2019 - 2020 Groundwater and Surface Water Monitoring Report
Camden Gas Project

Prepared for AGL Upstream Investments Pty Limited | September 2020

2019-2020 Groundwater and Surface Water Monitoring Report

Camden Gas Project

Report Number

J200417 RP1

Client

AGL Upstream Investments Pty Ltd

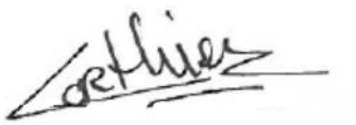
Date

24 September 2020

Version

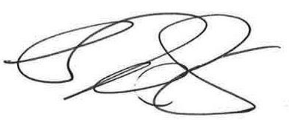
v2 Final

Prepared by



Claire Corthier
Hydrogeologist
24 September 2020

Approved by



James Duggleby
Associate Director – Water
24 September 2020

Executive Summary

AGL Upstream Investments Pty Ltd (AGL) owns and operates the Camden Gas Project (CGP) located in the Macarthur region, 65 kilometres (km) southwest of Sydney, NSW. The CGP has been producing natural gas from coal seams for the Sydney region since 2001 and currently consists of 144 gas wells (of which, 78 were operational as of 30 June 2020). The target coal seams are the Bulli and Balgownie Coal Seams within the Illawarra Coal Measures at depths of approximately 550–700 metres below ground level (mbgl).

The 2019-2020 CGP groundwater monitoring network comprises two nested monitoring sites (seven monitoring bores) targeting the alluvium near the Nepean River, the Ashfield Shale, and the Hawkesbury Sandstone overlying the target coal seams: Menangle Park (monitored since June 2013) and Glenlee (monitored since February 2014). Groundwater levels have been recorded at six-hourly intervals and water quality data have been collected on a six-monthly basis during the monitoring year.

Previously, there was an additional nested monitoring site at Denham Court (monitored from 2011 to 2016) with four monitoring bores. All bores at the Denham Court site were decommissioned in October 2016 at the landowner's request, with the final water quality monitoring undertaken at this site in April 2016 and groundwater level data available until October 2016. The Denham Court site was located 12 km from the CGP and acted as a control or background monitoring location.

Surface water is monitored at one monitoring location along the Nepean River next to the Menangle Park site for both surface water quality and water level. River levels have been recorded at three-hourly intervals and water quality data have been collected on two occasions during the 2019/20 monitoring year.

This report presents an assessment of water level and water quality data from the groundwater monitoring network and from the Nepean River for the period up to 30 June 2020, with an emphasis on data obtained during the past 12 months.

The groundwater level in the Nepean River alluvium is shallow and shows a direct response to rainfall and flood events (when occurring). Groundwater levels are shallow (approximately 8 mbgl to 15 mbgl) and follow similar trends in each of the screened Hawkesbury Sandstone water bearing zones (defined as upper, middle, and lower). There is no apparent response to individual rainfall events over the monitoring period at the Glenlee site, while a clear response to rainfall events can be observed at the Menangle Park site. The recorded groundwater levels, during the 2019/20 monitoring year, were overall comparable to groundwater levels recorded during previous monitoring years and consistent with the climatic variations.

Groundwater sampled from the alluvium at the Menangle Park site is fresh to marginally brackish, and generally has low dissolved metal concentrations. Groundwater sampled from the Hawkesbury Sandstone is fresh to marginally brackish at the Menangle Park site, and slightly saline at the Glenlee site. Dissolved metal concentrations in the Hawkesbury Sandstone are generally low and minor detections of hydrocarbons were reported in the lower Hawkesbury Sandstone at the two monitoring sites. Dissolved methane was detected at all monitoring bores, although concentrations at the Menangle Park were comparable to the former control site at Denham Court (sampled in previous monitoring years). Low concentrations of dissolved ethane and propane were reported at the Glenlee site, and toluene was detected at both lower Hawkesbury Sandstone monitoring bores.

Overall, groundwater quality during the 2019/20 monitoring year was comparable to the quality of groundwater as measured during previous monitoring years.

Based on assessment of the available data, there are no observable impacts to groundwater levels or quality that could be attributable to the CSG operations. There is also no evidence of connectivity between the shallower monitored zones and the coal seams. This corroborates the conceptual model (Parsons Brinckerhoff 2011) indicating the presence of extensive and thick claystone formations (aquitards and aquicludes) between the Hawkesbury Sandstone and coal seams restricts upward depressurisation and impedes the vertical flow of groundwater.

Table of Contents

Appendices

Tables

Figures

1 Introduction

1.1 Background

AGL Upstream Investments Pty Ltd (AGL) owns and operates the Camden Gas Project (CGP) located in the Macarthur region, 65 kilometres (km) southwest of Sydney, NSW. The CGP has been producing natural gas from coal seams for the Sydney region since 2001 and currently consists of 144 gas wells (of which, 78 were operational on 30 June 2020) within the Stage 1 and Stage 2 areas (Figure 1.1). The target coal seams are the Bulli and Balgownie Coal Seams within the Illawarra Coal Measures at depths of approximately 550–700 metres below ground level (mbgl).

EMM Consulting Pty Ltd (EMM) was engaged by AGL to compile groundwater and surface water monitoring results collected between 1 July 2019 and 30 June 2020 (the 2019/20 monitoring year) and to analyse with reference to the CGP activities. Installation of a dedicated water monitoring network of 11 monitoring bores occurred between October 2011 and February 2014. The current groundwater monitoring network comprises seven dedicated monitoring bores in the alluvium, the Ashfield Shale, and the Hawkesbury Sandstone. The collection of groundwater level and groundwater quality data commenced in October 2011. Groundwater levels have been recorded at six-hourly intervals and, following one initial sample in November 2011, water quality data were collected on a quarterly basis between May 2013 and April 2015 and on a six-monthly basis from April 2015 onwards. In addition, one surface water monitoring location has been sampled for water quality on two occasions during the 2019/20 monitoring year.

This report contains an evaluation of the data obtained during the 2019/20 monitoring year, with comparison to the data obtained during the previous monitoring years (EMM2019b; EMM2018b; EMM2017b; EMM 2016; Parsons Brinckerhoff 2012, 2013a, 2014a, 2014b and 2015e).

Monitoring was undertaken at two sites during the 2019/20 monitoring year: Menangle Park and Glenlee located within the existing CGP Stage 1 and 2 areas (Figure 1.1). During previous monitoring periods there was an additional nested monitoring site at Denham Court (monitored from 2011 to 2016) with four monitoring bores. All bores at the Denham Court site were decommissioned in October 2016 at the landowners' request with the final water quality monitoring undertaken at this site in April 2016 and groundwater level data available until October 2016. Denham Court was located 12 km from the CGP and acted as a control or background monitoring location (Figure 1.1).

The objective of the groundwater monitoring program is to provide water levels and water quality attributes for each of the monitored groundwater systems of the region, in areas within and distant from the currently operating CGP.

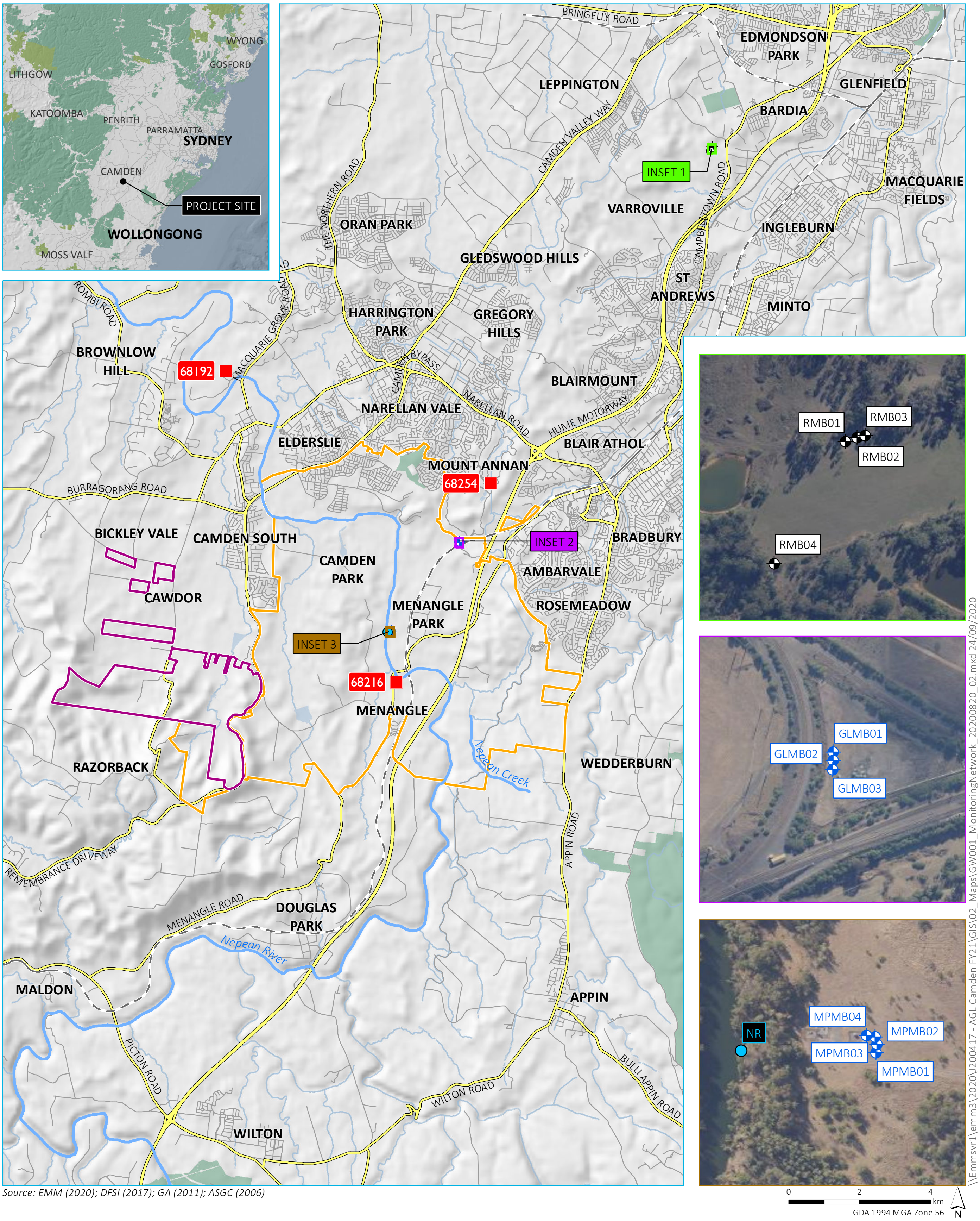
1.2 Scope of works for the 2019/2020 monitoring program

This report presents and interprets groundwater level and groundwater quality data collected since monitoring began at each of the established sites, with emphasis on the data obtained during the 2019/20 monitoring year.

The scope of works was to:

- conduct groundwater monitoring, including six-hourly groundwater level measurements and two groundwater quality sampling events (October 2019 and April 2020) testing for field parameters, major cations and anions, dissolved metals, nutrients, dissolved methane and hydrocarbons;
- conduct surface water quality sampling events (October 2019 and April 2020) at one location (the Nepean River near the Menangle Park site as shown on Figure 1.1);

- analyse and interpret water level and water quality results with reference to the conceptual model, where relevant; and
- establish whether there are any observable impacts from coal seam gas (CSG) activities within the shallow aquifers.



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

KEY

- Camden Gas Project Stage 1
- Camden Gas Project Stage 2
- Surface water sampling location
- Groundwater monitoring bore
- Decommissioned groundwater monitoring bore
- BOM weather station
- Nepean River
- Rail line
- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve

Groundwater monitoring locations

Camden Gas Project
2019 - 2020 groundwater and surface water monitoring report
Figure 1.1

agl

EMM
creating opportunities

\\Emmsvr1\emm3\2020\J200417 - AGL Camden FY21\GIS\02_Maps\GW001_MonitoringNetwork_20200820_02.mxd 24/09/2020

2 Site characterisation

2.1 Rainfall

The nearest Bureau of Meteorology (BoM) weather station with consistent historical climate measurements is located at Camden airport (BoM site number 68192), approximately 2.5 km northwest of the Stage 2 area (Figure 1.1). Mean temperatures at Camden airport range from 17.4°C in July to 29.8°C in January (based on records from 1971 to 2020). The average annual rainfall is 782.1 mm (based on records from 1972 to 2020). On average, July receives the least rain, with a mean rainfall of 35.8 mm, while February receives the most rain, with a mean of 101.6 mm (BoM 2020).

The long-term, annual cumulative deviation from mean (CDFM) rainfall for Camden airport is plotted in Figure 2.1. Annual rainfall data for BoM site number 68216 (located approximately 10 km southeast from the Camden airport 68192 station) is presented from 2009 onwards as recent rainfall records at Camden airport are incomplete. The long-term CDFM is generated by subtracting the long-term average annual rainfall for the recorded period from the actual annual 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 (Figure 2.1) shows a relatively wet period between 1972 and 1992, followed by a relatively dry period between 1998 and 2007. From 2007 to 2018, the rainfall was typically below the mean rainfall of 782.1 mm per year, showing a relatively dry period. 2019 was the driest year on record, with climatic observations indicating an unprecedented drought in NSW.

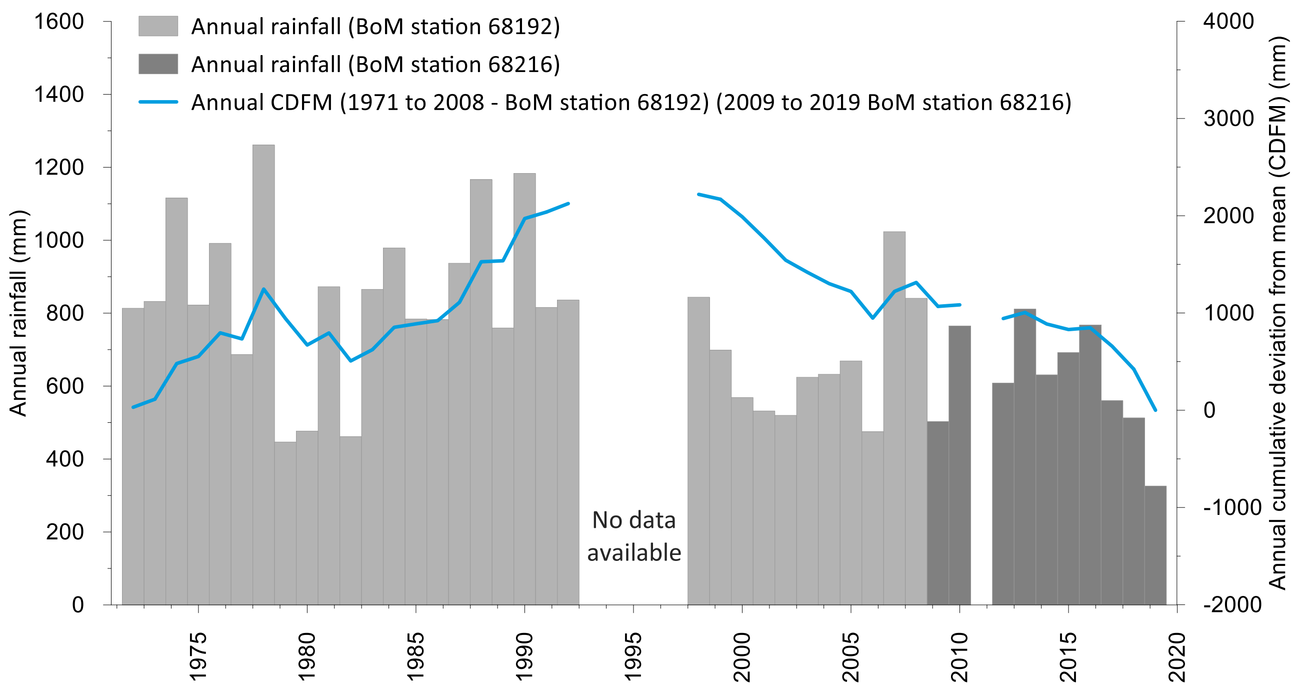


Figure 2.1 Cumulative deviation from annual mean rainfall

The monitoring bore sites are separated by up to a distance of approximately 4 km and therefore groundwater level data for each site have been compared with rainfall data from the closest BoM stations (Figure 1.1) as follows:

- Menangle Park: 68216 Menangle Bridge; and
- Glenlee: 68254 Mount Annan Botanic Garden.

The rainfall characteristics are broadly similar between these BoM stations during the monitoring period, as presented in Figure 2.2. Total monthly rainfall for the 2019/20 monitoring period indicates an exceptionally dry period between July 2019 and January 2020 followed by high rainfall and flood events in February 2020. The remainder of the monitoring period (March to June 2020) is consistent with the long-term average.

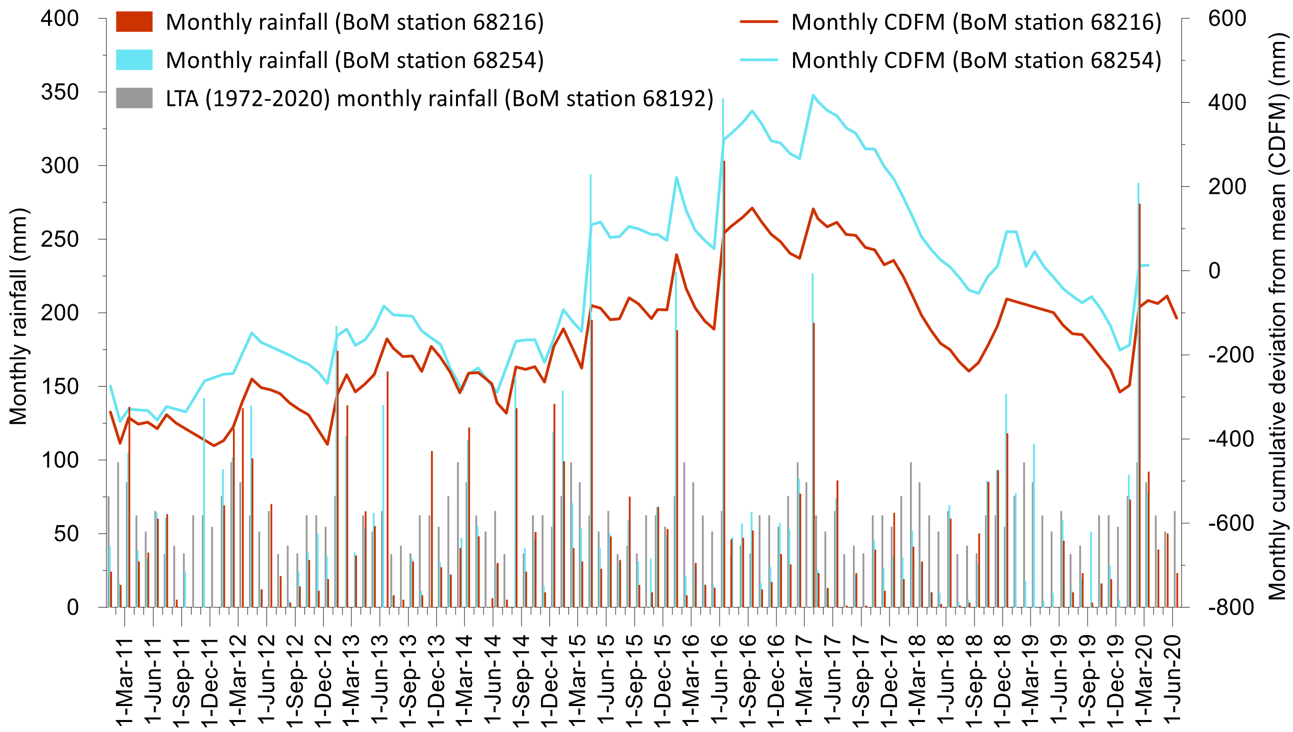


Figure 2.2 Monthly rainfall for the monitoring period (2011-2020)

2.2 Surface hydrology

The CGP is located within two catchment areas: the Hawkesbury Nepean Catchment and the Sydney Metropolitan Catchment. The major surface hydrology features in the CGP are the Nepean River and its tributaries, which meander in a south to north direction within the project area; and the Georges River, which flows in a northerly direction, in the south-east of the project area.

Small farm dams are common in rural areas and provide water for stock, limited garden and irrigation purposes. Dams are replenished by rainfall and runoff, although some seepage flow through the weathered soil profiles occurs after long wet periods. Dams and seepage flows are not related to the regional groundwater systems. There are no known springs in the CGP area.

2.3 Geological setting

The CGP is part of the Southern Coalfield of the Sydney Geological Basin. The Basin is primarily a Permo-Triassic sedimentary rock sequence (Parkin 2002) and is underlain by undifferentiated sediments of Carboniferous and Devonian age. The stratigraphy of the CGP in the Camden-Campbelltown area is summarised in Table 2.1. The geology and structure of the CGP is shown on Figure 2.3.

The Illawarra Coal Measures is the economic sequence of interest for CSG development in the area, and consists of interbedded sandstone, shale and coal seams, with a thickness of approximately 300 m. The upper sections of the Permian Illawarra Coal Measures (Sydney Subgroup) contain the major coal seams: Bulli Coal Seam, Balgownie Coal Seam, Wongawilli Coal Seam, and Tongarra Coal Seam. The seams targeted for CSG production within the CGP are the Bulli and Balgownie coal seams, both of which are 2 m to 5 m thick within the CGP.

The Illawarra Coal Measures is overlain by Triassic sandstones, siltstones and claystones of the Narrabeen Group and the Hawkesbury Sandstone. Overlying the Hawkesbury Sandstone is the Triassic Wianamatta Group shales which comprise the majority of the surficial geology (where thin alluvial deposits are not present).

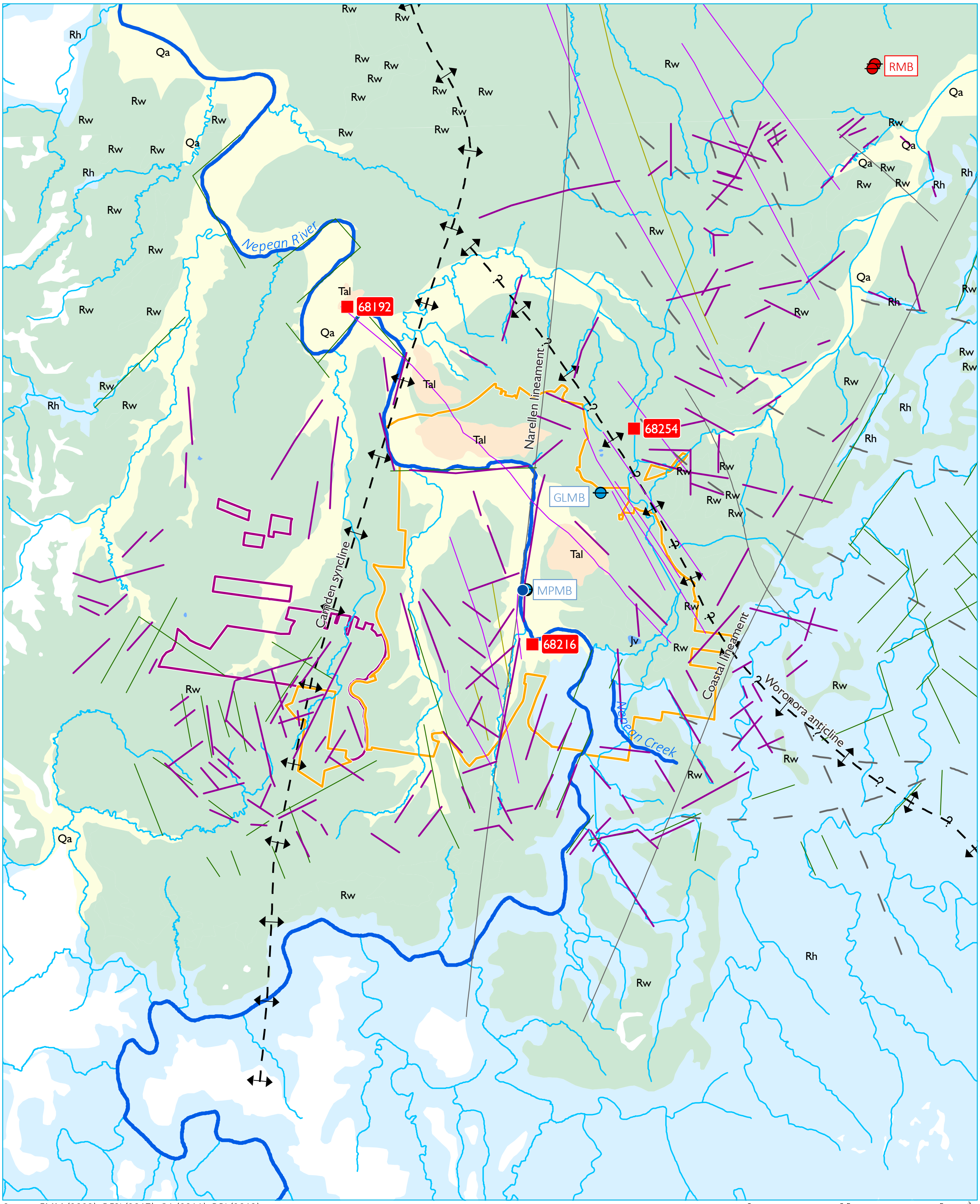
Structurally, the CGP area and surrounds are dominated by the north-northeast plunging Camden Syncline, which is a broad and gentle warp structure (Alder et al. 1991 and Bray et al. 2010). The Camden Syncline is bounded in the west and truncated in the south-west by the north-south trending Nepean Structural Zone, part of the Lapstone Structural Complex.

The CGP is relatively unaffected by major faulting apart from a set of NW-NNW trending faults associated with the Lapstone Monocline Structure (Alder et al. 1991 and Blevin et al. 2007). These faults have been identified from exploration and 2D seismic studies and they have been identified as high-angle, low to moderate displacement normal faults (Blevin et al. 2007). Many of these features intersect coal seams however very few, if any, affect the entire stratigraphic sequence and display no expression at surface.

Period	Group	Sub-group	Formation	Description	Average thickness (m)[1]
Quaternary			Alluvium	Quartz and lithic 'fluvial' sand, silt and clay.	<20
Tertiary			Alluvium	High level alluvium.	
Triassic	Wianamatta Group		Bringelly Shale	Shale, carbonaceous claystone, laminate, lithic sandstone, rare coal.	80 (top eroded)
			Minchinbury Shale	Fine to medium-grained lithic sandstone.	-
			Ashfield Shale[2]	Black to light grey shale and laminate (Bembrick et al. 1987).	-
	Mittagong Formation			Dark grey to grey alternating beds of shale laminate, siltstone and quartzose sandstone (Alder et al. 1991).	11
	Hawkesbury Sandstone			Massive or thickly bedded quartzose sandstone with siltstone, claystone and grey shale lenses up to several metres thick (Bowman 1974; Moffitt 2000).	173
	Narrabeen Group	Gosford Sub-group	Newport Formation	Fine-grained sandstone (less than 3 m thick) interbedded with light to dark grey, fine-grained sandstones, siltstones and minor claystones (Bowman 1974).	35
			Garie Formation	Cream, massive, kaolinite-rich pelletal claystone, which grades upwards to grey, slightly carbonaceous claystone containing plant fossils at the base of the Newport Formation (Moffitt 2000).	8
		Clifton Sub-group	Bald Hill Claystone[2]	Massive chocolate coloured and cream pelletal claystones and mudstones, and occasional fine-grained channel sand units (Moffitt 2000).	34
			Bulgo Sandstone	Thickly bedded sandstone with intercalated siltstone and claystone bands up to 3 m thick (Moffitt 2000).	251
			Stanwell Park Claystone[2]	Red-green-grey shale and quartz sandstone (Moffitt 1999).	36
			Scarborough Sandstone	Quartz-lithic sandstone, pebbly in part (Moffitt 1999).	20
			Wombarra Claystone[2]	Grey shale and minor quartz-lithic sandstone (Moffitt 1999).	32
Permian		Sydney Sub-group	Bulli Coal Seam	Coal interbedded with shale, quartz-lithic sandstone, conglomerate, chert, torbanite seams and occasionally carbonaceous mudstone (Moffitt 2000).	4
			Loddon Sandstone		12
			Balmain Coal Member		24
			Balgownie Coal Seam		2
			(Remaining Sydney Subgroup)		
		Cumberland Sub-group			
	Shoalhaven Group			Sandstone, siltstone, shale, polymictic conglomerate, claystone; rare tuff, carbonate, evaporate.	
Palaeozoic	Lachlan Fold Belt			Intensely folded and faulted slates, phyllites, quartzite sandstones and minor limestones of Ordovician to Silurian age (Moffitt 2000).	

Notes: *1. Average thickness from available well data within CGP (AGL 2013).*
2. Aquitard or aquiclude.

Summary of regional Permo-Triassic geological stratigraphy



Source: EMM (2020); DFSI (2017); GA (2011); DPI (2019)

0 2.5 5 km
GDA 1994 MGA Zone 56
N

KEY

- Surface water sampling location
- Groundwater monitoring bore
- Decommissioned groundwater monitoring bore
- BOM weather station
- Camden Gas Project stage 1
- Camden Gas Project stage 2
- Nepean River
- Watercourse

Structures

- Certain fault *(AGL Energy)*
- Possible fault *(AGL Energy)*
- Fault *(Geology 100k DPI / Mauger et al; Southern Coal Fields map)*
- Interpreted Fault *(Geology 100k DPI / Mauger et al; Southern Coal Fields map)*
- Syncline
- Anticline
- Lineament *(CSIRO 1:80,000 Landsat interpreted fracture analysis)*
- Lineaments (air photo interpreted; CSIRO)

250k Geology

- Jv - Basalt, dolerite & volcanic breccia
- Qa - Quaternary alluvium
- Tal - High level gravels
- Rw - Bringelly Shale, Minchinbury Sandstone & Ashfield Shale
- Rh - Hawkesbury Sandstone

Surface geology

Camden Gas Project
2019 - 2020 groundwater and surface water monitoring report
Figure 2.3

agl

EMM
creating opportunities

\\emmsvr1\EMM\Jobs\2020\J200417 - AGL Camden FY21\GIS\02_Maps\GW002_SurfaceGeology_20200819_01.mxd 21/08/2020

2.4 Hydrogeological setting

The Southern Coalfield is located within the area covered by the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources. The CGP is located across two porous rock water sources – the Sydney Basin Nepean water source to the south and the Sydney Basin Central water source to the north (NOW 2011). The recognised hydrogeological units within the CGP are shown in Table 2.2.

Table 2.2 Hydrogeological units within the CGP area

Hydrogeological unit	Aquifer type
Alluvium	Unconfined aquifer
Ashfield Shale (Wianamatta Group)	Aquitard or unconfined/perched
Hawkesbury Sandstone	Unconfined/semi-confined aquifer
Bald Hill Claystone (Narrabeen Group)	Aquitard/aquiclude
Bulgo Sandstone (Narrabeen Group)	Confined aquifer
Stanwell Park Claystone (Narrabeen Group)	Aquitard/aquiclude
Scarborough Sandstone (Narrabeen Group)	Confined aquifer
Wombarra Claystone (Narrabeen Group)	Aquitard/aquiclude
Illawarra Coal Measures	Confined water bearing zones

Alluvium occurs along the floodplain of the Nepean River and its tributaries. Alluvial deposits are generally thin, discontinuous (except along the Nepean River) and relatively permeable. The unconfined groundwater systems within the alluvium are responsive to rainfall and stream flow and form a minor beneficial groundwater system. There are also small terrace areas of Tertiary alluvium within the CGP area that contain localised groundwater systems of variable quality (Figure 2.3).

The Ashfield Shale (which outcrops across the majority of the CGP) is generally of low permeability and yield; however small water bearing zones are sometimes present. Water is typically brackish to saline, especially in low relief areas of western Sydney (due to the marine depositional environment of the shales) (Old 1942). Average bore yields are 1.3 litres per second (L/s) (AGL 2013).

The Hawkesbury Sandstone and Narrabeen Group form part of an extensive generally semi-confined regional groundwater system within the Sydney Basin sequence. The Hawkesbury Sandstone is more widely exploited for groundwater than the overlying and underlying formations, being of generally higher yield, better water quality and either outcropping or buried to shallow depths over the basin. Groundwater flow within the Hawkesbury Sandstone and Narrabeen Group groundwater systems at a regional scale has a major horizontal component, due to the alternation of sheet and massive facies, with some vertical leakage. The Hawkesbury Sandstone and Narrabeen Group are characterised by dual porosity. The primary porosity is imparted by connected void space between sand grains and the secondary porosity is due to the interconnected rock defects such as joints, fractures, faults and bedding planes. Superior bore yield in the sandstone groundwater systems of the Hawkesbury Sandstone is often associated with major fractures or a high fracture zone density, and yields of up to 40 L/s have been recorded in bores intercepting these zones within deformed areas of the Sydney Basin (McLean and Ross 2009). Typically, within the CGP area bore yields within the Hawkesbury Sandstone rarely exceed 2 L/s (SCA 2007 and Ross 2014). The Narrabeen Group aquifer is generally not used as a water source as it is considered to be poorer quality and lower permeability compared to the overlying Hawkesbury Sandstone groundwater systems (Madden 2009).

There is a lack of major fracturing and fault systems intersecting the Hawkesbury Sandstone within the CGP. Yields in the Hawkesbury Sandstone are highest and salinities are freshest south of the Nepean River due to the proximity to recharge areas. North of the Nepean River, the groundwater within the Hawkesbury Sandstone is characterised by higher salinity, becoming moderately saline. Groundwater is used for irrigation and domestic purposes to the south and immediately to the north of the Nepean River; however, further north of the river, groundwater quality is typically only suitable for stock (AGL 2013).

The coal seams present in the Illawarra Coal Measures are both regionally and locally minor water bearing zones. Due to the greater depth of burial of the coal measures and fine-grained nature of the sedimentary rocks, the permeability is generally lower than the overlying sandstone aquifers. Recharge to the Permian water bearing zones is likely to occur where formations are outcropping, which occurs at a significant distance to the south of the CGP. Salinity of the water bearing zones is typically brackish to moderately saline.

Within the CGP, there is limited rainfall recharge to the Ashfield Shale with most rainfall generating runoff and overland flow. Some leakage through the Ashfield Shale into the Hawkesbury Sandstone is expected where there is adequate fracture spacing, however, it is anticipated that most recharge to the sandstone aquifers occurs via lateral groundwater through-flow from upgradient and up-dip areas to the south. There is insufficient data within the CGP to define local flow paths and natural discharge zones; however, regionally, groundwater flow is predominantly towards the north or northeast, eventually discharging via the Georges, Parramatta or Hawkesbury River systems, and ultimately offshore to the east. Locally, there may be a small base flow or interflow discharge component to local stream headwaters during wet periods; however, groundwater-surface water interactions are not well defined within the area (Parsons Brinckerhoff 2010).

3 Monitoring program

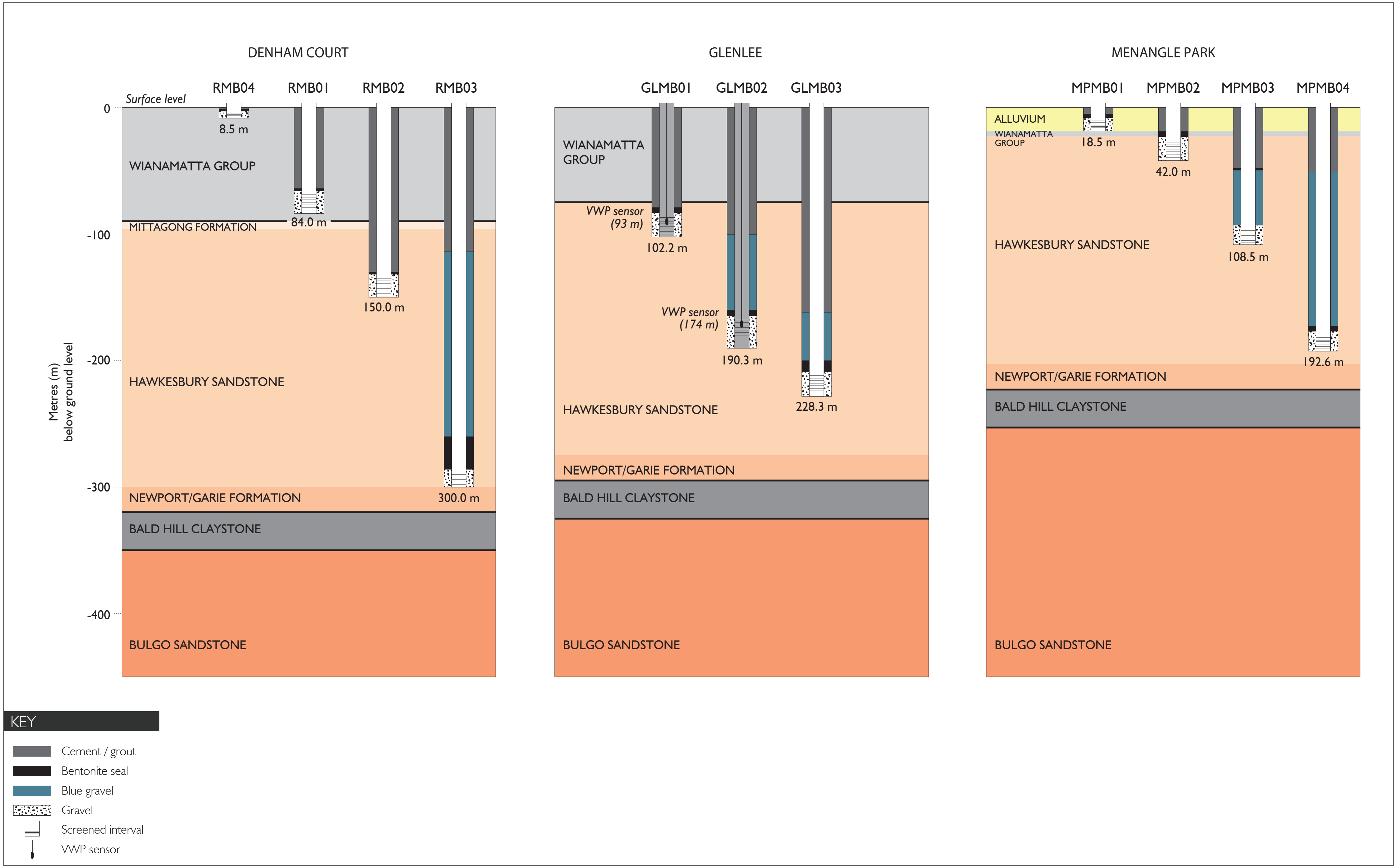
3.1 Monitoring network

Construction details for the 11 monitoring bores within the CGP area are presented in Table 3.1 and Figure 3.1. Currently, only the Menangle Park and Glenlee monitoring bores are being monitored as the Denham Court monitoring bores (RMB01-04) were decommissioned in October 2016.

Table 3.1 Groundwater monitoring bore details

Monitoring bore	Location	Total depth (mbgl)	Screened depth (mbgl)	Lithology	Formation
RMB01[2]	Denham Court	84.0	69.0 – 81.0	Siltstone	Ashfield Shale
RMB02[2]	Denham Court	150.0	135.0 – 147.0	Sandstone	Hawkesbury Sandstone (upper)
RMB03[2]	Denham Court	300.0	290.0 – 299.0	Sandstone	Hawkesbury Sandstone (lower)
RMB04[2]	Denham Court	8.5	4.5 – 7.5	Clay/siltstone	Ashfield Shale (weathered)
MPMB01	Menangle Park	18.5	10.0 – 16.0	Clay	Alluvium
MPMB02	Menangle Park	42.0	27.4 – 39.4	Sandstone	Hawkesbury Sandstone (upper)
MPMB03	Menangle Park	108.5	97.0 – 106.0	Sandstone	Hawkesbury Sandstone (middle)
MPMB04	Menangle Park	192.6	182.6 – 191.6	Sandstone	Hawkesbury Sandstone (lower)
GLMB01	Glenlee	102.2	87.0 – 99.0[1]	Sandstone	Hawkesbury Sandstone (upper)
GLMB02	Glenlee	190.3	168.0 – 180.0[1]	Sandstone	Hawkesbury Sandstone (middle)
GLMB03	Glenlee	228.3	212.0 – 224.0	Sandstone	Hawkesbury Sandstone (lower)

Notes: 1. Monitoring bores GLMB01 and GLMB02 were converted to vibrating wire piezometers (VWP) on 12 March 2015 to maintain borehole integrity (Parsons Brinckerhoff 2015b); the VWP sensors are installed at 93 mbgl and 174 mbgl respectively.
2. Monitoring bores RMB01-04 were decommissioned early October 2016 and are no longer monitored.
mbgl – metres below ground level.



bŜăúŜŘ ǁĞůů ĐŽŶƐƚƌƵĐƚŝŽŶ ĚĞƚĂŝůƐ ĂŶĚ ŐĞŽůŽŐǇ

Camden Gas Project

2019 – 2020 Water Monitoring Report

Figure 3.1

3.2 Water level monitoring

3.2.1 Groundwater levels

Pressure transducers (Solinst Levelogger (M30) dataloggers) are suspended from a galvanised steel wire in the water column and programmed to record a groundwater level every six hours. To verify the level recorded by the dataloggers, manual measurements are recorded periodically using an electronic dip meter. The monitoring start date of the datalogger data at each monitoring bores is shown in Table 3.2.

A barometric logger installed above the water table at monitoring bore MPMB01 records changes in atmospheric pressure. Data from this logger are used to correct for the effects of changing barometric pressure on water level loggers in the adjacent monitoring bores.

Table 3.2 Summary of water level monitoring locations and data collection periods

Monitoring locations	Monitoring period
Denham Court (RMB01, RMB02, RMB03, RMB04)	November 2011 (June 2013 for RMB04) – October 2016
Menangle Park (MPMB01, MPMB02, MPMB03, MPMB04)	June 2013 – present
Glenlee (GLMB01, GLMB02, GLMB03)	February 2014 – present

The vibrating wire piezometer (VWP) sensors at GLMB01 and GLMB02, which were installed in March 2015, are interpreted to have stabilised at lower piezometric pressure head levels compared with pressures observed from the former standpipe monitoring bores prior to conversion to VWPs. The resulting data are not considered to be representative of formation pressures. It is possible that during the conversion of the monitoring bores to VWP's the grout did not fully penetrate the gravel pack of the former standpipe monitoring bore, creating an unnatural pressure gradient adjacent to the piezometer and bore wall. The gravel pack has a much higher hydraulic conductivity (K) (both horizontal and vertical K) than the grouted VWP sensor and the surrounding formation. In this case the higher vertical gradient in the gravel pack may be responsible for reducing horizontal pressure on the sensor hence the observed pressure difference. Although the absolute pressure values post-VWP installation are not representative of formation pressures, the trends in the data are. These trends are therefore still useful.

3.2.2 Surface water levels

Water levels in the Nepean River are monitored by the BoM (gauging station 68216) using automatic dataloggers close to the Menangle Park site (Figure 1.1). These water levels have been included in the hydrograph for the Menangle Park site for comparison (refer to Section 4; Figure 4.1). The river height is derived from automated telemetric real-time data that have been processed to remove erroneous data.

3.3 Water quality monitoring

Groundwater sampling has been undertaken on 11 occasions at Denham Court (since November 2011), 17 occasions at Menangle Park (since August 2013) and 15 occasions at Glenlee (since February 2014) with details provided in Table 3.3.

Surface water quality sampling has been undertaken on nine occasions (since 2013) at the Nepean River site next to the Menangle Park groundwater monitoring site.

Groundwater and surface water sampling was undertaken twice in the 2019/20 monitoring year at Menangle Park, Glenlee and the Nepean River on 16 October 2019 and 15 April 2020.

Sampling of groundwater and surface water was undertaken by Parsons Brinckerhoff from October 2011 through to April 2016. Sampling from October 2016 onwards has been undertaken by EMM.

Table 3.3 Groundwater quality program

Sampling event	Denham Court	Menangle Park	Glenlee	Reference report
November 2011	√[1]	-	-	Parsons Brinckerhoff (2012)
May 2013	√[1]	-	-	Parsons Brinckerhoff (2013a)
August 2013	√[2]	√[3]	-	Parsons Brinckerhoff (2013c)
November 2013	√[4]	√	-	Parsons Brinckerhoff (2014c)
February 2014	√[2]	√	√	Parsons Brinckerhoff (2014d)
May 2014	√[2]	√	√	Parsons Brinckerhoff (2014e)
August 2014	√[2]	√	√	Parsons Brinckerhoff (2014f)
January 2015	√[2]	√	√	Parsons Brinckerhoff (2015a)
April 2015	√[2]	√	√[5]	Parsons Brinckerhoff (2015b)
October 2015	√[4]	√	√[5]	Parsons Brinckerhoff (2015d)
April 2016	√[4]	√	√[5]	Parsons Brinckerhoff (2016a)
October 2016	*	√	√[5]	EMM (2016)
April 2017	*	√	√[5]	EMM (2017a)
October 2017	*	√	√[5]	EMM (2017c)
April 2018	*	√	√[5 6]	EMM (2018a)
October 2018	*	√	√[5]	EMM (2018c)
April 2019	*	√	√[5]	EMM (2019a)
October 2019	*	√	√[5]	EMM (2019c)
April 2020	*	√	√[5]	EMM (2020a)

Notes: 1. RMB01 not sampled due to insufficient water in monitoring bore.
2. RMB01 and RMB02 not sampled due to insufficient water in monitoring bores.
3. MPMB04 not sampled due to blockage in monitoring bore (Parsons Brinckerhoff 2013b).
4. RMB04 not sampled due to insufficient water in monitoring bore.
5. GLMB01 and GLMB02 not sampled as converted to vibrating wire piezometers (VWP) in March 2015 (Parsons Brinckerhoff 2015b).
6. GLMB03, MPMB03, and MPMB04 were re-sampled on 24 April 2018 to include dissolved methane analysis,
– = monitoring locations not yet installed.
*= Site not sampled due to bore decommissioning in early October 2016.

3.3.1 Sampling techniques

Two methods were used to obtain groundwater quality samples from the monitoring bores. The methods were selected based on the permeability of the screened formation of each bore, which was determined during hydraulic conductivity testing. In summary:

- a submersible 12V pump was used at higher yielding bores MPMB01 and MPMB02; and
- a micro-purge™ low flow sampling pump was used at lower yielding monitoring bores and selected deeper bores: MPMB03, MPMB04 and GLMB03.

Where a submersible pump was used, a minimum of three well volumes was purged from the monitoring bore prior to sampling to allow a representative groundwater sample to be collected. Water quality parameters were measured during and immediately after purging to monitor water quality changes and to indicate representative groundwater suitable for sampling and analysis.

The micro-purge™ system allows groundwater to be drawn into the pump intake directly from the screened portion of the aquifer, eliminating the need to purge relatively large volumes of groundwater from these bores. Water quality parameters were monitored during the micro-purge™ pumping to ensure that a representative groundwater sample was collected.

Physicochemical parameters (pH, electrical conductivity (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.

The surface water samples were taken at the river bank using a telescopic sampler. The sample was collected from just below the water surface and approximately 1 m away from the river bank.

3.3.2 Chemical analysis of water

Groundwater and surface water samples collected in the field 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 3.4 details the analytical suite.

Table 3.4 Analytical suite

Category	Parameters		
Physicochemical parameters (measured in the field)	EC	pH	
	Temperature	ORP	
	DO	TDS	
General parameters	EC[1]	pH[1, 3]	
	TDS		
Major ions	Calcium	Chloride	
	Magnesium	Bicarbonate	
	Sodium	Sulphate	
	Potassium	Fluoride	
	Bromine	Silica	
Metals and minor/trace elements	Aluminium	Cobalt	Mercury[2]
	Antimony[1]	Copper	Nickel
	Arsenic	Cyanide[1]	Selenium
	Barium	Iron	Strontium
	Boron	Lead	Zinc
	Beryllium	Manganese	Uranium
	Cadmium	Molybdenum	Vanadium
Nutrients	Ammonia	Total organic carbon (TOC)	
	Nitrite	Phosphorus (total)	
	Nitrate	Phosphorus (reactive)	

Table 3.4 Analytical suite

Category	Parameters	
Hydrocarbons	Phenol compounds	Total petroleum hydrocarbons (TPH)
	Polycyclic aromatic hydrocarbons (PAH)	Benzene, toluene, ethyl benzene and xylenes (BTEX)
Dissolved gases	Methane	Propane
	Ethene	Butene
	Ethane	Butane
	Propene	

Notes: 1. For samples collected since the May 2013 event.
2. For samples collected since the August 2013 sampling event.
3. Generally analysed outside of recommended holding times.

Samples requiring laboratory analysis were analysed by Australian Laboratory Services (ALS) in Smithfield, a NATA accredited laboratory.

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.

3.3.3 Quality assurance and quality control (QA/QC)

i Field QA/QC

The following field sampling QA/QC procedures were applied in order to prevent cross-contamination and preserve sample integrity:

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

ii 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 to assess sampling and laboratory analysis accuracy.

4 Groundwater levels

Hydrographs showing groundwater levels and rainfall from the start of monitoring until April 2020 (the most recent collection of data) are presented for Menangle Park in Figure 4.1 and Glenlee in Figure 4.2. The Menangle Park site is located close to the Nepean River and river levels from BoM gauging station 068216 have also been included in the hydrograph for comparison (Figure 4.1). Individual hydrographs for each monitoring bore are included in Appendix A.

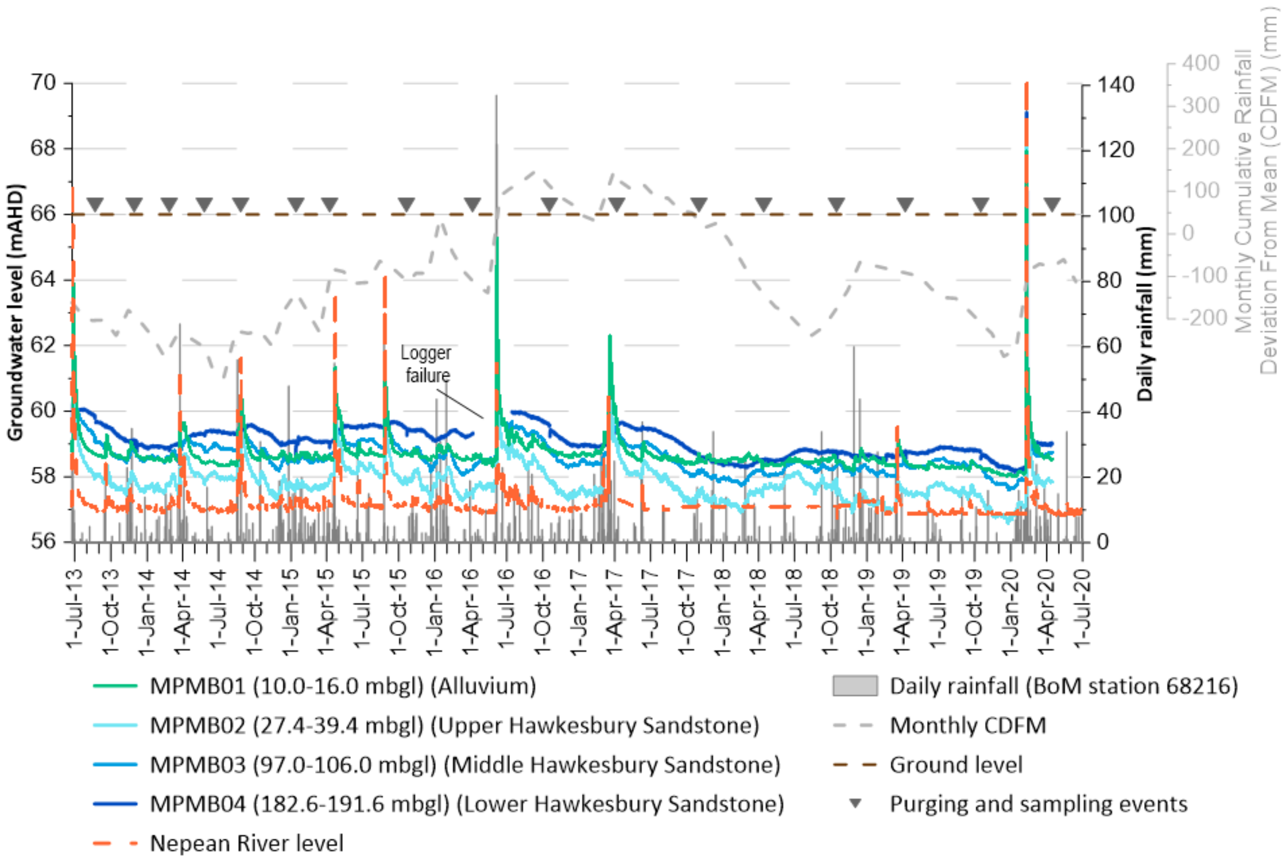


Figure 4.1 Groundwater levels at the Menangle Park site

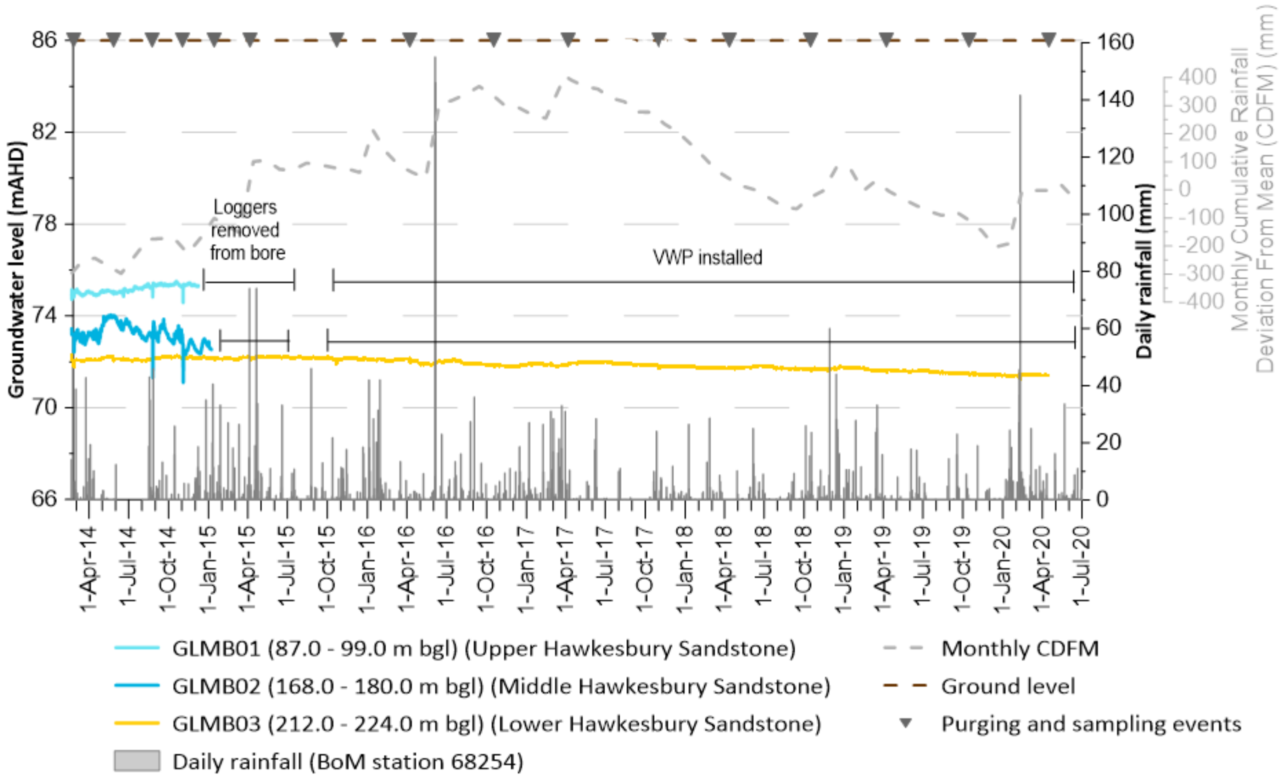


Figure 4.2 Groundwater levels at the Glenlee site

As discussed in Section 3.2.1, VWPs were installed at GLMB01 and GLMB02 in March 2015. It is interpreted that the pressures of the VWP have stabilised at lower piezometric pressure head levels compared with pressures observed from the former standpipe monitoring bores prior to conversion to VWPs, likely caused by inaccurate completion techniques. Although the absolute pressure values post-VWP installation are not representative of formation pressures, the trends in the data are. These data are presented on individual hydrographs for each monitoring bore are in Appendix A.

4.1 Temporal trends

4.1.1 Alluvium

The groundwater level in the alluvium (MPMB01) is shallow (less than 10 mbgl) and shows a direct response to rainfall and flood events (Figure 4.1). During the monitoring year, the groundwater level exhibited a declining trend in response to the drought and prior to the high rainfall events of 2020. A spike was recorded in February 2020 in response to the floods and remained relatively constant for the remainder of the monitoring year.

4.1.2 Ashfield Shale

Monitoring of the Ashfield Shale is no longer completed as the Denham Court bores have been decommissioned.

Previous results have shown that groundwater levels in the Ashfield Shale (RMB01) are typically deep (approximately 80 mbgl) and showed no apparent response to rainfall (EMM 2017b).

4.1.3 Hawkesbury Sandstone

At the Menangle Park site, located next to the Nepean River, groundwater levels are shallow (less than 10 mbgl). A definite response to rainfall and flood events is observed in the upper and middle Hawkesbury Sandstone (monitoring bores MPMB02 and MPMB03), while a slightly subdued and delayed response is generally observed in the lower Hawkesbury Sandstone (MPMB04) (Figure 4.1). A spike was immediately recorded in all the monitoring bores in response to the flood events of February 2020.

At the Glenlee site, groundwater levels are shallow (less than 15 mbgl). In the lower Hawkesbury Sandstone (GLMB03), there is no apparent response to individual rainfall events over the monitoring year (Figure 4.2). The groundwater level followed a slow and steady decreasing trend from 2016 to early 2020 (about 0.1 m/year) consistent with the observed dry period but has stabilised since the high rainfall events of 2020.

4.2 Spatial trends in the Hawkesbury Sandstone

The conceptual model (AGL 2013) and hydrogeological setting (Section 2.4) suggest that regional groundwater flow within the Hawkesbury Sandstone is from south to north towards the incised river systems of the Sydney Basin.

The groundwater level elevations in the Hawkesbury Sandstone aquifer can be compared between the two monitoring sites. The data collected at the CGP suggests that groundwater flow (in the Hawkesbury Sandstone at least) is more complex than the regional conceptual model. The data suggests that:

- the Nepean River in the vicinity of the Menangle Park site is a probable groundwater discharge area (as there is upward groundwater flow within the Hawkesbury Sandstone and there is no Ashfield Shale to act as a cap rock) - groundwater elevations here are between 57 mAHD and 61 mAHD and the Nepean River height is typically between 57 mAHD and 58 mAHD; and
- the Glenlee site may be close to a groundwater divide as groundwater elevations are between 71 mAHD and 75 mAHD.

4.3 Groundwater-surface water interactions

Hydraulic connection between surface water and groundwater exists where the river is in direct contact with the underlying aquifer (Bouwer and Maddock 1997). A 'gaining' stream exists where the water table or groundwater level in a connected aquifer is higher than the running level in a stream and groundwater will flow or discharge to the stream (Land and Water Australia 2007).

The Nepean River level shows a clear response to rainfall (Figure 4.1). The river level is usually lower than the level in the alluvium and Hawkesbury Sandstone units, indicating the river is a gaining river at the Menangle Park site during most of the monitoring period, except for short periods during extremely high rainfall events, when recharge to the alluvial groundwater system occurs.

4.4 Vertical gradients

Vertical gradients provide an indication of the potential for groundwater to flow vertically upward or downward at a particular location. A downward hydraulic gradient indicates a potential for downward flow from the shallower unit to the deeper unit, while an upward gradient indicates the opposite. It is noted that the actual flow direction and velocity is also governed by permeability, particularly the permeability of the confining units.

Potential vertical gradients between the various hydrogeological units were assessed and vary between sites. The following observations are made:

- There is an apparent upward hydraulic gradient at the Menangle Park site within the monitored zones of the Hawkesbury Sandstone; however, a downward gradient exists between the alluvium and the upper Hawkesbury Sandstone. The similar response to rainfall and flood events between the alluvial monitoring bore and the Hawkesbury Sandstone monitoring bores indicates connectivity between the two formations at this location, which is expected given the lack of a substantial confining layer (for example shale) between the formations.

- There is an apparent downward hydraulic gradient within the Hawkesbury Sandstone at the Glenlee site.

Vertical gradients can be influenced by structural geological features (ie faults, folds, and lineaments) and low permeability strata, as described in sections 2.3 and 2.4 respectively.

5 Water quality

Water quality monitoring has been undertaken between November 2011 and April 2020. Water quality samples for the 2019/20 monitoring year were collected on the 16 October 2019 and the 15 April 2020. These results are summarised in this chapter and are compared to previous monitoring years (EMM 2016, EMM 2017b, EMM 2018b, EMM 2019b; Parsons Brinckerhoff 2014, 2014b and 2015e).

The 2019/20 monitoring year full water quality results are presented in Appendix B and laboratory results in Appendix C.

5.1 Groundwater quality

5.1.1 Field parameters

Time series of field EC and pH for the CGP monitoring bores are presented in Figure 5.1 and Figure 5.2. It is suspected that the field pH probe used during the sampling event on 12 April 2018 was calibrated incorrectly; the measured pH values in all monitoring bores were approximately 1 unit lower than historical and following measurements.

Groundwater sampled from the alluvium at Menangle Park (MPMB01) is classified as fresh to marginally brackish. The pH at MPMB01 is acidic and was measured between 4.9 to 5.6 during the 2019/20 monitoring round. The Menangle Park site is a former sand and gravel quarry that has been subsequently rehabilitated. The observed low pH may be related to these previous land use activities.

Groundwater in the Hawkesbury Sandstone at the Menangle Park site (MPMB02-04) is classified as fresh to marginally brackish, while slightly saline conditions are observed at the Glenlee site (GLMB01-03). The fresh to marginally brackish conditions at the Menangle Park site are likely due to the influence of rainfall recharge and connectivity with the Nepean River.

Salinity within the Hawkesbury Sandstone does not show a clear depth related trend at Menangle Park however, salinity decreases with depth at the Glenlee site. This decrease is likely a result of saline groundwater within the Ashfield Shale migrating into the underlying aquifer as a result of vertical leakage. The pH generally increases with depth within the Hawkesbury Sandstone.

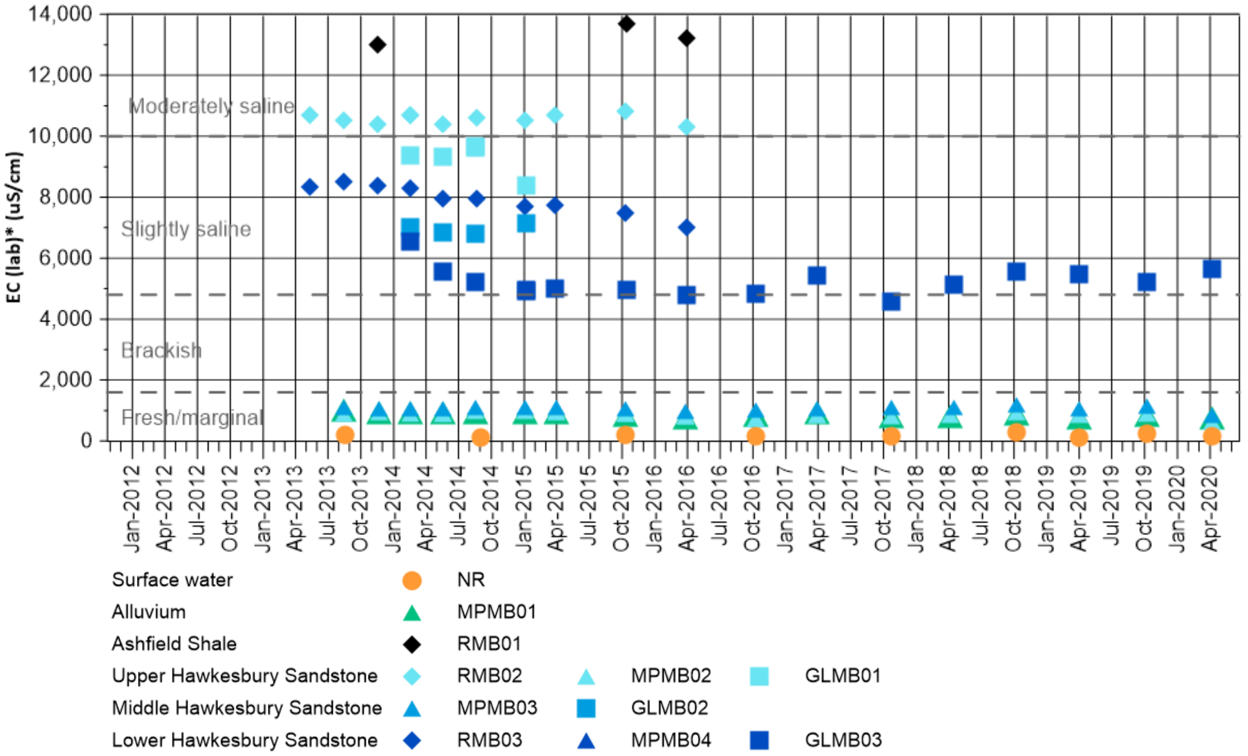


Figure 5.1 EC time series for CGP monitoring bores and Nepean River sample

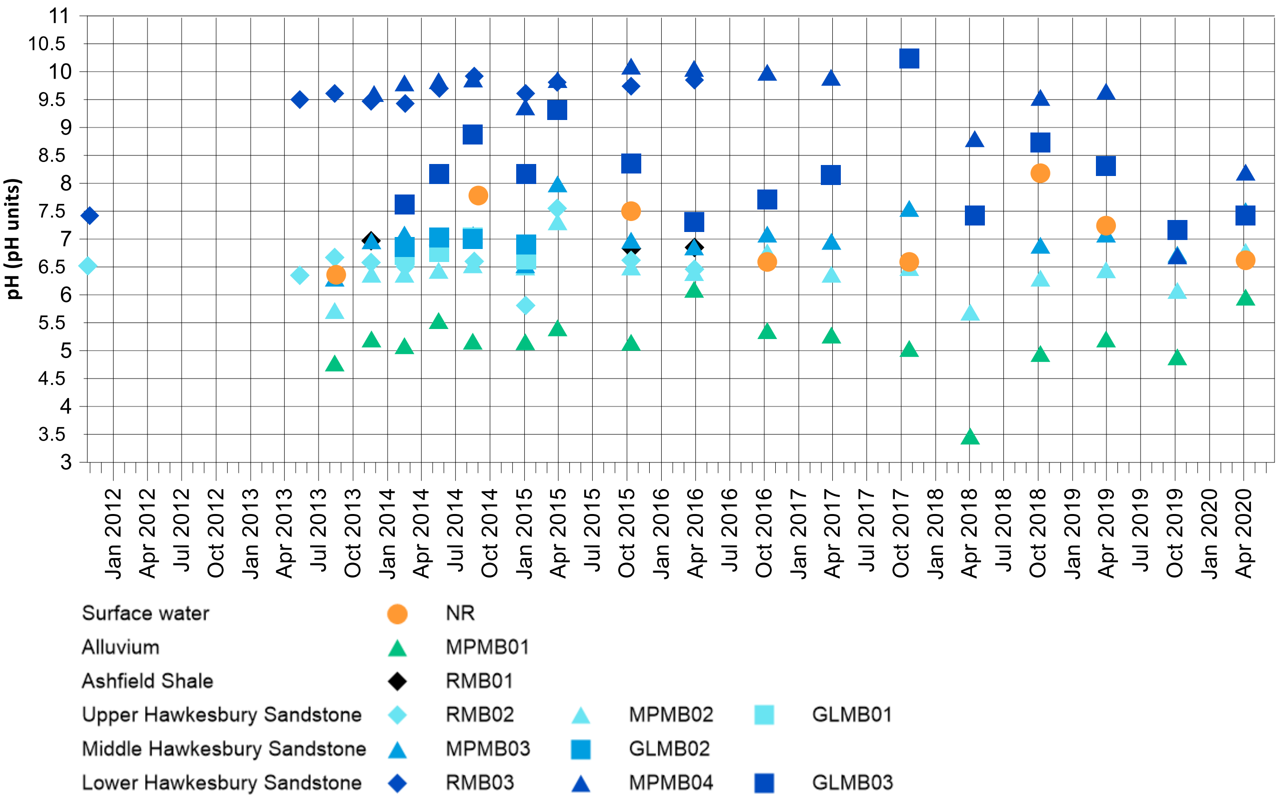


Figure 5.2 pH time series for CGP monitoring bores and Nepean River sample

5.1.2 Major ions

The major ion characteristics of groundwater samples for this monitoring year are shown in a piper diagram and representative bi-variate plots in 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 ratios of sodium/chloride and magnesium/chloride versus chloride concentrations are also presented in two bi-variate plots. Chloride is typically assumed to be a conservative (non-reactive) ion in groundwater systems. Evapotranspiration of the initial water with low chloride concentration would therefore be expected to result in a horizontal trend in a major ion/chloride versus chloride plot.

The alluvium has a different geochemical signature to the Hawkesbury Sandstone. Groundwater in the alluvium is dominated by sodium and chloride and groundwater in the Hawkesbury Sandstone is dominated by sodium and bicarbonate.

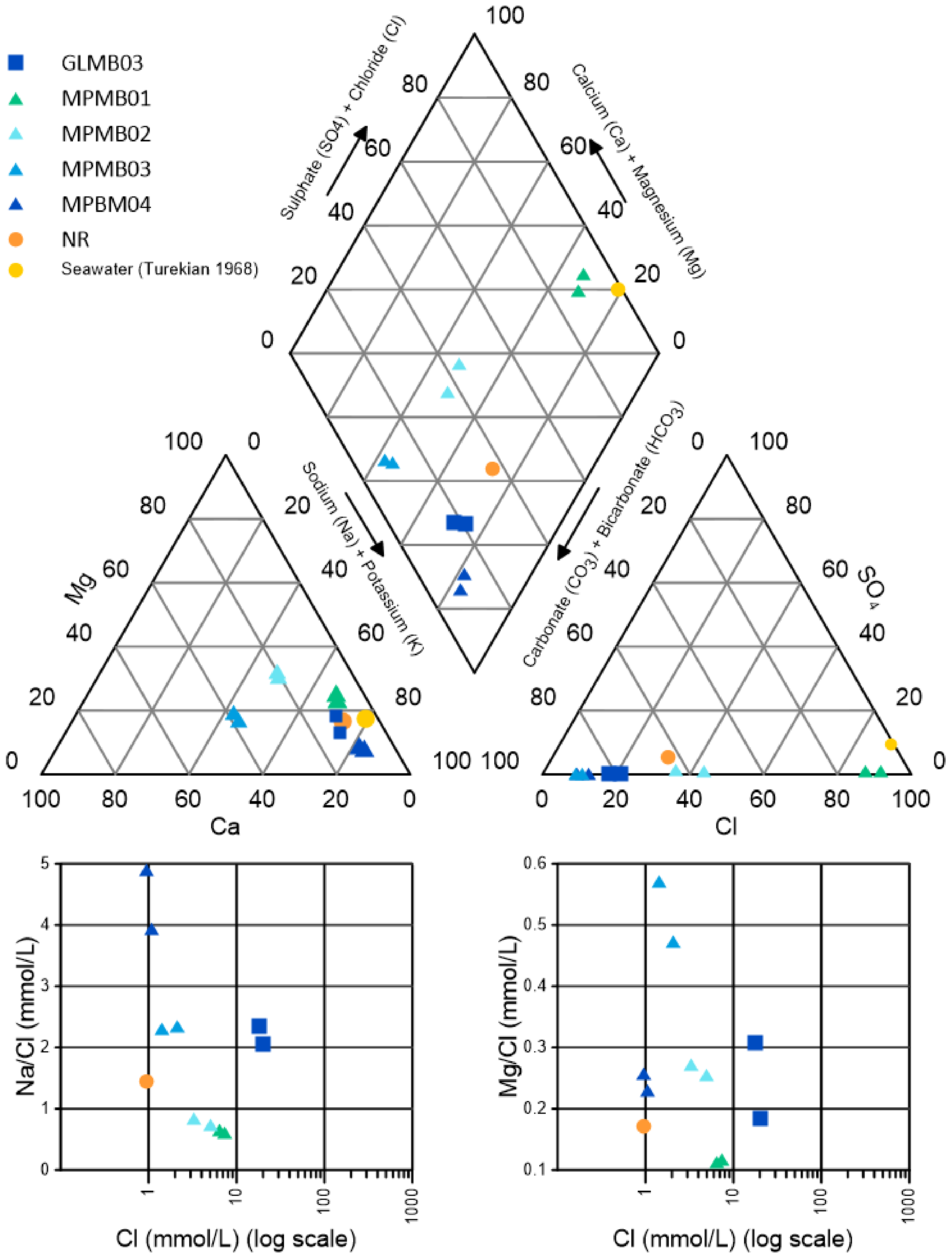


Figure 5.3 **Major ion chemistry of groundwater for CGP monitoring bores (2019/20 monitoring year)**

5.1.3 Dissolved metals

Concentrations of dissolved metals in groundwater are presented in Figure 5.4. The major findings for dissolved metals for this monitoring year are as follows:

- Dissolved metal concentrations are generally similar in the alluvium and the Hawkesbury Sandstone, with exceptions to arsenic, cobalt and nickel concentrations. Dissolved metal concentrations in the alluvium were generally comparable to the previous monitoring year.

- Dissolved metal concentrations in the Hawkesbury Sandstone were generally comparable to the previous monitoring year. However the iron and manganese concentrations measured in April 2020 at MPMB03 were an order of magnitude higher than the previous sampling events. Although these measurements are likely erroneous, future trends should be monitored.

- Slightly elevated dissolved metal concentrations were detected in the Hawkesbury Sandstone at the Glenlee site (eg arsenic, barium and strontium) compared with the Menangle Park site. This is not unexpected given the higher salinity at these locations and the influence from the overlying Ashfield Shale.

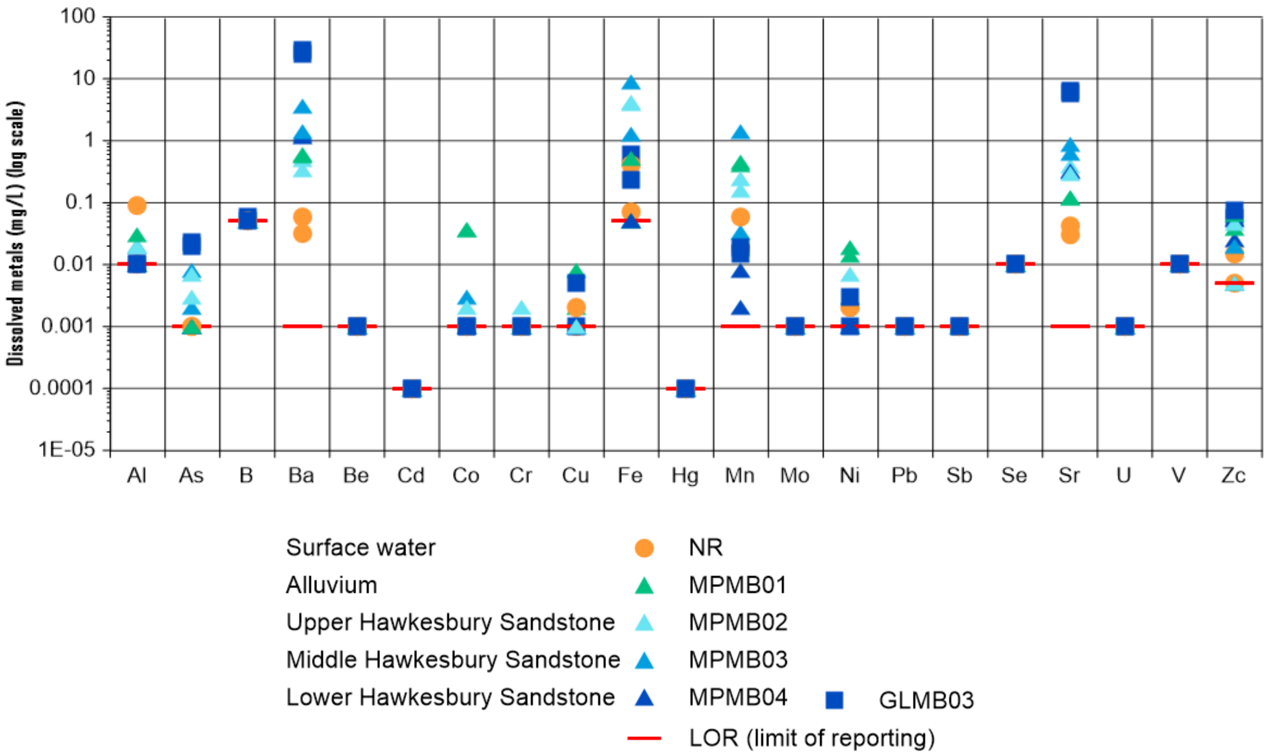


Figure 5.4 Dissolved metal concentrations in groundwater for CGP monitoring bores (2019/20 monitoring year)

5.1.4 Nutrients

A plot showing ammonia versus nitrate in groundwater is presented in Figure 5.5.

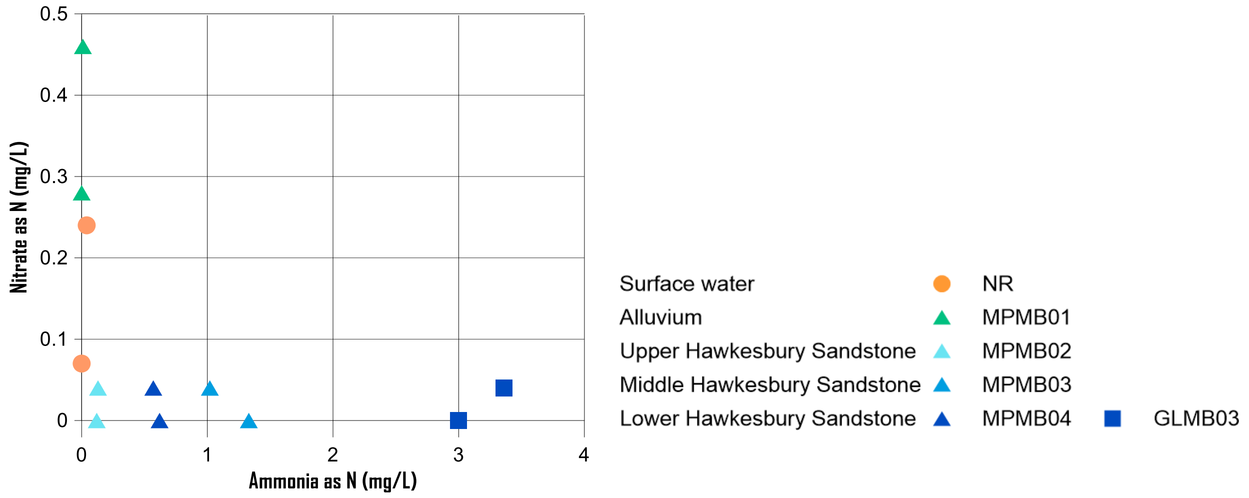


Figure 5.5 Ammonia versus nitrate concentrations in groundwater for CGP monitoring bores (2019/20 monitoring year)

The major findings for nutrients are as follows:

- nitrate concentrations in the Hawkesbury Sandstone groundwater remained low at both sites (<0.1 mg/L as N). Higher concentrations (up to 0.46 mg/L) continued to be recorded in the alluvial aquifer (MPMB01) (Figure 5.5);
- ammonia concentrations were the lowest at Menangle Park, which is consistent with previous monitoring years (Figure 5.5);
- nitrite concentrations remained below the laboratory LOR at all monitoring bores and in the Nepean River;
- low total phosphorus concentrations were detected in all hydrogeological units. Reactive phosphorus concentrations (up to 0.05 mg/L) were detected at the deeper bore of the Glenlee site only (GLMB03); and
- total organic carbon (TOC) concentrations differ between hydrogeological units, being generally the highest in the lower Hawkesbury Sandstone at both sites and comparable in the middle and upper Hawkesbury Sandstone, alluvium and Nepean River.

5.1.5 Dissolved gasses

A time series plot of dissolved methane concentrations in groundwater is presented in Figure 5.6.

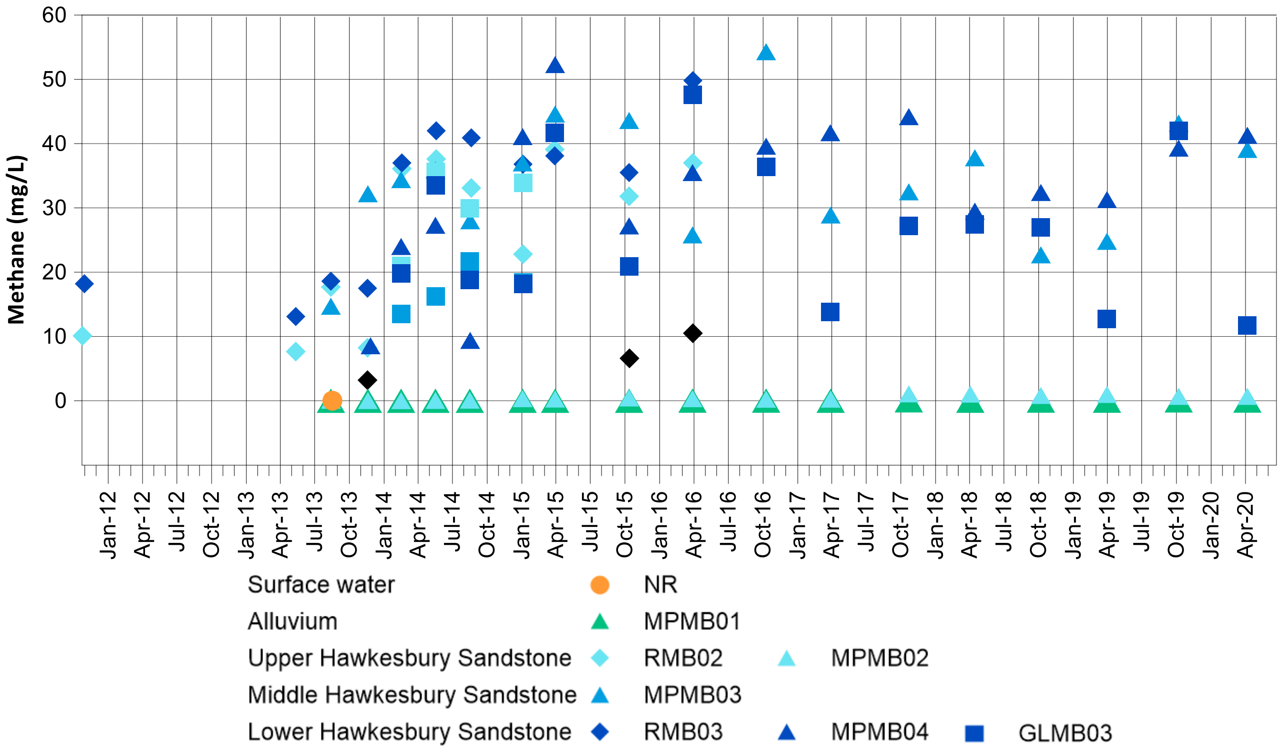


Figure 5.6 Dissolved methane time series for CGP monitoring bores and Nepean River samples

The major findings for dissolved gases are as follows:

- Low concentrations of dissolved methane were detected in the alluvium (MPMB01) in October 2019 (0.06 mg/L) and April 2020 (0.04 mg/L).
- Dissolved methane was detected in the Hawkesbury Sandstone at all monitoring sites. Dissolved methane concentrations were lowest at MPMB02 with concentrations of about 1 mg/L while concentrations range between 12 to 43 mg/L at all other Hawkesbury Sandstone bores (Figure 5.6).
- Propane was detected at low concentrations (less than 0.05 mg/L) in groundwater in the lower Hawkesbury Sandstone at Glenlee site (GLMB03) but was not detected above the laboratory detection limits in any of the other monitoring bores.
- Dissolved ethane was detected at GLMB03 at 0.17 mg/L and 0.07 mg/L during the October 2019 and April 2020 monitoring rounds, respectively.

Dissolved methane is shown to be of mostly thermogenic origin (Parsons Brinckerhoff 2014). The presence of dissolved hydrocarbons observed in the groundwater within the Hawkesbury Sandstone is assessed to be naturally occurring, based on the values present within the groundwater at the former control site (Denham Court, RMB) located at significant distance from the CGP gas production wells.

5.1.6 Dissolved hydrocarbons

The Menangle Park site is a former sand and gravel quarry that has been subsequently rehabilitated. Hydrocarbon detections (PAHs and TRHs) at this site may be related to these previous land use activities. During the 2019/20 monitoring year, hydrocarbon detections were not reported (ie reported below the laboratory LOR), with the exception of TRH (C_6-C_{10} fraction) and TPH (C_6-C_9 fraction) detected at the lower Hawkesbury Sandstone monitoring bores (GLMB03 and MPMB04), which is consistent with the previous monitoring years.

Toluene continued to be present in the lower Hawkesbury Sandstone (Appendix B). It is assessed to be naturally occurring, given that it has been detected in groundwater at all monitoring sites at similar concentrations since monitoring commenced, including the former control site (Denham Court, RMB) located at a significant distance from development activities. No other BTEX compounds (ie benzene, xylenes and ethyl benzene) were detected during this monitoring year.

Dissolved hydrocarbons can occur naturally in groundwater, with concentrations derived from carbonaceous material (CSIRO 2011).

5.2 Surface water quality

Surface water quality results of the Nepean River are overall consistent with previous monitoring periods. The results of the 2019/20 monitoring round were compared to ANZECC (2000) guidelines for freshwater ecosystems (95% protection level):

- pH is neutral to slightly acidic, 7.0 and 6.2 in October 2019 and April 2020 respectively, slightly exceeding the ANZECC (2000) guideline range (6.5–8.0 pH units). The pH of the Nepean River is generally higher than the pH of groundwater in the alluvium;
- salinity is fresh, with electrical conductivities measured at 228 and 148 µS/cm in October 2019 and April 2020, respectively; within the guideline range (125–2,200 µS/cm) and lower than groundwater in the alluvium;
- dominant major ions are sodium and bicarbonate;
- dissolved metal concentrations are typically lower than those of groundwater in the alluvium and underlying Hawkesbury Sandstone units and below the guideline values. However, a few exceedances were anecdotally recorded in April 2020 and future trends should be monitored:
  - aluminium concentration of 0.09 mg/L slightly exceeded the guideline value of 0.055 mg/L;
  - copper concentration of 0.002 mg/L slightly exceeded the guideline value of 0.0014 mg/L; and
  - zinc concentration of 0.015 mg/L slightly exceeded the guideline value of 0.008 mg/L;
- nutrient concentrations are generally low with the exception of the April 2020 ammonia concentration of 0.04 mg/L which slightly exceeded the guideline concentration of 0.02 mg/L but was lower than the groundwater concentrations in the alluvium and Hawkesbury Sandstone;
- dissolved methane was detected at a concentration similar to that of groundwater in the alluvium; and
- no detections of dissolved hydrocarbons.

6 Discussion and conclusions

Monitoring of groundwater levels at the nested monitoring bore sites was undertaken using dataloggers, allowing water level trends to be identified in the alluvium, Ashfield Shale, and Hawkesbury Sandstone. Sampling of water quality at all sites also established useful trends.

The Denham Court nested groundwater monitoring site (monitoring bores RMB01, RMB02, RMB03 and RMB04) was decommissioned by AGL at the landowners' request in October 2016. The final water quality monitoring event from the Denham Court bores was in April 2016 (EMM 2016), water level data continued to be collected until decommissioning.

The main findings for the 2019/20 monitoring year regarding **water levels** are:

- The groundwater level in the alluvium at Menangle Park is less than 10 mbgl and shows a direct response to rainfall and flood events.
- Groundwater levels are shallow (less than 15 mbgl) in the Hawkesbury Sandstone at the Menangle Park and Glenlee sites.
- Groundwater levels appear to follow similar trends in each of the Hawkesbury Sandstone units (upper, middle and lower) at Menangle Park. A clear response to rainfall events can be observed even though this is an apparent groundwater discharge area.
- The lower Hawkesbury Sandstone monitoring bore did not record apparent responses to rainfall events at the Glenlee site. However, the groundwater level follows the average rainfall trends; a slow and steady decline was observed during the dry years and drought from 2016 to 2019 but has stabilised since the high rainfall events of early 2020.
- The pressures in the VWP installed at GLMB01 and GLMB02 (installed in 2015) have stabilised at lower piezometric pressure head levels compared with pressures observed from the former standpipe monitoring bores, likely caused by inaccurate installation techniques. The measured pressures are not likely to be representative of formation pressures; however, the trends in the data are, which show changes in pressures consistent with the trends observed at GLMB03.
- For the regional Hawkesbury Sandstone aquifer, groundwater elevations are higher at the Glenlee site (approximately 72-75 mAHD) than the Menangle Park site (approximately 57-60 mAHD).
- Vertical gradients vary between sites. Upward gradients are evident at Menangle Park and downward gradients are evident the Glenlee site.
- The Nepean River elevation is usually lower than the groundwater elevation in the alluvium and Hawkesbury Sandstone units, indicating the river is a gaining stream around the Menangle Park site, except for short periods during very high rainfall events when recharge to the underlying groundwater systems is observed.
- The groundwater level data collected in the alluvium and Hawkesbury Sandstone are indicative of natural systems in long-term equilibrium with occasional seasonal responses to recharge when there is a connection with surface features, as evident at the Menangle site within the alluvium and Hawkesbury Sandstone.

No long-term groundwater level drawdown trends that can be associated to CSG operations (which involves dewatering of the deep coal seams) have been observed in the groundwater level data at any of the monitored locations.

The main findings for the 2019/20 monitoring year regarding **water quality** are:

- Groundwater quality in the alluvium at the Menangle Park site is characterised as fresh to marginally saline and slightly acidic pH. Dissolved metal concentrations are typically low. Minor dissolved hydrocarbons were detected and may be related to previous land use activities.

- Groundwater quality in the Hawkesbury Sandstone ranges from fresh to marginally brackish at the Menangle Park site and is slightly to moderately saline at the Glenlee site. Salinity decreases with depth at the Glenlee site.

- Minor detections of dissolved hydrocarbons were present in the lower Hawkesbury Sandstone. Dissolved methane was detected at all Hawkesbury Sandstone bores and is likely related to degassing of naturally occurring methane after purging during groundwater sampling events. Dissolved ethane and propane were detected at the Glenlee site only. These compounds are assessed to be naturally occurring given that methane has been observed to occur at all sites, including the former control site (Denham Court) which was located at a significant distance from any development activities.

- Toluene was detected at both lower Hawkesbury Sandstone monitoring points. It is assessed to be naturally occurring given that it has been detected at all sites, including the former control site (Denham Court) which was located at a significant distance from the CGP gas production wells. No other BTEX compounds were detected.

- No significant change in water quality was detected during the 2019/20 monitoring year compared to the previous monitoring year (EMM 2019b).

No adverse water quality impacts that can be attributed to CSG operations were observed at any of the monitored sites. Water quality results are not significantly different between the former control site (Denham Court) and monitoring sites located within the CGP footprint (Menangle Park and Glenlee).

From the available data, there are no observable impacts to groundwater levels or quality or surface water quality that could be attributable to the CSG operations. There is also no evidence of connectivity between the shallower monitored zones and the coal seams which corroborates the conceptual model developed during the Phase 1 studies (Parsons Brinckerhoff 2011). The presence of extensive and thick claystone formations (aquitards and aquicludes) between the Hawkesbury Sandstone and the targeted coal seams restricts depressurisation and impedes the vertical flow of groundwater.

References

AGL Upstream Investments Pty Ltd 2013, 'Hydrogeological Summary of the Camden Gas project area'.

Alder, D, Byrnes, J, Cozens, S, Hill, M and Armstrong, M 1991, Programme Completion Report - Camden Drilling Programme, Coal and Petroleum Geology Branch, Department of Mineral Resources, Sydney.

ANZECC 2000, 'Chapter 3 Aquatic Ecosystems', in Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Australian Water Resources Council 1988, 'Guidelines for the preparation of Australian hydrogeological maps', Department of Primary Industries and Energy, Australian Water Resources Council, Water Management Series no. 13.

Bembrick, CS, Herbert, C & Clarke, NR 1987, 'Permo-Triassic Stratigraphy', in Jones and Clarke (eds), Geology of the Penrith 1:100,000 Sheet 9030, Department of Minerals and Energy, Geological Survey of New South Wales, Sydney.

Blevin, J., Hall, L., Chapman, J., and Pryer, L. 2007, 'Sydney Basin Reservoir Prediction Study and GIS', Project MR705, Confidential Report to NSW DPI and Macquarie Energy by FrOG Tech Pty Ltd.

Bouwer H, Maddock T III 1997, 'Making sense of the interactions between groundwater and streamflow; lessons for water masters and adjudicators', Rivers, vol. 6, no. 1, pp. 19–31.

Bowman, HN 1974, Geology of the Wollongong, Kiama and Robertson 1:50,000 sheets, 9029-II, 9028-I & II. Geological Survey of New South Wales, Sydney, 179 pp.

Bray, A, Hatherly, P and Fergusson, CL 2010, 'Seismic reflection evidence for the evolution of the Camden Syncline and Lapstone Structural Complex, central Sydney Basin, Australia'. Australian Journal of Earth Sciences, vol. 57, pp. 993-1004.

Bureau of Meteorology, Climate Data Online, accessed 8 August 2019, http://www.bom.gov.au/climate/data/

CSIRO 2011, 'A desktop study of the occurrence of Total Petroleum Hydrocarbons (TPH) and partially water-soluble organic compounds in Permian coals and associated coal seam groundwater', Report for AGL Energy, EP-13-09-11-11.

EMM 2016, 2015-2016 Groundwater and Surface Water Monitoring Report – Camden Gas Project, prepared for AGL Upstream Investments Pty Ltd by EMM Consulting Pty Ltd.

- 2017a, FY17 Six-monthly monitoring update – April 2017, letter prepared for AGL Upstream Investments Pty Ltd, dated 21 April 2017.
- 2017b, 2016-2017 Groundwater and surface water monitoring report – Camden Gas Project, prepared by EMM for AGL Upstream Investments Pty Ltd.
- 2017c, FY18 Six-monthly monitoring update – October 2017, letter prepared for AGL Upstream Investments Pty Ltd, dated 10 November 2017.
- 2018a, FY18 Six-monthly monitoring update – April 2018, letter prepared for AGL Upstream Investments Pty Ltd, dated 28 May 2018.
- 2018b, 2017-2018 Groundwater and surface water monitoring report – Camden Gas Project, prepared by EMM for AGL Upstream Investments Pty Ltd, dated 24 September 2018.

- 2018c, FY19 Six-monthly monitoring update – October 2018, letter prepared for AGL Upstream Investments Pty Ltd, dated 21 November 2018.

- 2019a, FY19 Six-monthly monitoring update – April 2019, letter prepared for AGL Upstream Investments Pty Ltd, dated 22 May 2019.

- 2019b, 2018-2019 Groundwater and surface water monitoring report – Camden Gas Project, prepared by EMM for AGL Upstream Investments Pty Ltd, dated 23 September 2019.

- 2019c, FY20 Six-monthly monitoring update – October 2019, letter prepared for AGL Upstream Investments Pty Ltd, dated 7 November 2019.

- 2020a, FY20 Six-monthly monitoring update – April 2020, letter prepared for AGL Upstream Investments Pty Ltd, dated 6 May 2020.

Land and Water Australia 2007, 'The Impact on Groundwater Use on Australia's Rivers', Technical report, April 2007.

Madden, A 2009, The Scarborough Sandstone and its connectivity with longwall mining in a water supply catchment', Groundwater 2010, National Groundwater conference, Canberra, NSW, Australia, 31 October – 4 November 2010.

McLean, W and Ross, JB 2009, 'Hydrochemistry of the Hawkesbury Sandstone Aquifers in Western Sydney and the Upper Nepean Catchment', IAH NSW, Groundwater in the Sydney Basin Symposium, Sydney, NSW, Australia, 4-5 August 2009.

Moffit, RS 1999, Southern Coalfield Regional Geology 1:100 000, 1st edition, Geological Survey of New South Wales, Sydney.

- 2000, A Compilation of the Geology of the Southern Coalfield, Notes to Accompany the 1:100,000 Southern Coalfield Geological Map, Geological Survey Report No. GS1998/277, Geological Survey of New South Wales, Sydney.

NSW Office of Water (NOW) 2011, 'Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources – Background document', dated July 2011.

Old, AN 1942, 'The Wianamatta Shale Waters of the Sydney District', Agricultural Gazette of New South Wales, Misc. pub. No. 3225.

Parkin, TJ 2002, 'Disrupted flow in a localised area of the Georges River above longwall mining operations in Appin, NSW. A geophysical investigation based on earth resistivity techniques', Honours Thesis, Department of Earth and Planetary Sciences, Macquarie University.

Parsons Brinckerhoff 2006, 'Hydrochemical and environmental isotope program — Upper Nepean groundwater investigation sites', Report to the Sydney Catchment Authority, Sydney.

- 2011, 'Phase 1 Groundwater Assessment and Conceptual Hydrogeological Model for the Northern Expansion of the Camden Gas Project', 2114759A PR_5375 RevF, dated February 2011, Parsons Brinckerhoff, Sydney.

- 2012, 'Update on the Camden North Phase 2 Groundwater Program – Denham Court Road', 2114759B-SCW-LTR-5637 Rev A, dated August 2012, Parsons Brinckerhoff, Sydney.

- 2013a, 'Camden Gas Project – 2012–2013 Annual Groundwater Monitoring Status Report', dated October 2013, RPT_7568 Rev C, dated October 2013, Parsons Brinckerhoff, Sydney.

- 2013b, Water quality investigation Camden Gas Project, 2114759C PT_7196 RevD, dated July 2013, Parsons Brinckerhoff, Sydney.
- 2013c, ‘Camden Gas project – FY14 Q1 Groundwater Monitoring Update – September 2013’, RPT_7573 Rev B, dated October 2013, Parsons Brinckerhoff, Sydney.
- 2014a, ‘Drilling Completion Report – Denham Court, Menangle Park and Glenlee. Camden Gas Project’, 2114759B-WAT-RPT-7763 Rev01, draft dated August 2014, Parsons Brinckerhoff, Sydney.
- 2014b, ‘Camden Gas Project – 2013-2014 Groundwater and Surface Water Monitoring Status Report’, 2268518A-WAT-RPT-7779 RevC, dated October 2014, Parsons Brinckerhoff, Sydney.
- 2014c, ‘Camden Gas Project – FY14 Q2 Groundwater Monitoring Update – December 2013’, 2193361A-WAT-RPT-7640 RevC, dated April 2014, Parsons Brinckerhoff, Sydney.
- 2014d, ‘Camden Gas Project – FY14 Q3 Groundwater Monitoring Update – March 2014’, 2193361A-WAT-RPT-7720 RevB, dated April 2014, Parsons Brinckerhoff, Sydney.
- 2014e, ‘Camden Gas Project – FY14 Q4 Groundwater Monitoring Update – June 2014’, 2193361A-WAT-RPT-7748 RevB, dated June 2014, Parsons Brinckerhoff, Sydney.
- 2014f, ‘Camden Gas Project – FY15 Q1 Groundwater Monitoring Update – October 2014’, 2268518A-WAT-MEM-001 RevA, dated October 2014, Parsons Brinckerhoff, Sydney.
- 2015a, ‘Camden Gas Project – FY15 Q2 Groundwater Monitoring Update – January 2015’, 2268518A-WAT-MEM-003 RevB, dated March 2015, Parsons Brinckerhoff, Sydney.
- 2015b, ‘Camden Gas Project – FY15 Q3 Groundwater Monitoring Update – April 2015’, 2268518B-WAT-MEM-001 RevD, dated May 2015, Parsons Brinckerhoff, Sydney.
- 2015c, ‘Camden Gas Project – FY15 Q4 Groundwater Monitoring Update – June 2015’, 2268518B-WAT-MEM-002 RevB, dated July 2015, Parsons Brinckerhoff, Sydney.
- 2015d, ‘Camden Gas Project – FY16 Six-monthly monitoring update – October 2015’, 2200644A-WAT-MEM-001 RevC, dated November 2015, Parsons Brinckerhoff, Sydney.
- 2015e, ‘Camden Gas Project – 2014-2015 Groundwater and Surface Water Monitoring Status Report, 2200644A-WAT-RPT-001 RevD, dated October 2015, Parsons Brinckerhoff, Sydney.
- 2016a, ‘Camden Gas Project – FY16 Six-monthly monitoring update – April 2016, 2200644A-WAT-MEM-002 RevB, dated May 2016, Parsons Brinckerhoff, Sydney.

Ross, JB 2014, ‘Groundwater resource potential of the Triassic sandstones of the southern Sydney Basin: an improved understanding’, Australian Journal of Earth Sciences, vol. 61, no. 3, pp.463-474.

Sydney Catchment Authority (SCA) 2007, ‘Appendix 5 - Draft Water Monitoring Guidelines’, Submission to Inquiry into the NSW Southern Coalfields July 2007, Sydney Catchment Authority.

Turekian, KK 1968, Oceans. Prentice-Hall.

Glossary

Acidity	Base neutralising capacity.
Alkalinity	Acid neutralising capacity.
Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains, and alluvial fans.
Alluvial aquifer	Permeable zones that store and produce groundwater from unconsolidated alluvial sediments. Shallow alluvial aquifers are generally unconfined aquifers.
Ammonia	A compound of nitrogen and hydrogen (NH3) that is a common by-product of animal waste and landfills but is also found naturally in reduced environments. Ammonia readily converts to nitrate in soils and streams.
Anion	An ion with a negative charge – usually non-metal ions when disassociated and dissolved in water.
Aquatic ecosystem	The stream channel, lake or estuary bed, water, and (or) biotic communities and the habitat features that occur therein.
Aquiclude	An impermeable unit that acts as a barrier to the flow of groundwater from one formation to another.
Aquifer	Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquifer properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, confined	An aquifer that is overlain by low permeability strata. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.
Aquifer, semi-confined	An aquifer overlain by a low-permeability layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the leaky confining layer – also known as a leaky artesian or leaky confined aquifer.
Aquifer, unconfined	Also known as a water table aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of an unconfined aquifer.
Aquitard	A low permeability unit that can store groundwater and also transmit it slowly from one formation to another. Aquitards retard but do not prevent the movement of water to or from adjacent aquifers.
Australian Height Datum (AHD)	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Beneficial aquifer	An aquifer with a water resource of sufficient quality and quantity to provide either ecosystem protection, raw water for drinking water supply, and agricultural or industrial water.
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.
Boundary	A lateral discontinuity or change in the aquifer resulting in a significant change in hydraulic conductivity, storativity or recharge.
Cation	An ion with a positive charge – usually metal ions when disassociated and dissolved in water.
Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Coal	A sedimentary rock derived from the compaction and consolidation of vegetation or swamp deposits to form a fossilised carbonaceous rock.
Coal seam	A layer of coal within a sedimentary rock sequence.
Coal seam gas (CSG)	Coal seam gas is a form of natural gas (predominantly methane) that is extracted from coal seams.

Concentration	The amount or mass of a substance present in a given volume or mass of sample, usually expressed as milligram per litre (water sample) or micrograms per kilogram (sediment sample).
Conceptual model	A simplified and idealised representation (usually graphical) of the physical hydrogeologic setting and the hydrogeological understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.
Confining layer	Low permeability strata that may be saturated but will not allow water to move through it under natural hydraulic gradients.
Datalogger	A digital recording instrument that is inserted in monitoring and pumping bores to record pressure measurements and water level variations.
Dual permeability aquifer	An aquifer in which groundwater flow is through both the primary porosity of the rock matrix and the secondary porosity of fractures and fissures.
Electrical conductivity (EC)	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved. It is often used as a measure of water salinity.
Facies	An assemblage or association of mineral, rock, or fossil features reflecting the environment and conditions of origin of the rock. It refers to the appearance and peculiarities that distinguish a rock unit from associated or adjacent units.
Fault	A fracture in rock along which there has been an observable amount of displacement. Faults are rarely single planar units; normally they occur as parallel to sub-parallel sets of planes along which movement has taken place to a greater or lesser extent. Such sets are called fault or fracture zones.
Groundwater	The water contained in interconnected pores or fractures located below the water table in the saturated zone.
Groundwater level	The water level measured in a bore; this may be at or close to the water table in unconfined aquifers, or represent the average piezometric level across the screened interval in confined aquifers.
Groundwater flow	The movement of water through openings in sediment and rock within the zone of saturation.
Groundwater system	A system that is hydrogeologically more similar than different in regard to geological province, hydraulic characteristics and water quality, and may consist of one or more geological formations.
Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).
Hydraulic gradient	The change in total hydraulic head with a change in distance in a given direction.
Hydraulic head	A specific measurement of water pressure above a datum. It is usually measured as a water surface elevation, expressed in units of length. In an aquifer, it can be calculated from the depth to water in a monitoring bore. The hydraulic head can be used to determine a hydraulic gradient between two or more points.
Hydrogeology	The study of the interrelationships of geologic materials and processes with water, especially groundwater.
Hydrology	The study of the occurrence, distribution, and chemistry of all surface waters.
Ion	An ion is an atom or molecule where the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge.
Limit or reporting (LOR)	The concentration below which a particular analytical method cannot determine, with a high degree of certainty, a concentration.
Lithology	The study of rocks and their depositional or formational environment on a large specimen or outcrop scale.

Major ions	Constituents commonly present in concentrations exceeding 10 milligram per litre. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulphate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.
Methane (CH_4)	An odourless, colourless, flammable gas, which is the major constituent of natural gas. It is used as a fuel and is an important source of hydrogen and a wide variety of organic compounds.
MicroSiemens per centimetre (µS/cm)	A measure of water salinity commonly referred to as EC (see also electrical conductivity). Most commonly measured in the field with calibrated field meters.
Monitoring bore	A non-pumping bore, is generally of small diameter that is used to measure the elevation of the water table and/or water quality. Bores generally have a short well screen against a single aquifer through which water can enter.
Monitoring period	Refers to data collected between October 2011 and June 2015.
Monitoring year	Refers to data collected between July 2015 and June 2016.
Normal faulting	Where the fault plane is vertical or dips towards the downthrow side of a fault.
Oxidising conditions	Conditions in which a species loses electrons and is present in oxidised form.
Permeability	The property or capacity of a porous rock, sediment, clay or soil to transmit a fluid. It is a measure of the relative ease of fluid flow under unequal pressure. The hydraulic conductivity is the permeability of a material for water at the prevailing temperature.
Permeable material	Material that permits water to move through it at perceptible rates under the hydraulic gradients normally present.
Permian	The last period of the Palaeozoic era that finished approximately 252 million years before present.
pH	Potential of Hydrogen; the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is alkaline and less than 7 is acidic).
Porosity	The proportion of open space within an aquifer, comprised of intergranular space, pores, vesicles and fractures.
Porosity, primary	The porosity that represents the original pore openings when a rock or sediment formed.
Porosity, secondary	The porosity caused by fractures or weathering in a rock or sediment after it has been formed.
Quaternary	The most recent geological period extending from approximately 2.6 million years ago to the present day.
Quality assurance	Evaluation of quality-control data to allow quantitative determination of the quality of chemical data collected during a study. Techniques used to collect, process, and analyse water samples are evaluated.
Recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and by river water reaching the water table or exposed aquifers. The addition of water to an aquifer.
Recharge area	A geographic area that directly receives infiltrated water from surface and in which there are downward components of hydraulic head in the aquifer. Recharge generally moves downward from the water table into the deeper parts of an aquifer then moves laterally and vertically to recharge other parts of the aquifer or deeper aquifer zones.

Recovery	The difference between the observed water level during the recovery period after cessation of pumping and the water level measured immediately before pumping stopped.
Redox potential (ORP or Eh)	The redox potential is a measure (in volts) of the affinity of a substance for electrons – its electronegativity – compared with hydrogen (which is set at 0). Substances more strongly electronegative than (i.e. capable of oxidising) hydrogen have positive redox potentials. Substances less electronegative than (i.e. capable of reducing) hydrogen have negative redox potentials. Also known as oxidation-reduction potential and Eh.
Redox reaction	Redox reactions, or oxidation-reduction reactions, are a family of reactions that are concerned with the transfer of electrons between species, and are mediated by bacterial catalysis. Reduction and oxidation processes exert an important control on the distribution of species like O2, Fe2+, H2S and CH4 etc. in groundwater.
Salinity	The concentration of dissolved salts in water, usually expressed in EC units or milligrams of total dissolved solids per litre (mg/L TDS).
Salinity classification	Fresh water quality – water with a salinity <800 µS/cm. Marginal water quality – water that is more saline than freshwater and generally waters between 800 and 1,600 µS/cm. Brackish quality – water that is more saline than freshwater and generally waters between 1,600 and 4,800 µS/cm. Slightly saline quality – water that is more saline than brackish water and generally waters with a salinity between 4,800 and 10,000 µS/cm. Moderately saline quality – water that is more saline than slightly saline water and generally waters between 10,000 and 20,000 µS/cm. Saline quality – water that is almost as saline as seawater and generally waters with a salinity greater than 20,000 µS/cm. Seawater quality – water that is generally around 55,000 µS/cm. (Australian Water Resources Council 1988)
Sandstone	Sandstone is a sedimentary rock composed mainly of sand-sized minerals or rock grains (predominantly quartz).
Screen	A type of bore lining or casing of special construction, with apertures designed to permit the flow of water into a bore while preventing the entry of aquifer or filter pack material.
Sedimentary rock aquifer	These occur in consolidated sediments such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. These aquifers are generally located in sedimentary basins that are continuous over large areas and may be tens or hundreds of metres thick. In terms of quantity, they contain the largest volumes of groundwater.
Shale	A laminated sedimentary rock in which the constituent particles are predominantly of clay size.
Siltstone	A fine-grained rock of sedimentary origin composed mainly of silt-sized particles (0.004 to 0.06 mm).
Standing water level (SWL)	The height to which groundwater rises in a bore after it is drilled and completed, and after a period of pumping when levels return to natural atmospheric or confined pressure levels.
Stratigraphy	The depositional order of sedimentary rocks in layers.
Surface water-groundwater interaction	This occurs in two ways: (1) streams gain water from groundwater through the streambed when the elevation of the water table adjacent to the streambed is greater than the water level in the stream; and (2) streams lose water to groundwater through streambeds when the elevation of the water table is lower than the water level in the stream.
Tertiary	Geologic time at the beginning of the Cainozoic era, 65 to 2.6 million years ago, after the Cretaceous and before the Quaternary.
Total Dissolved Solids (TDS)	A measure of the salinity of water, usually expressed in milligrams per litre (mg/L). See also EC.

Water quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water quality data	Chemical, biological, and physical measurements or observations of the characteristics of surface and ground waters, atmospheric deposition, potable water, treated effluents, and waste water and of the immediate environment in which the water exists.
Well	Pertaining to a gas exploration well or gas production well.

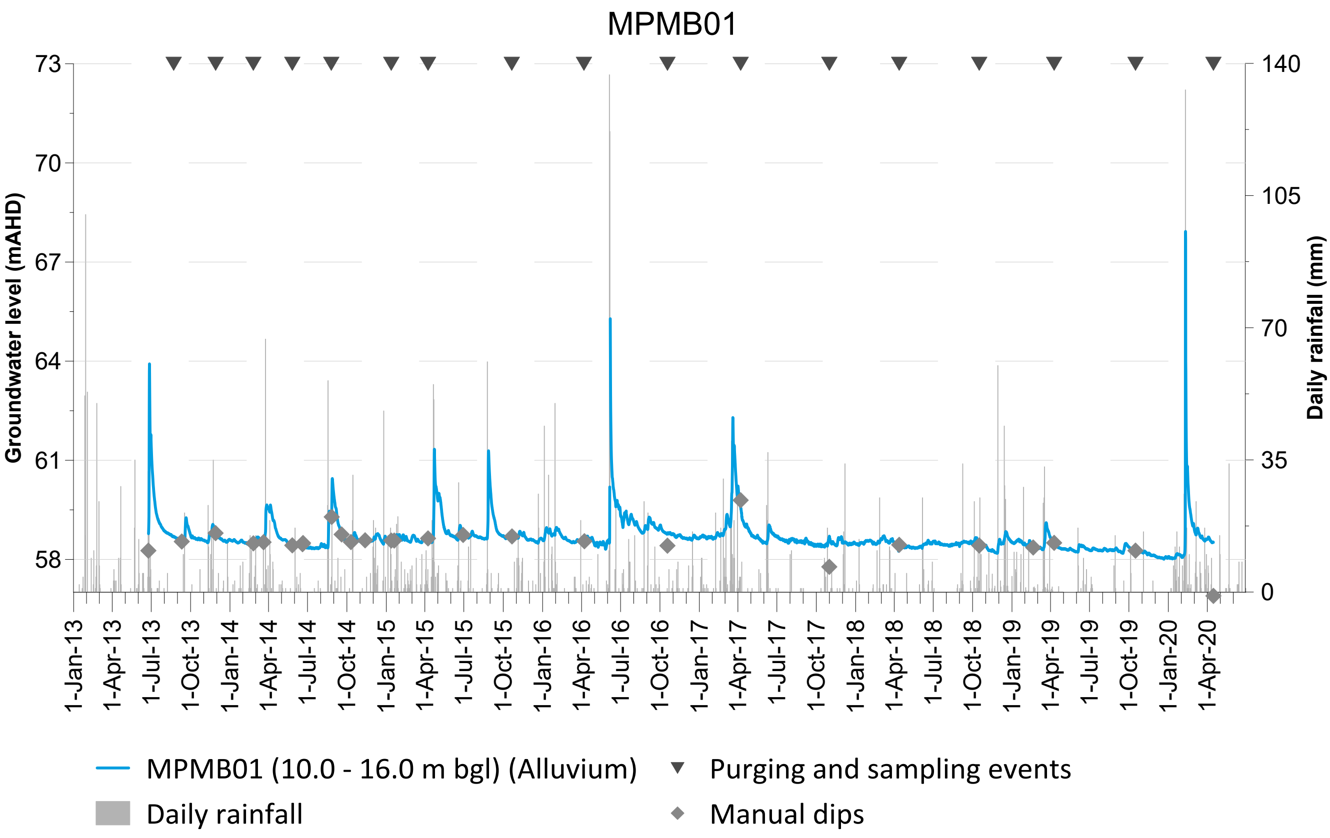
Abbreviations

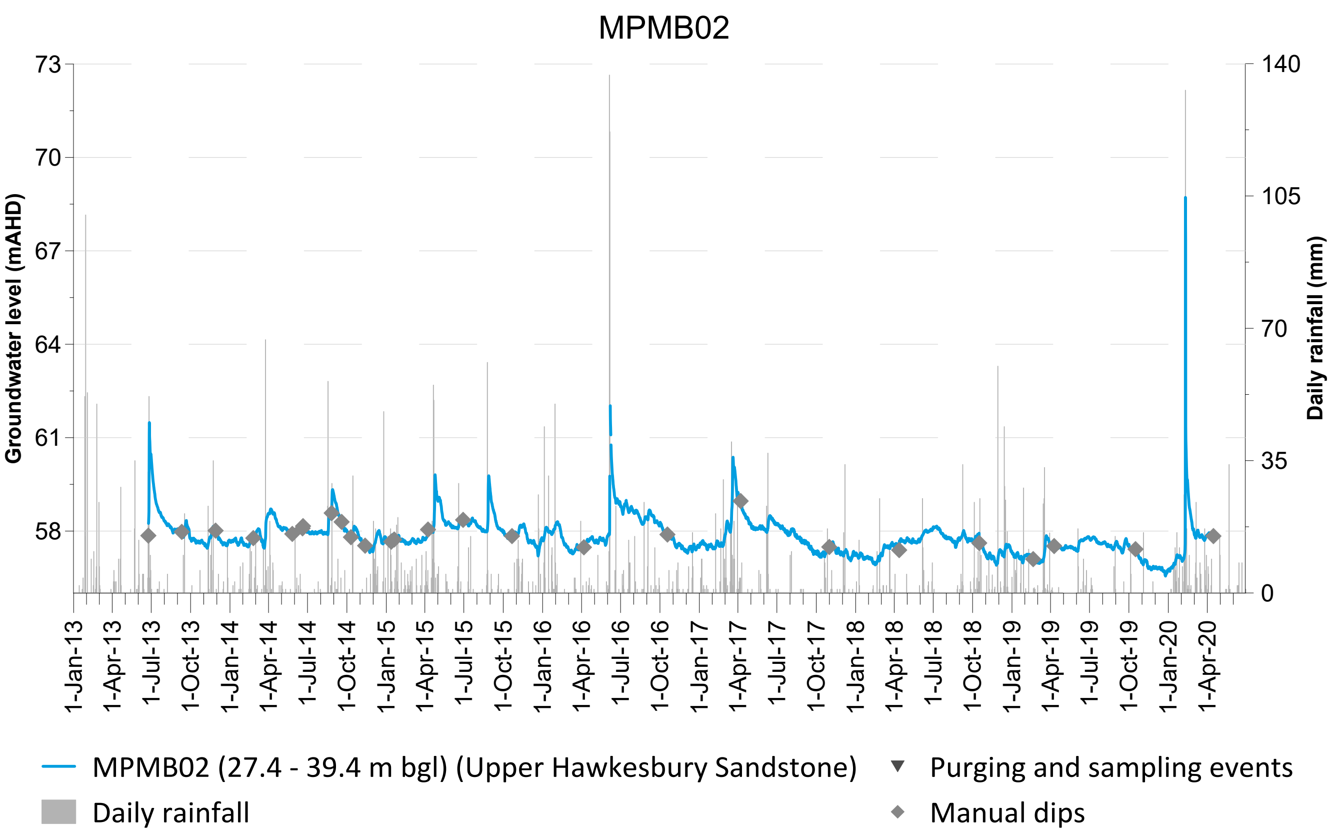
AGL	AGL Upstream Investments Pty Ltd
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethyl benzene and xylenes
CDFM	Cumulative deviation from mean
CGP	Camden Gas Project
CSG	Coal seam gas
DO	Dissolved oxygen
EC	Electrical conductivity
LOR	Limit of reporting
ORP	Oxidation reduction potential
PAH	Polycyclic aromatic hydrocarbons
SCA	Sydney Catchment Authority
TDS	Total dissolved solids
TPH	Total petroleum hydrocarbons
VWP	Vibrating wire piezometer

°C	degrees Celsius
L/s	litres per second
m	metres
mAHD	metres Australian Height Datum
mbgl	metres below ground level
m/d	metres per day
mg/L	milligrams per litre
µg/L	micrograms per litre
mV	millivolt
µS/cm	microSiemens per centimetre

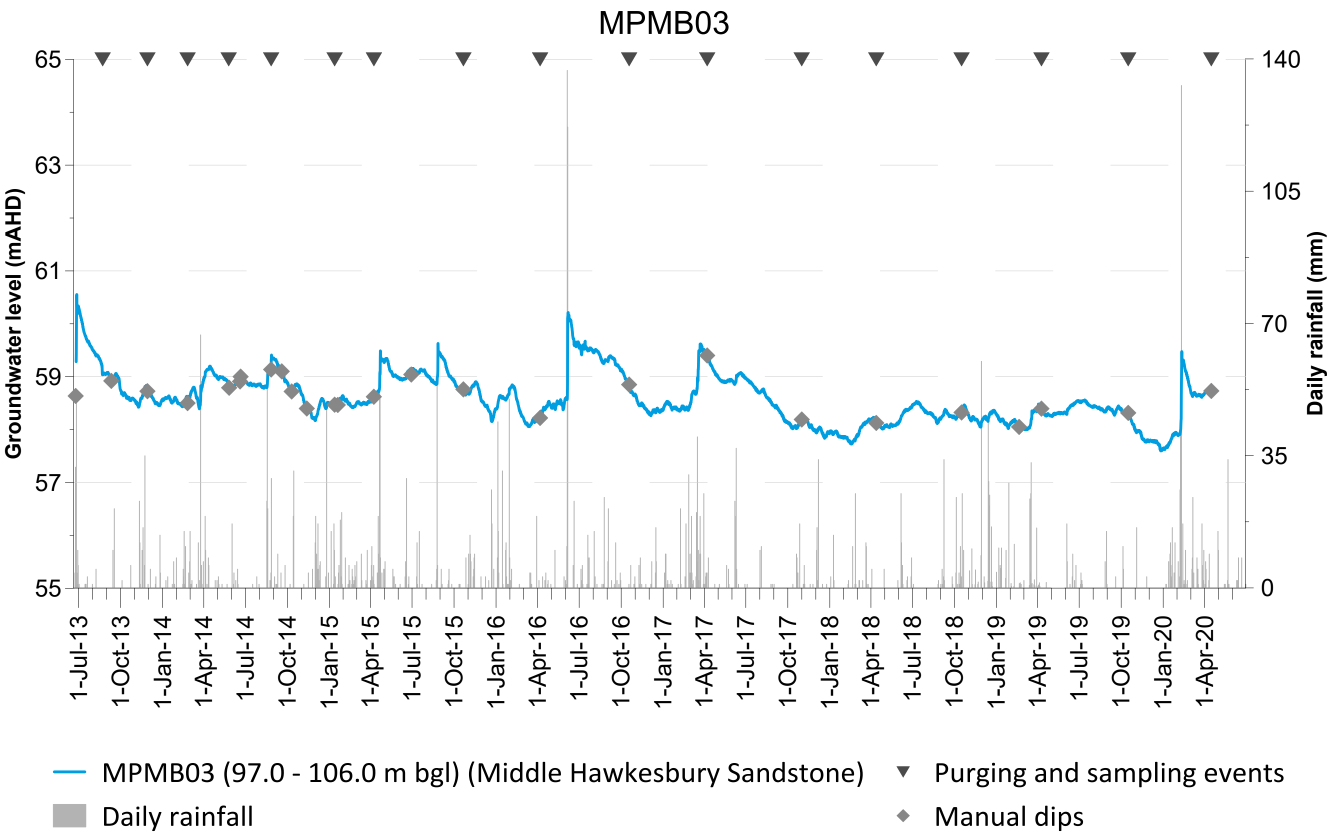
Appendix A

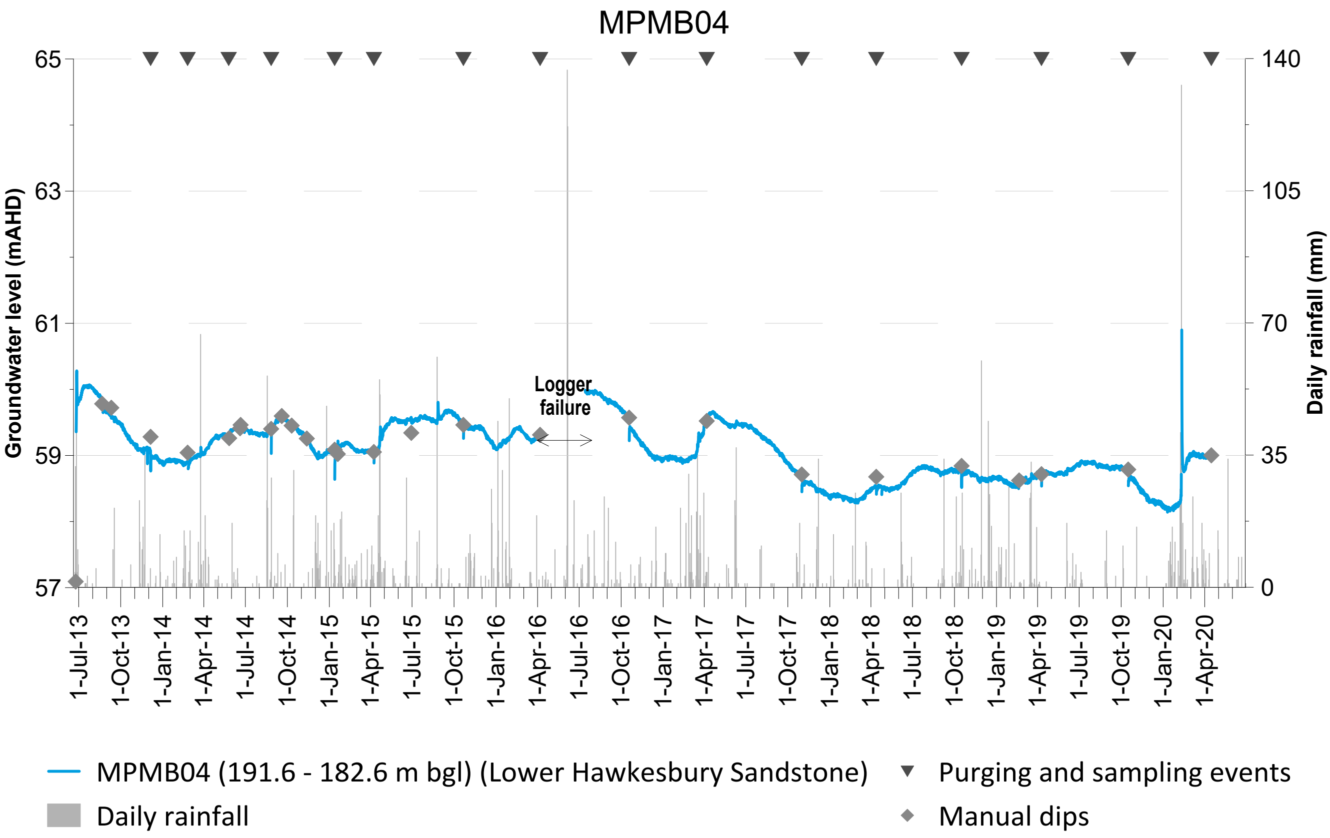
Groundwater hydrographs





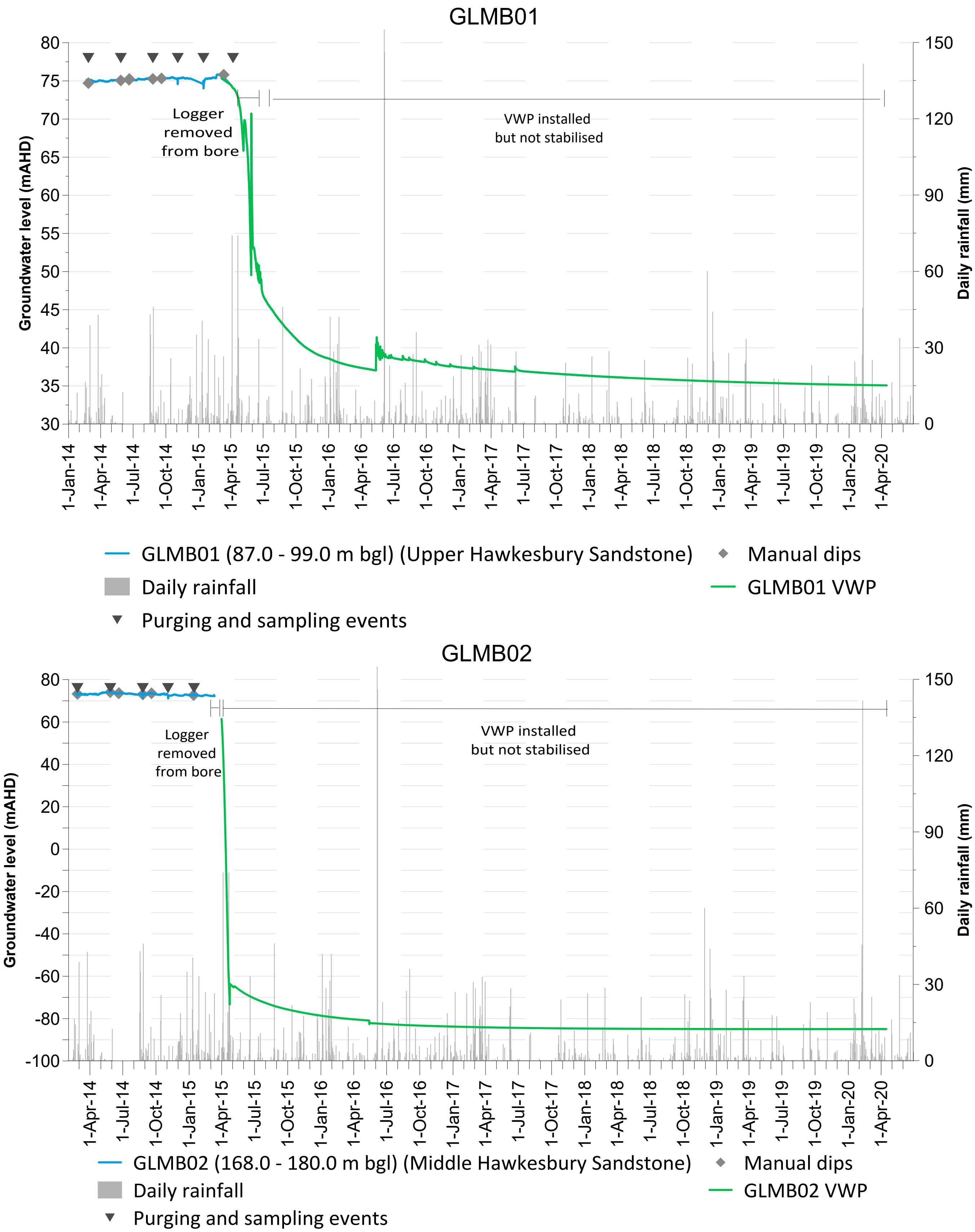
MPMB01 and MPMB02 hydrographs
Camden Gas Project
2019-2020 Water Monitoring Report
Figure A.1





EMM

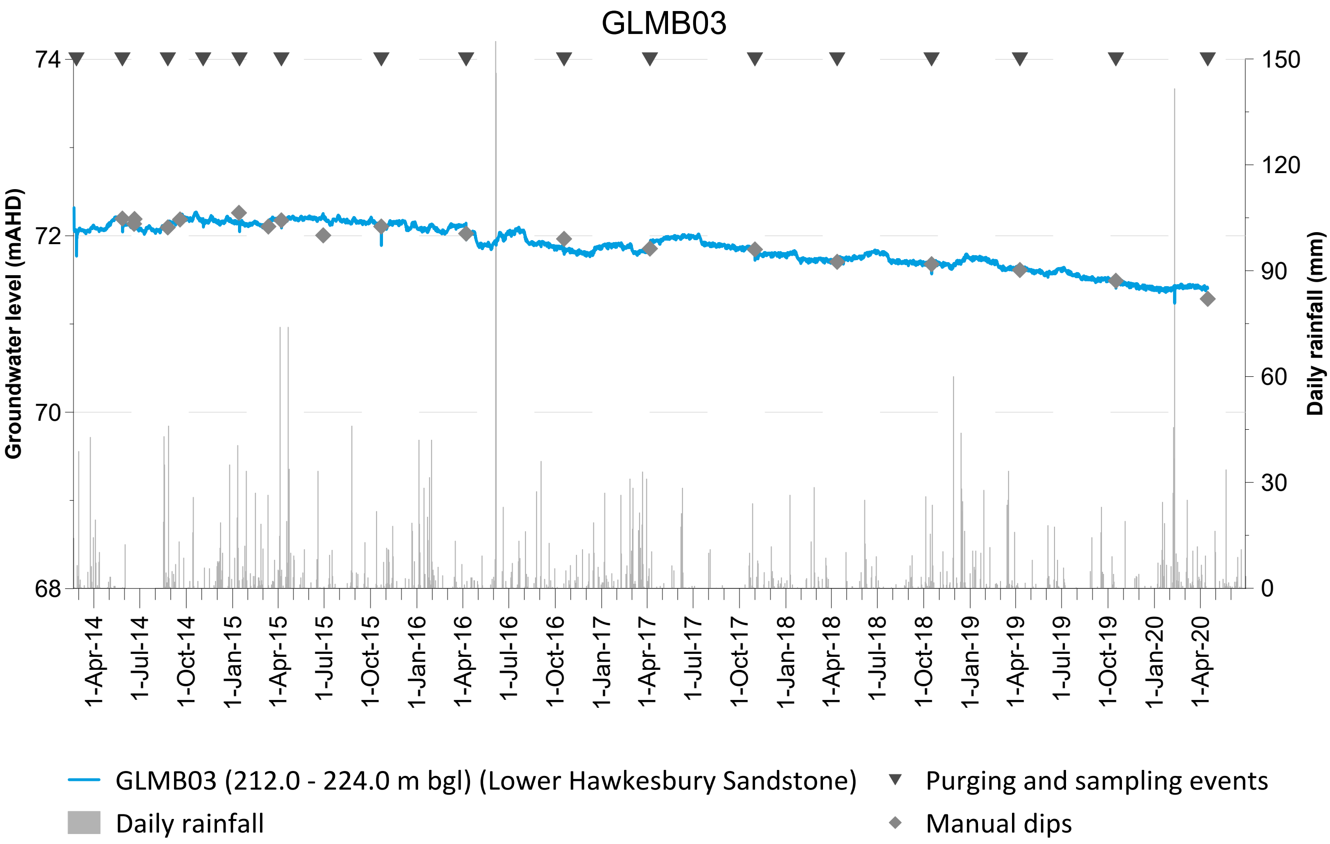
MPMB03 and MPMB04 hydrographs
Camden Gas Project
2019 - 2020 Water Monitoring Report
Figure A.2



Although the absolute piezometric pressure values at GLMB01 and GLMB02 post-VWP installation are not representative of formation pressures, the trends in the data are and are therefore still useful.

EMM

GLMB01 and GLMB02 hydrographs
Camden Gas Project
2019 - 2020 Water Monitoring Report
Figure A.3



GLMB03
Groundwater level (mAHD)
Daily rainfall (mm)
74
72
70
68
150
120
90
60
30
0
1-Apr-14
1-Jul-14
1-Oct-14
1-Jan-15
1-Apr-15
1-Jul-15
1-Oct-15
1-Jan-16
1-Apr-16
1-Jul-16
1-Oct-16
1-Jan-17
1-Apr-17
1-Jul-17
1-Oct-17
1-Jan-18
1-Apr-18
1-Jul-18
1-Oct-18
1-Jan-19
1-Apr-19
1-Jul-19
1-Oct-19
1-Jan-20
1-Apr-20
GLMB03 (212.0 - 224.0 m bgl) (Lower Hawkesbury Sandstone)
Purging and sampling events
Daily rainfall
Manual dips

Appendix B

Water quality summary table

SUMMARY TABLE B.1 - Water quality results at the Glenlee and Menangle Park sites (2019/20 monitoring year)

			Site ID	GLMB03		MPMB01		MPMB02		MPMB03		MPMB04		ANZECC 2000	NR	
			Sample date	16/10/2019	15/04/2020	16/10/2019	15/04/2020	16/10/2019	15/04/2020	16/10/2019	15/04/2020	16/10/2019	15/04/2020	guideline	16/10/2019	15/04/2020
Chemical group	**Analyte**	**Units**	**EQL**											values for		
General parameters	pH (field)	pH units		7.16	7.84	4.89	5.57	6.08	5.92	6.73	6.78	6.7	7.50	6.5 - 8.0**	6.96	6.15
	Electrical conductivity (field)	uS/cm		5079	4664	789	702	863	575	1058	795	514.9	548	125 - 2,200**	213.2	130.4
	Electrical Conductivity @ 25°C	µS/cm	1	5210	5660	839	774	881	628	1130	831	555	583		228	148
	Temperature	°C		22.4	20.9	21.1	22.8	22.3	22.7	20.4	19.4	21.5	21.3		22.5	23.9
	Dissolved oxygen	%		6.1	8	14.1	9	6.2	4.5	10.2	3	7.3	3	80 - 110**	71.5	83
	Total dissolved solids (field)	mg/L		3302	-	513.5	455	559	377	689	-	334.8	-		138.5	85.15
	Total Dissolved Solids @180°C	mg/L	10	3110	3080	452	428	489	319	582	450	397	405		122	84
	Suspended Solids (SS)	mg/L	5	<5	<5	6	61	19	58	<5	74	<5	12		<5	<5
	Redox	mV		-18.7	-164	200.2	66.1	11.2	-91.5	-19.2	4.3	112.5	-89		88.4	-44.2
Major Ions	Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	2	<1		<1	<1
	Bicarbonate Alkalinity as CaCO3	mg/L	1	1890	2,050	16	22	160	148	439	365	185	235		48	22
	Total Alkalinity as CaCO3	mg/L	1	1890	2,050	16	22	160	148	439	365	187	235		48	22
	Sulfate as SO4 - Turbidimetric	mg/L	1	<1	<1	4	4	5	6	<1	<1	<1	<1		8	6
	Bromine	mg/L	0.1	1.5	1.6	0.5	0.5	0.4	0.2	0.2	0.1	<0.1	<0.1		<0.1	<0.1
	Chloride	mg/L	1	720	637	263	231	177	118	74	51	38	34		34	26
	Calcium	mg/L	1	143	134	10	10	32	24	89	65	10	10		4	3
	Magnesium	mg/L	1	91	134	21	18	31	22	24	20	6	6		4	3
	Sodium	mg/L	1	959	973	104	98	85	64	113	76	97	108		32	17
	Potassium	mg/L	1	37	37	1	2	4	4	13	11	10	11		2	2
	Reactive Silica	mg/L	0.05	22.5	22.9	17.5	17.2	11.9	9.85	9.53	7.92	2.38	2.76		0.46	3.2
	Fluoride	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1		<0.1	<0.1
	Bromide	mg/L	0.01	1.19	1.01	0.421	0.383	0.264	0.165	0.114	0.078	0.06	0.052		0.072	0.045
	Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.007	<0.004	<0.004
Dissolved metals	Aluminium	mg/L	0.01	<0.01	0.01	0.01	0.03	<0.01	0.02	<0.01	0.02	<0.01	<0.01	0.055	<0.01	0.09
	Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
	Arsenic	mg/L	0.001	0.02	0.023	<0.001	<0.001	0.003	0.007	0.002	0.008	<0.001	<0.001		<0.001	<0.001
	Barium	mg/L	0.001	29.6	24.7	0.601	0.565	0.495	0.342	3.63	1.4	1.18	1.26		0.058	0.032
	Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
	Boron	mg/L	0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37	<0.05	<0.05
	Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001
	Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
	Cobalt	mg/L	0.001	<0.001	<0.001	0.036	0.036	<0.001	0.002	<0.001	0.003	<0.001	<0.001		<0.001	<0.001
	Copper	mg/L	0.001	0.001	0.005	0.002	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	<0.001	0.002
	Iron	mg/L	0.05	0.59	0.23	<0.05	0.53	4.14	4.05	1.26	9	<0.05	<0.05		0.07	0.4
	Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0034	<0.001	<0.001
	Manganese	mg/L	0.001	0.019	0.015	0.404	0.454	0.162	0.248	0.034	1.37	0.002	0.008	1.9	0.019	0.058
	Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	<0.0001	<0.0001
	Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
	Nickel	mg/L	0.001	<0.001	0.003	0.014	0.019	0.001	0.007	<0.001	0.003	<0.001	0.001	0.011	0.002	0.002
	Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011	<0.01	<0.01
	Strontium	mg/L	0.001	6.23	5.78	0.121	0.118	0.392	0.294	0.874	0.617	0.319	0.33		0.042	0.03
	Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
	Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01
	Zinc	mg/L	0.005	0.056	0.073	0.039	0.066	<0.005	0.046	<0.005	0.02	0.025	0.054	0.008	<0.005	0.015
Nutrients	Ammonia as N	mg/L	0.01	3.36	3	0.01	<0.01	0.13	0.12	1.02	1.33	0.57	0.62	0.02*	<0.01	0.04
	Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01
	Nitrate as N	mg/L	0.01	0.04	<0.01	0.46	0.28	0.04	<0.01	0.04	<0.01	0.04	<0.01		0.07	0.24
	Nitrite + Nitrate as N	mg/L	0.01	0.04	<0.01	0.46	0.29	0.04	<0.01	0.04	<0.01	0.04	<0.01		0.07	0.24
	Total Phosphorus as P	mg/L	0.01	<0.01	0.02	<0.01	0.02	0.02	0.06	<0.01	0.1	<0.01	<0.01	0.05*	<0.01	0.02
	Reactive Phosphorus as P	mg/L	0.01	0.02	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02*	<0.01	<0.01
	Total Organic Carbon	mg/L	1	28	15	1	2	3	4	5	12	43	54		4	6
Dissolved gases	Methane	µg/L	10	42000	11700	58	36	683	679	43200	39,100	39300	41,300		40	13
	Ethane	µg/L	10	169	67	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
	Ethene	µg/L	10	<0.01	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
	Propane	µg/L	10	37	16	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
	Propene	µg/L	10	<0.01	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
	Butene	µg/L	10	<0.01	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
	Butane	µg/L	10	<0.01	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10
Phenolic compounds	Phenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	320	<1	<1
	2-Chlorophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	490	<1	<1
	2-Methylphenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	3- & 4-Methylphenol	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	<2
	2-Nitrophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	2.4-Dimethylphenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	2.4-Dichlorophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	160	<1	<1
	2.6-Dichlorophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	4-Chloro-3-methylphenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	2.4.6-Trichlorophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	20	<1	<1
	2.4.5-Trichlorophenol	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Pentachlorophenol	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	10	<2	<2
Polycyclic aromatic hydrocarb	Acenaphthene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Acenaphthylene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Fluorene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Phenanthrene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Anthracene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Fluoranthene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Pyrene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Benz(a)anthracene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Chrysene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Benzo(k)fluoranthene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Benzo(b+j)fluoranthene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5
	Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5
	Indeno(1.2.3.cd)pyrene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Dibenz(a.h)anthracene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Benzo(g.h.i)perylene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1
	Sum of polycyclic aromatic hydrocarbon	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5
Total petroleum hydrocarbons	C6 - C9 Fraction	µg/L	20	110	100	<20	<20	<20	<20	<20	<20	50	30		<20	<20
	C_{10} - C_{14} Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		<50	<50
	C_{15} - C_{28} Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100		<100	<100
	C_{29} - C_{36} Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		<50	<50
Total recoverable hydrocarbons	C6 - C10 Fraction	µg/L	20	110	100	<20	<20	<20	<20	<20	<20	50	30		<20	<20
	C6 - C10 Fraction minus BTEX (F1)	µg/L	20	30	30	<20	<20	<20	<20	<20	<20	20	<20		<20	<20
	>C10 - C16 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100		<100	<100
	>C16 - C34 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100		<100	<100
	>C34 - C40 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100		<100	<100
	>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100		<100	<100
Aromatic hydrocarbons	Benzene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	950	<1	<1
	Toluene	µg/L	2	77	70	<2	<2	<2	<2	<2	<2	26	23		<2	<2
	Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	<2
	meta- & para-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	<2
	ortho-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	350	<2	<2
	Total Xylenes	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	<2
	Sum of BTEX	µg/L	1	77	70	<1	<1	<1	<1	<1	<1	26	23		<1	<1
	Naphthalene	µg/L	5	<1	<5	<1	<5	<1	<5	<1	<5	<1	<5	16	<1	<5

Notes: * ANZECC (2000) Water Quality Guidelines only apply to Nepean River (NR) sample.

** ANZECC (2000) Water Quality Guidelines: 95% protection levels for the protection of freshwater aquatic ecosystems, south-east Australia, low lying river ecosystems.

Appendix C

ALS laboratory reports

CERTIFICATE OF ANALYSIS

Work Order	: **ES1933960**	Page	: 1 of 13
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Claire Corthier	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	: AGL CAMDEN GAS PROJECT J17200	Date Samples Received	: 16-Oct-2019 16:50
Order number	: ----	Date Analysis Commenced	: 16-Oct-2019
C-O-C number	: ----	Issue Date	: 23-Oct-2019 17:46
Sampler	: James Duggleby, Steve Rocks		
Site	: ----		
Quote number	: SY/416/16 - AGL Camden Planned Event		
No. of samples received	: 9		
No. of samples analysed	: 9		

Accreditation No. 825
Accredited for compliance with
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
- Surrogate Control Limits

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
Edwandy Fadjar	Organic Coordinator	Sydney Organics, 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.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EG020: Bromine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EK071G: It has been noted that Reactive P is greater than Total P on sample No 1 , however this difference is within the limits of experimental variation.
- EN055: Ionic Balance out of acceptable limits for sample ES1933960-#002 and #005 due to analytes not quantified in this report.
- EP80: Sample TRIP SPIKE contains volatile compounds spiked into the sample containers prior to dispatch from the laboratory. BTEX compounds spiked at 20 ug/L.
- 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	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	16-Oct-2019 13:30	16-Oct-2019 10:00	16-Oct-2019 11:15	16-Oct-2019 11:00	16-Oct-2019 10:30
Compound	CAS Number	LOR	Unit	ES1933960-001	ES1933960-002	ES1933960-003	ES1933960-004	ES1933960-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.95	6.14	7.18	7.72	8.40
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	5210	839	881	1130	555
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	3110	452	489	582	397
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	6	19	<5	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	2
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1890	16	160	439	185
Total Alkalinity as CaCO3	----	1	mg/L	1890	16	160	439	187
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	4	5	<1	<1
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	720	263	177	74	38
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	143	10	32	89	10
Magnesium	7439-95-4	1	mg/L	91	21	31	24	6
Sodium	7440-23-5	1	mg/L	959	104	85	113	97
Potassium	7440-09-7	1	mg/L	37	1	4	13	10
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.020	<0.001	0.003	0.002	<0.001
Boron	7440-42-8	0.05	mg/L	0.06	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L	29.6	0.601	0.495	3.63	1.18
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.036	<0.001	<0.001	<0.001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.002	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.019	0.404	0.162	0.034	0.002
Nickel	7440-02-0	0.001	mg/L	<0.001	0.014	0.001	<0.001	<0.001

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
Client sampling date / time				16-Oct-2019 13:30	16-Oct-2019 10:00	16-Oct-2019 11:15	16-Oct-2019 11:00	16-Oct-2019 10:30
				ES1933960-001	ES1933960-002	ES1933960-003	ES1933960-004	ES1933960-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.056**	**0.039**	<0.005	<0.005	**0.025**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**6.23**	**0.121**	**0.392**	**0.874**	**0.319**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	7439-89-6	0.05	mg/L	**0.59**	<0.05	**4.14**	**1.26**	<0.05
Bromine	7726-95-6	0.1	mg/L	**1.5**	**0.5**	**0.4**	**0.2**	<0.1
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.05	mg/L	**22.5**	**17.5**	**11.9**	**9.53**	**2.38**
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	**0.1**	**0.1**	**0.1**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**3.36**	**0.01**	**0.13**	**1.02**	**0.57**
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	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.04**	**0.46**	**0.04**	**0.04**	**0.04**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.04**	**0.46**	**0.04**	**0.04**	**0.04**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	**0.02**	<0.01	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.02**	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**58.1**	**7.82**	**8.29**	**10.8**	**4.81**
ø Total Cations	----	0.01	meq/L	**57.3**	**6.78**	**7.95**	**11.7**	**5.47**
ø Ionic Balance	----	0.01	%	**0.68**	**7.16**	**2.13**	**3.58**	**6.42**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	16-Oct-2019 13:30	16-Oct-2019 10:00	16-Oct-2019 11:15	16-Oct-2019 11:00	16-Oct-2019 10:30
Compound	CAS Number	LOR	Unit	ES1933960-001	ES1933960-002	ES1933960-003	ES1933960-004	ES1933960-005
				Result	Result	Result	Result	Result
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**28**	**1**	**3**	**5**	**43**
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**42000**	**58**	**683**	**43200**	**39300**
Ethene	74-85-1	10	µg/L	<10	<10	<10	<10	<10
Ethane	74-84-0	10	µg/L	**169**	<10	<10	<10	<10
Propene	115-07-1	10	µg/L	<10	<10	<10	<10	<10
Propane	74-98-6	10	µg/L	**37**	<10	<10	<10	<10
Butene	25167-67-3	10	µg/L	<10	<10	<10	<10	<10
Butane	106-97-8	10	µg/L	<10	<10	<10	<10	<10
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
Client sampling date / time				16-Oct-2019 13:30	16-Oct-2019 10:00	16-Oct-2019 11:15	16-Oct-2019 11:00	16-Oct-2019 10:30
				ES1933960-001	ES1933960-002	ES1933960-003	ES1933960-004	ES1933960-005
				Result	Result	Result	Result	Result
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	**110**	<20	<20	<20	**50**
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	**110**	<20	<20	<20	**50**
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	**30**	<20	<20	<20	**20**
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	**77**	<2	<2	<2	**26**
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	**77**	<1	<1	<1	**26**
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**1.19**	**0.421**	**0.264**	**0.114**	**0.060**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

			Client sample ID	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	16-Oct-2019 13:30	16-Oct-2019 10:00	16-Oct-2019 11:15	16-Oct-2019 11:00	16-Oct-2019 10:30
Compound	CAS Number	LOR	Unit	ES1933960-001	ES1933960-002	ES1933960-003	ES1933960-004	ES1933960-005
				Result	Result	Result	Result	Result
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	18.9	19.5	17.6	20.6	18.4
2-Chlorophenol-D4	93951-73-6	1.0	%	52.6	57.6	50.7	60.4	45.3
2.4.6-Tribromophenol	118-79-6	1.0	%	45.4	43.6	42.7	45.5	38.5
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	78.8	81.9	78.7	87.3	78.0
Anthracene-d10	1719-06-8	1.0	%	76.3	77.6	73.8	83.4	74.6
4-Terphenyl-d14	1718-51-0	1.0	%	69.2	64.7	61.0	68.1	62.0
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	110	107	97.0	105	102
Toluene-D8	2037-26-5	2	%	111	112	91.6	112	103
4-Bromofluorobenzene	460-00-4	2	%	105	103	92.2	105	98.3

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	TS	----
			Client sampling date / time	16-Oct-2019 12:00	16-Oct-2019 00:00	14-Oct-2019 00:00	11-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1933960-006	ES1933960-007	ES1933960-008	ES1933960-009	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.96	7.21	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	228	891	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	122	468	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	16	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	48	172	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	48	172	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	8	6	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	34	177	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	33	----	----	----
Magnesium	7439-95-4	1	mg/L	4	31	----	----	----
Sodium	7440-23-5	1	mg/L	32	86	----	----	----
Potassium	7440-09-7	1	mg/L	2	4	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.003	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L	0.058	0.508	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.019	0.163	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.002	0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	TS	----
			Client sampling date / time	16-Oct-2019 12:00	16-Oct-2019 00:00	14-Oct-2019 00:00	11-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1933960-006	ES1933960-007	ES1933960-008	ES1933960-009	--------
				Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.005**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.042**	**0.403**	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.07**	**4.11**	----	----	----
Bromine	7726-95-6	0.1	mg/L	<0.1	**0.3**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.05	mg/L	**0.46**	**11.8**	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.1**	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	**0.14**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.07**	**0.02**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.07**	**0.02**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	**0.03**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**2.08**	**8.55**	----	----	----
ø Total Cations	----	0.01	meq/L	**1.97**	**8.04**	----	----	----
ø Ionic Balance	----	0.01	%	----	**3.09**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	TS	----
			Client sampling date / time	16-Oct-2019 12:00	16-Oct-2019 00:00	14-Oct-2019 00:00	11-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1933960-006	ES1933960-007	ES1933960-008	ES1933960-009	--------
				Result	Result	Result	Result	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**4**	**4**	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**40**	**642**	----	----	----
Ethene	74-85-1	10	µg/L	<10	<10	----	----	----
Ethane	74-84-0	10	µg/L	<10	<10	----	----	----
Propene	115-07-1	10	µg/L	<10	<10	----	----	----
Propane	74-98-6	10	µg/L	<10	<10	----	----	----
Butene	25167-67-3	10	µg/L	<10	<10	----	----	----
Butane	106-97-8	10	µg/L	<10	<10	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	TS	----
			Client sampling date / time	16-Oct-2019 12:00	16-Oct-2019 00:00	14-Oct-2019 00:00	11-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1933960-006	ES1933960-007	ES1933960-008	ES1933960-009	--------
				Result	Result	Result	Result	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	**16**	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	**16**	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	**15**	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	**15**	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	**16**	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	**31**	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	**78**	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	**18**	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**0.072**	**0.266**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	TS	----
			Client sampling date / time	16-Oct-2019 12:00	16-Oct-2019 00:00	14-Oct-2019 00:00	11-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1933960-006	ES1933960-007	ES1933960-008	ES1933960-009	--------
				Result	Result	Result	Result	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	18.1	20.0	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	57.2	58.3	----	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	55.0	41.6	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	84.6	84.6	----	----	----
Anthracene-d10	1719-06-8	1.0	%	78.3	86.1	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	67.0	69.9	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	102	106	110	106	----
Toluene-D8	2037-26-5	2	%	99.4	107	114	105	----
4-Bromofluorobenzene	460-00-4	2	%	97.8	101	104	103	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2012717**	Page	: 1 of 13
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Claire Corthier	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	: AGL CAMDEN GAS PROJECT J17200	Date Samples Received	: 15-Apr-2020 17:00
Order number	: ----	Date Analysis Commenced	: 16-Apr-2020
C-O-C number	: ----	Issue Date	: 21-Apr-2020 18:05
Sampler	: Claire Corthier, Steve Rocks		
Site	: ----		
Quote number	: SY/416/16 - AGL Camden Planned Event		
No. of samples received	: 9		
No. of samples analysed	: 8		

Accreditation No. 825
Accredited for compliance with
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
- Surrogate Control Limits

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
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EG020: Bromine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EK071G: It has been noted that Reactive P is greater than Total P on sample No 1 , however this difference is within the limits of experimental variation.
- EN055: Ionic Balance out of acceptable limits for sample ES1933960-#002 and #005 due to analytes not quantified in this report.
- EP80: Sample TRIP SPIKE contains volatile compounds spiked into the sample containers prior to dispatch from the laboratory. BTEX compounds spiked at 20 ug/L.
- 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	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	15-Apr-2020 14:00	15-Apr-2020 09:00	15-Apr-2020 09:30	15-Apr-2020 10:00	15-Apr-2020 11:00
Compound	CAS Number	LOR	Unit	ES2012717-001	ES2012717-002	ES2012717-003	ES2012717-004	ES2012717-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.42**	**5.96**	**6.78**	**7.51**	**8.20**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**5660**	**774**	**628**	**831**	**583**
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**3080**	**428**	**319**	**450**	**405**
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	**61**	**58**	**74**	**12**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**2050**	**22**	**148**	**365**	**235**
Total Alkalinity as CaCO3	----	1	mg/L	**2050**	**22**	**148**	**365**	**235**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	**4**	**6**	<1	<1
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**637**	**231**	**118**	**51**	**34**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**134**	**10**	**24**	**65**	**10**
Magnesium	7439-95-4	1	mg/L	**134**	**18**	**22**	**20**	**6**
Sodium	7440-23-5	1	mg/L	**973**	**98**	**64**	**76**	**108**
Potassium	7440-09-7	1	mg/L	**37**	**2**	**4**	**11**	**11**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	**0.03**	**0.02**	**0.02**	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.023**	<0.001	**0.007**	**0.008**	<0.001
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L	**24.7**	**0.565**	**0.342**	**1.40**	**1.26**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.036**	**0.002**	**0.003**	<0.001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	**0.002**	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.005**	**0.008**	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.015**	**0.454**	**0.248**	**1.37**	**0.008**
Nickel	7440-02-0	0.001	mg/L	**0.003**	**0.019**	**0.007**	**0.003**	**0.001**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	15-Apr-2020 14:00	15-Apr-2020 09:00	15-Apr-2020 09:30	15-Apr-2020 10:00	15-Apr-2020 11:00
Compound	CAS Number	LOR	Unit	ES2012717-001	ES2012717-002	ES2012717-003	ES2012717-004	ES2012717-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.073**	**0.066**	**0.046**	**0.020**	**0.054**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**5.78**	**0.118**	**0.294**	**0.617**	**0.330**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	7439-89-6	0.05	mg/L	**0.23**	**0.53**	**4.05**	**9.00**	<0.05
Bromine	7726-95-6	0.1	mg/L	**1.6**	**0.5**	**0.2**	**0.1**	<0.1
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.05	mg/L	**22.9**	**17.2**	**9.85**	**7.92**	**2.76**
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	**0.1**	<0.1
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**3.00**	<0.01	**0.12**	**1.33**	**0.62**
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	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	**0.28**	<0.01	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	**0.29**	<0.01	<0.01	<0.01
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	**0.02**	**0.06**	**0.10**	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.05**	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**58.9**	**7.04**	**6.41**	**8.73**	**5.65**
ø Total Cations	----	0.01	meq/L	**61.0**	**6.29**	**5.89**	**8.48**	**5.97**
ø Ionic Balance	----	0.01	%	**1.71**	**5.58**	**4.19**	**1.48**	**2.73**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	15-Apr-2020 14:00	15-Apr-2020 09:00	15-Apr-2020 09:30	15-Apr-2020 10:00	15-Apr-2020 11:00
				ES2012717-001	**ES2012717-002**	**ES2012717-003**	**ES2012717-004**	**ES2012717-005**
				Result	Result	Result	Result	Result
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**15**	**2**	**4**	**12**	**54**
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**11700**	**36**	**679**	**39100**	**41300**
Ethene	74-85-1	10	µg/L	<10	<10	<10	<10	<10
Ethane	74-84-0	10	µg/L	**67**	<10	<10	<10	<10
Propene	115-07-1	10	µg/L	<10	<10	<10	<10	<10
Propane	74-98-6	10	µg/L	**16**	<10	<10	<10	<10
Butene	25167-67-3	10	µg/L	<10	<10	<10	<10	<10
Butane	106-97-8	10	µg/L	<10	<10	<10	<10	<10
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	15-Apr-2020 14:00	15-Apr-2020 09:00	15-Apr-2020 09:30	15-Apr-2020 10:00	15-Apr-2020 11:00
Compound	CAS Number	LOR	Unit	ES2012717-001	ES2012717-002	ES2012717-003	ES2012717-004	ES2012717-005
				Result	Result	Result	Result	Result
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	**100**	<20	<20	<20	**30**
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	**100**	<20	<20	<20	**30**
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	**30**	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	**70**	<2	<2	<2	**23**
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	**70**	<1	<1	<1	**23**
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**1.01**	**0.383**	**0.165**	**0.078**	**0.052**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	GLMB03	MPMB01	MPMB02	MPMB03	MPMB04
			Client sampling date / time	15-Apr-2020 14:00	15-Apr-2020 09:00	15-Apr-2020 09:30	15-Apr-2020 10:00	15-Apr-2020 11:00
Compound	CAS Number	LOR	Unit	ES2012717-001	ES2012717-002	ES2012717-003	ES2012717-004	ES2012717-005
				Result	Result	Result	Result	Result
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	**15.2**	**28.2**	**31.0**	**27.5**	**26.1**
2-Chlorophenol-D4	93951-73-6	1.0	%	**32.6**	**64.7**	**66.5**	**56.3**	**48.7**
2.4.6-Tribromophenol	118-79-6	1.0	%	**28.3**	**56.8**	**63.9**	**64.1**	**34.8**
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	**38.4**	**70.6**	**70.8**	**73.4**	**66.4**
Anthracene-d10	1719-06-8	1.0	%	**50.4**	**95.1**	**107**	**107**	**89.2**
4-Terphenyl-d14	1718-51-0	1.0	%	**76.8**	**102**	**115**	**123**	**111**
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**105**	**92.8**	**99.3**	**103**	**96.7**
Toluene-D8	2037-26-5	2	%	**108**	**100**	**100**	**105**	**95.8**
4-Bromofluorobenzene	460-00-4	2	%	**93.4**	**89.5**	**88.3**	**90.3**	**86.2**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	----	----
			Client sampling date / time	15-Apr-2020 00:00	15-Apr-2020 00:00	09-Apr-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2012717-006	ES2012717-007	ES2012717-008	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.62**	**6.80**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**148**	**632**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**84**	**367**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	**42**	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**2.8**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**22**	**153**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**22**	**153**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**6**	**6**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**26**	**118**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**3**	**24**	----	----	----
Magnesium	7439-95-4	1	mg/L	**3**	**22**	----	----	----
Sodium	7440-23-5	1	mg/L	**17**	**63**	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	**4**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.09**	**0.01**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.007**	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.032**	**0.346**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.001**	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	NR	QA1	TB	----	----
Client sampling date / time				15-Apr-2020 00:00	15-Apr-2020 00:00	09-Apr-2020 00:00	----	----
				ES2012717-006	ES2012717-007	ES2012717-008	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Manganese	7439-96-5	0.001	mg/L	**0.058**	**0.251**	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.003**	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.015**	**0.006**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.030**	**0.301**	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.40**	**4.23**	----	----	----
Bromine	7726-95-6	0.1	mg/L	<0.1	**0.2**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.05	mg/L	**3.20**	**9.88**	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.04**	**0.14**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.24**	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.24**	<0.01	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	**0.05**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**1.30**	**6.51**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	----	----
			Client sampling date / time	15-Apr-2020 00:00	15-Apr-2020 00:00	09-Apr-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2012717-006	ES2012717-007	ES2012717-008	--------	--------
				Result	Result	Result	----	----
EN055: Ionic Balance - Continued								
ø Total Cations	----	0.01	meq/L	**1.19**	**5.85**	----	----	----
ø Ionic Balance	----	0.01	%	----	**5.34**	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**6**	**4**	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**13**	**613**	----	----	----
Ethene	74-85-1	10	µg/L	<10	<10	----	----	----
Ethane	74-84-0	10	µg/L	<10	<10	----	----	----
Propene	115-07-1	10	µg/L	<10	<10	----	----	----
Propane	74-98-6	10	µg/L	<10	<10	----	----	----
Butene	25167-67-3	10	µg/L	<10	<10	----	----	----
Butane	106-97-8	10	µg/L	<10	<10	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	----	----
			Client sampling date / time	15-Apr-2020 00:00	15-Apr-2020 00:00	09-Apr-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2012717-006	ES2012717-007	ES2012717-008	--------	--------
				Result	Result	Result	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	----	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	----	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	NR	QA1	TB	----	----
			Client sampling date / time	15-Apr-2020 00:00	15-Apr-2020 00:00	09-Apr-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2012717-006	ES2012717-007	ES2012717-008	--------	--------
				Result	Result	Result	----	----
EP080: BTEXN - Continued								
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	0.045	0.162	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	25.9	26.4	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	54.1	56.8	----	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	47.9	55.2	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	72.9	77.5	----	----	----
Anthracene-d10	1719-06-8	1.0	%	89.5	92.0	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	106	102	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	98.8	102	98.7	----	----
Toluene-D8	2037-26-5	2	%	97.4	102	103	----	----
4-Bromofluorobenzene	460-00-4	2	%	84.6	89.1	89.1	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

SYDNEY
Ground floor, 20 Chandos Street
St Leonards, New South Wales, 2065
T 02 9493 9500 F 02 9493 9599

NEWCASTLE
Level 3, 175 Scott Street
Newcastle, New South Wales, 2300
T 02 4907 4800 F 02 4907 4899

BRISBANE
Level 1, 87 Wickham Terrace
Spring Hill, Queensland, 4000
T 07 3839 1800 F 07 3839 1866