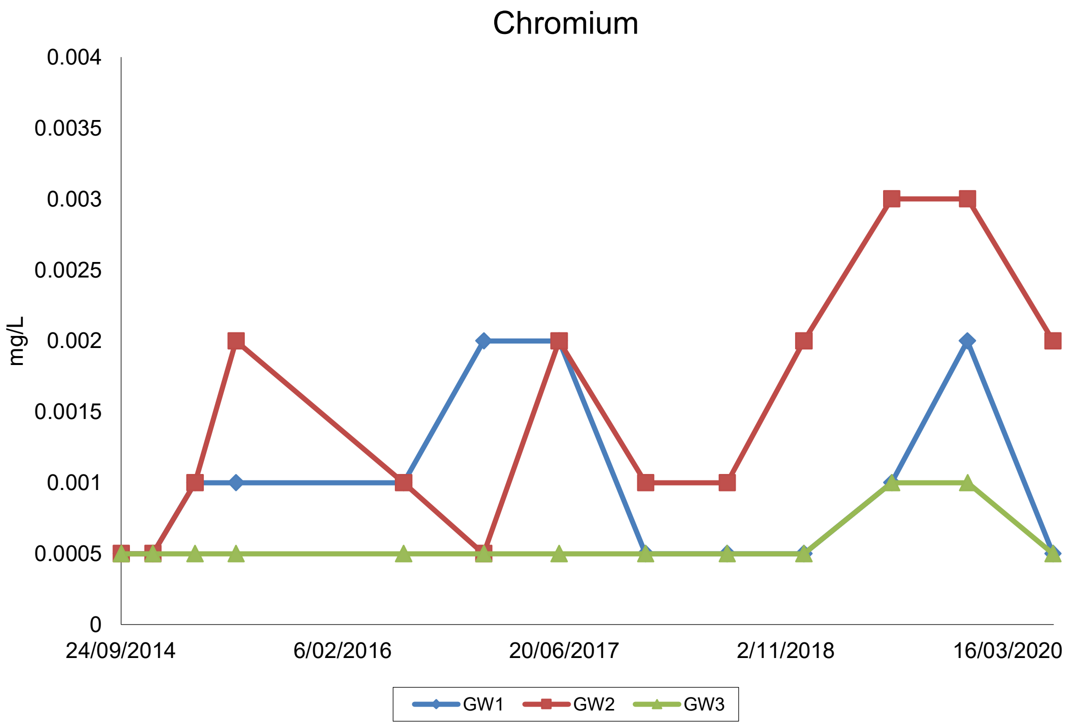

Note: Concentrations below the EQL are presented as half the EQL

Figure D.2

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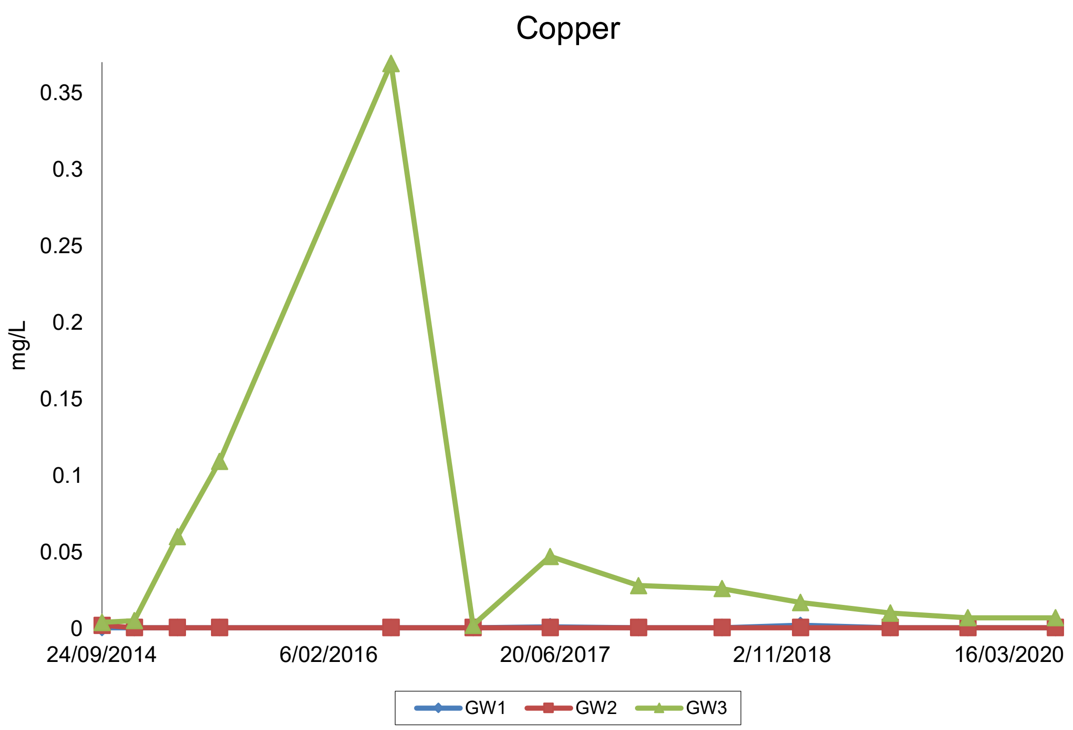
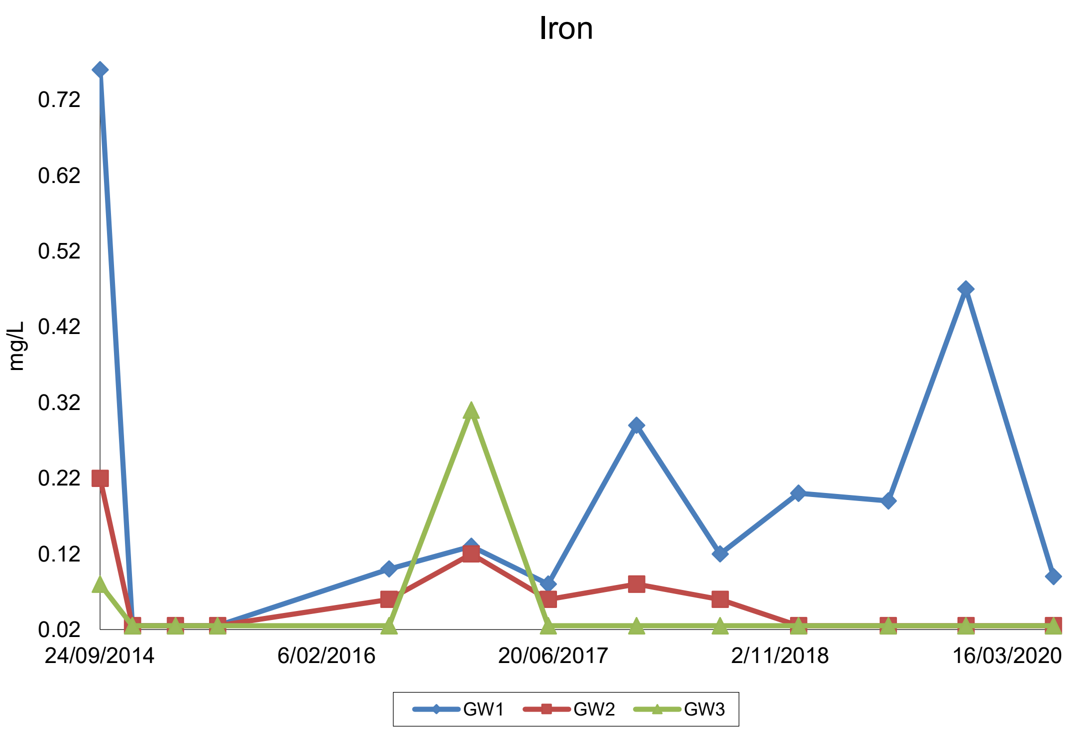
EMM





Note: Concentrations below the EQL are presented as half the EQL

Figure D.3

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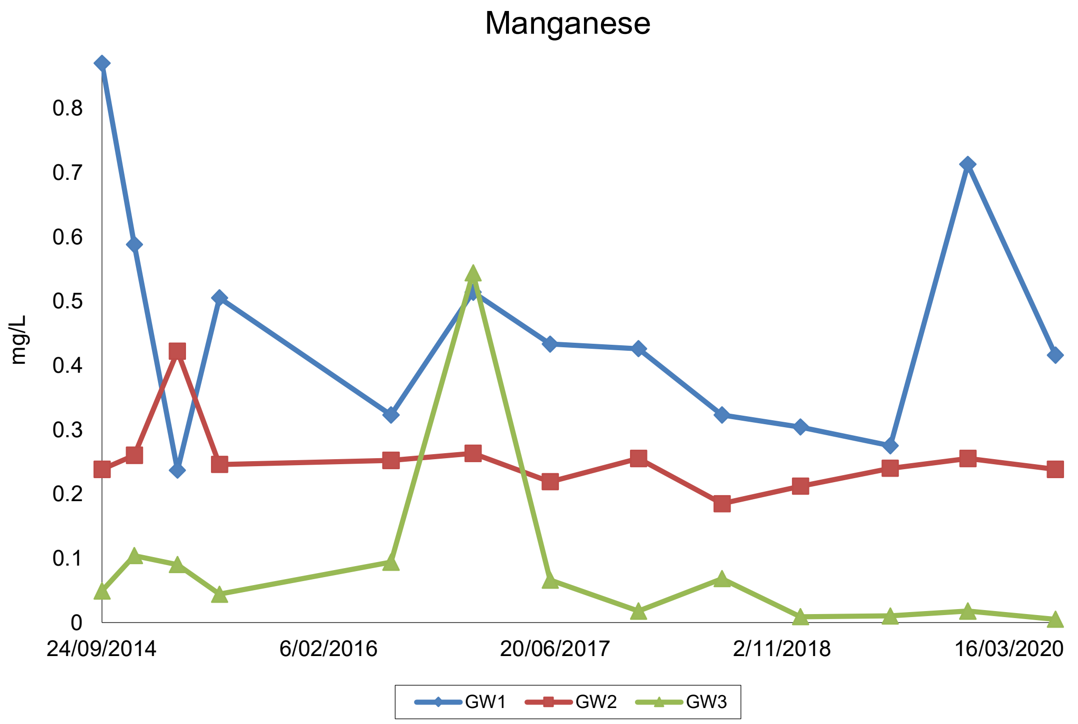

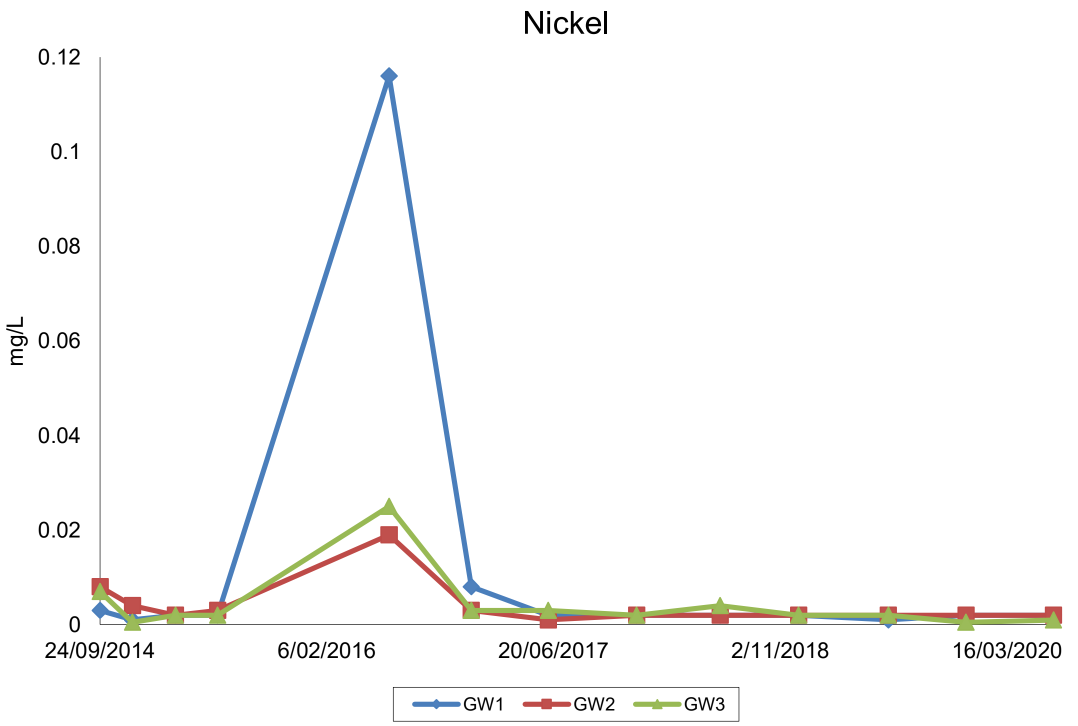

Note: Concentrations below the EQL are presented as half the EQL

Figure D.4

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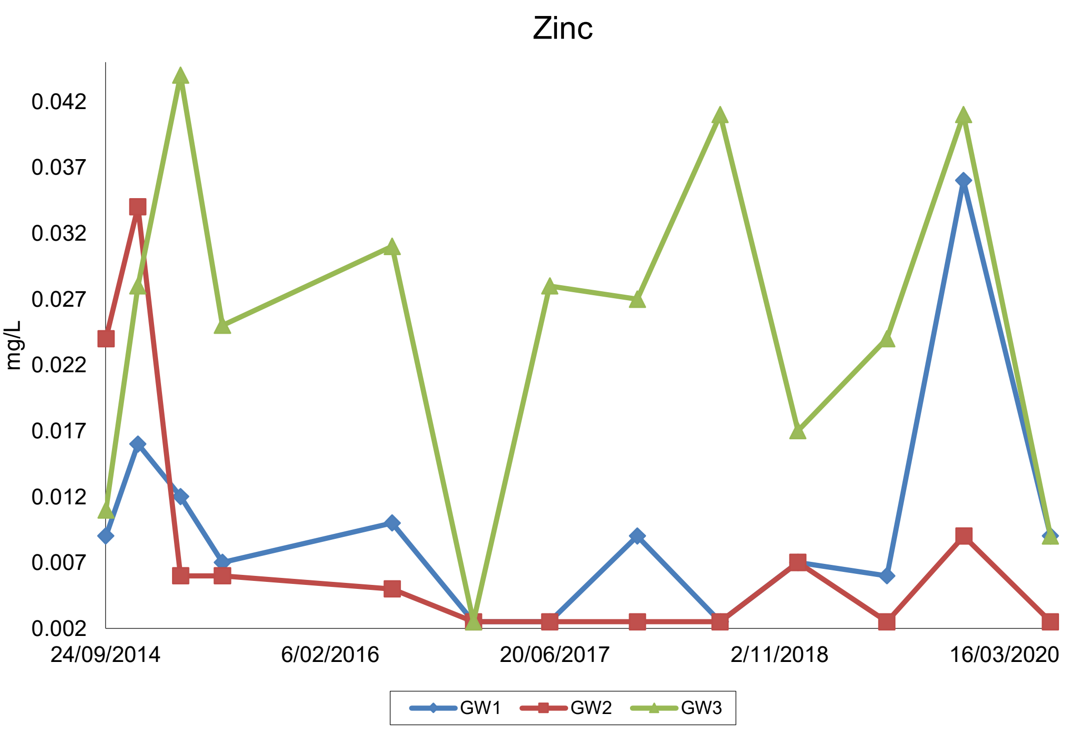
EMM



Note: Concentrations below the EQL are presented as half the EQL

Figure D.5

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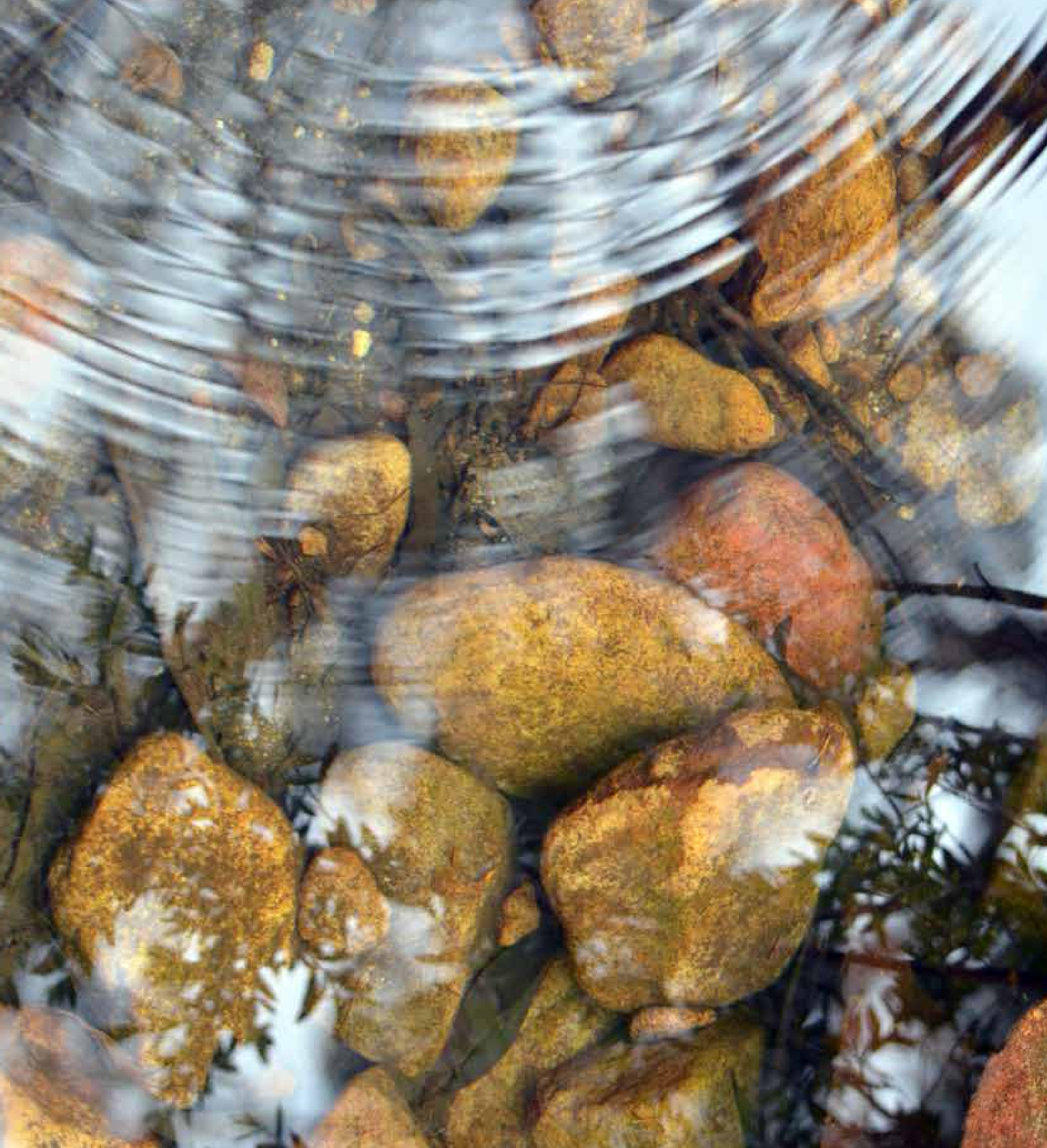

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