Bayswater Power Station - Water and Other Associated Operational Works Project

EIS Response to Submissions - Water

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AGL Macquarie Pty Ltd

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Contents

1. Introduction ... 3
1.1 Project summary ... 4
1.2 Project overview ... 4
2. Document review ... 5
3. Environmental setting ... 6
3.1 Topography and drainage ... 6
3.2 Climate ... 6
3.3 Geology ... 7
3.4 Hydrogeology ... 7
3.5 Sensitive receiving environments ... 8
3.5.1 Drinking water catchment ... 8
3.5.2 Areas that contribute to aquaculture and commercial fishing ... 8
3.5.3 Threatened aquatic species ... 8
3.5.4 Groundwater dependent ecosystems (GDE) ... 8
3.5.5 Registered groundwater bores ... 9
4. Water quality review ... 10
4.1 BWAD ... 10
4.1.1 Contaminants of potential concern (CoPCs) ... 10
4.1.2 Analysis results ... 10
4.2 Seepage ... 15
4.3 Surface water ... 19
4.3.1 Bayswater Creek ... 21
4.3.2 Pikes Creek ... 23
4.3.3 Eye Creek ... 27
4.3.4 Chilcotts Creek and Lake Liddell ... 29
4.4 Groundwater quality ... 33
4.5 Water ways ... 40
4.6 Conceptual model ... 40
5. Dam and pond liners ... 42
6. BWAD post-closure and rehabilitation ... 43
7. Ash disposal ... 44
8. Salt Cake landfill review ... 45
9. Coal handling plant ... 48
10. Water balance modelling ... 50
11. Water pollution risks mitigation measures ... 51
12. References ... 52

Executive Summary

AGL Macquarie Pty Ltd (**AGLM**) own and operate the Bayswater Power Station (**Bayswater**). Prior to its retirement, water and wastewater infrastructure and site improvements are required to ensure its continued operational and environmental performance. Jacobs was commissioned to prepare an Environmental Impact Statement (**EIS**) for the proposed Water and Other Associated Operational Works (**WOAOW**) project (**the Project**) to ensure the continued safe, efficient and reliable operation of Bayswater. The EIS went on public exhibition on 1 July 2020 and comments closed on 30 July 2020. Jacobs was subsequently engaged to develop a response to submissions for comments by the NSW Environmental Protection Authority (**EPA**) on the EIS (this report). The EPA's comments were in relation to: surface water and groundwater quality and potential impacts of the project, closure and rehabilitation, ash disposal off site, the salt cake landfill, the coal handling plant, water balance modelling details and water pollution risk mitigation measures.

Groundwater at Bayswater is hosted in two main geological units: alluvium and fractured rock aquifers. Both can host unconfined water table aquifers, and the fractured rock units of the Permian aged rock units that can host unconfined, semi-confined and confined aquifers. Groundwater recharge occurs from rainfall runoff and surface water to the underlying geology. At the site, seepage from the Bayswater Ash Dam (**BWAD**) also contribute an additional amount of recharge, and the groundwater in the alluvium is likely to be a combination of rainfall run-off, BWAD seepage and discharge from the fractured rock units (including the coal seams).

Currently, seepage from the BWAD appears to occur predominantly at the Main Embankment and the Saddle Dam. Seepage from the Main Embankment is collected at Seepage Collection Ponds 1 and 2, with a proportion of seepage that is lost to the surrounding environment, including Pikes Creek, Eye Creek, Bayswater Creek, Chilcotts Creek and Lake Liddell. Discharge from Lake Liddell meets the required criteria for discharge.

The water quality of the BWAD decant and waste stream water has a pH ranging from 7 to 8 and an Electrical Conductivity (**EC**) of between 4500 and 5000 µS/cm. Dissolved metals concentrations are elevated with exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria for aluminium, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, molybdenum, nickel, lead, selenium, vanadium, zinc and total nitrogen. No detects above limits of reporting were recorded in the BWAD for PAHs, TPHs, TRHs, BTEXN, PCBs, lead, mercury or cyanide.

Dissolved metals concentrations decrease with increasing distance from the BWAD, which his likely due to heavy metals binding on to the clay in the ground. EC increases with distance from the BWAD, which is likely due to a combination of discharge of brackish/saline water from adjacent seam subcrops to the shallow groundwater and concentration of salinity due to evapotranspiration.

No waterways within the Project footprint area have been classified as sensitive receiving environments; therefore, the risk of negatively impacting the surrounding environment is low.

Generally, pH and many trace metals were below recommended guideline values for protection of aquatic ecosystems and other nominated environmental values. There were however some trace metals that were above ANZECC (2018) water quality guidelines at numerous sites and included chloride, copper, fluoride nickel, sodium, zinc.

With the exception of potential salinisation associated with the proposed salt cake landfill, the Project is expected to generate negligible impacts to groundwater and risks to groundwater are assessed as low. This conclusion is based on a detailed review of background groundwater level and quality data, along with an analysis of the existing environmental setting and an assessment of the Project elements. Saline/briny water may migrate to underlying and surrounding groundwater systems, if the salt cake landfill liner were to leak.

Additionally, the seepage control upgrades associated with the Main Embankment and Saddle Dam walls will improve seepage recovery. It is proposed that a seepage collection system will be installed at the Saddle Dam seepage area that will return the loss. Also, proposed seepage control upgrades at the Main Embankment area are expected to double the estimated lower limit of the seepage water return.

Historically and more recently, liners have been considered as an option to reduce seepage from the BWAD and from the Main Embankment Seepage Ponds. The options of lining these structures are not considered feasible from a practical and a financial point of view. Aside from the cost, a liner would not reduce seepage from the BWAD because the currently emplaced material (predominantly, ash) is saturated and would constitute an ongoing source of seepage water. The Bayswater Ash Dam Pollution Reduction Program (PRP) (AECOM 2016b), recommended that the BWAD Main Embankment Seepage Ponds be upgraded and/or have new seepage cut-off / collection ponds constructed. The existing ponds, and any additional ponds that are constructed, will be lined if considered necessary at the time of design.

The EIS outlines a proposed BWAD closure and rehabilitation plan. The EIS states that once the augmented BWAD has reached capacity, rehabilitation would be undertaken to integrate the BWAD within the existing landform, as far as possible. Rehabilitation would be undertaken in accordance with the AGLM Rehabilitation Management Plan to be prepared and approved under the conditions of consent and would include capping, measures to prevent any ponding or disruption to water flows, stabilisation and revegetation.

Disposal of Bayswater ash into Ravensworth South Mine voids commenced in 2014 and is expected to be completed in 2035. AGLM is currently working on an application to modify its consent to operate the Ravensworth South Mine ash emplacement area. AGLM have commissioned a groundwater study that is currently taking place (as at 26 November 2020).

The Project includes the construction and operation of a salt cake landfill facility to dispose of salt cake waste from the Bayswater water treatment plant. The EIS stated that the key landfill risks were to surface water quality from the operation of the landfill facility and are related to contaminated leachate from the landfill site or by uncontrolled stormwater flows containing sediments and contaminants entering downstream waterways. To reduce the risk of leachate and waste entering the surrounding environment, the landfill facility would be designed in accordance with EPA (2016) requirements and would include a liner. In the event of a liner failure, saline/briny water was modelled to migrate from the landfill beyond a distance of 40 metres, such that the beneficial use category of the groundwater source may be lowered. Therefore, the Project is assessed to not meet the NSW Aquifer Interference Policy (DPI, 2012) minimal impact consideration with regards to groundwater quality. Further consideration will be given to the selection of an appropriate salt cake landfill liner. This will be undertaken at the design stage of the landfill. Additionally, site management protocols will be developed to mitigate risks from erosion, uncontrolled stormwater flows, stockpiles and sediment transport. A water monitoring plan for the site, established prior to construction, will also assist in monitoring and managing potential leachate discharges.

Discharges (overflows) to Tinkers Creek from the Coal Handling Plant (**CHP**) sediment basin currently occur on a daily basis. CHP water and wastewater infrastructure upgrades are proposed as part of an environmental improvement program at Bayswater to reduce the quantity of discharges to Tinkers Creek from the sediment basin and associated drainage systems. These actions will result in better treatment and management of water prior to discharge through increased detention time.

The EIS also outlines the water pollution risk mitigation measures, which include upgrading the seepage recovery system to improve the collection of seepage from BWAD to reduce the risk of overflow and discharge to Pikes Creek, Chilcotts Creek and Lake Liddell, construction of an ash pipeline to Ravensworth ash emplacement area and upgrading the CHP water use and coal basin to reduce the quantity of water discharged and improve the quality. Additionally, AGLM has an ongoing programme of surface water and groundwater monitoring, which will continue to be implemented and reviewed regularly to assess its suitability for a long-term monitoring programme at the site to meet the Project requirements.

The improvement works will be carried out in collaboration with the EPA.

1. Introduction

AGL Macquarie Pty Ltd (AGLM) own and operate the Bayswater Power Station (Bayswater), located approximately 16 km south-east of Muswellbrook, NSW. Bayswater was commissioned in 1985 to utility standards of the time and has a current technical life up to 2035. Prior to its retirement, water and wastewater infrastructure and site improvements are required to ensure its continued operational and environmental performance.

The proposed Water and Other Associated Operational Works (**WOAOW**) project (**the Project**) at Bayswater would ensure the continued safe, efficient and reliable operation of Bayswater until its retirement. This project provides the opportunity for improvements based on post-construction advances in water and wastewater management.

Jacobs, on behalf of AGLM has been commissioned to prepare a response to submissions for comments by the NSW Environmental Protection Authority (**EPA**) on the Environmental Impact Statement (**EIS**) for the assessment of infrastructure and water upgrade works, in accordance with Division 4.7 of the *Environmental Planning and Assessment Act 1979* (**EP& A Act**).

The EPA submission items are summarised in the following table, together with a link to the chapter that address the submission item.

EPA Submission no.	EPA Submission Item	Relevant report section(s)
1	Information on the existing impact of the Bayswater (BWAD) seepage on receiving groundwaters	Sections 0, 4, 4.6
2	Information on the proposed upgrades to the BWAD seepage collection system, demonstrating an increase to the protection of receiving groundwaters.	Sections 4.2, 4.6, 9, 10
3	Information on the technical specifications of the BWAD augmentation, including the use of a liner, to prevent increased seepage to local and regional groundwaters.	Sections 5, 11
4	Information on the post-closure and rehabilitation of the BWAD including any ongoing seepage management.	Section 6
5	Further information on the underground ash disposal and discharge of excess ash process water to mining voids and impact to groundwaters.	Section 7
6	Information on the site design, technical specifications and liner compatibility of the proposed salt cake landfill.	Section 8
7	An investigation of the feasibility of additional liner properties to meet the Aquifer Interference Policy quality minimum impact criteria.	Section 8
8	Preparation and submission of a detailed Groundwater Monitoring Plan for the proposed Salt Cake Landfill.	Section 8
9	A contemporary characterisation of surface water quality and assessment of potential water pollution risks from the existing development. Limited surface water monitoring results are provided, largely from historical data that does not include information for key waterways potentially impacted by the existing development.	Section 4
10	Information to demonstrate that all practical and reasonable options to avoid, minimise and mitigate water pollution impacts have been investigated and where feasible implemented.	Sections 4, 5, 6, 9, 11

EPA Submission no.	EPA Submission Item	Relevant report section(s)
11	An assessment of options considered to avoid or minimise managed overflows from the ash dam and mitigate the potential impacts of these overflows.	Sections 4.2, 4.3.4, 4.6, 11
12	Assessment of control discharge impacts from the ash dam.	Section 4, 4.2, 4.2, 11
13	A water pollution impact assessment.	Section 4
14	Inclusion of daily time-step water balance modelling.	Section 10
15	Details of the coal handling plant water management systems.	Section 9
16	Details of measures to mitigate water pollution risks to waterways.	Sections 4, 11

1.1 Project summary

Bayswater was commissioned in 1985 and has a current technical life up to 2035. AGLMs asset management strategy has identified that the ageing water and wastewater infrastructure assets on site require upgrade and/or replacement to ensure the continued and efficient operation of Bayswater until its planned retirement. Furthermore, since Bayswater was initially commissioned, there have been advances in water and wastewater management. AGLM have identified enhancement and upgrades to existing infrastructure that will result in improved environmental outcomes.

In addition, based on current emplacement and beneficial reuse of ash rates, the existing BWAD is forecast to reach capacity within approximately two years. To enable the ongoing operation of Bayswater, it is critical to augment the existing BWAD to provide additional emplacement capacity for fly ash and bottom ash from Bayswater.

1.2 Project overview

The Project will include the following elements:

- Augmentation of the existing BWAD to provide additional ash storage capacity (**Ash Dam augmentation**);
- Improvements to water management structures and systems to ensure continued collection and reuse of process water and return waters from the BWAD (**Ash Dam augmentation**);
- Improvements to the management of water and waste materials within the coal handling plant sediment basin and associated drainage system (**Coal handling plant upgrades**);
- Increasing coal ash recycling activities to produce up to 1,000,000 tonnes (t) per annum of ash derived product material and reuse of coal ash (**Ash harvesting**);
- Upgrades to existing fly ash harvesting infrastructure including the installation of weighbridges, construction of a new 240 t silo, tanker wash facility and additional truck parking (**Ash harvesting**);
- Construction and operation of a new coal ash pipeline to Ravensworth Void No. 3 for ash emplacement (**Ravensworth ash line**);
- Construction and operation of a salt cake landfill facility to dispose of salt cake waste from the approved salt caking plant to be constructed at the Bayswater water treatment plant (**Salt cake landfill**);
- Construction and operation of a borrow pit(s) on AGLM land to facilitate the improvements proposed for the Project and other works on AGLM land (**Borrow Pits 1 to 4**); and
- Ancillary infrastructure works including repositioning of underground pipelines to above ground, replacement or upgrading of ageing pipelines, vegetation clearing associated with maintaining existing infrastructure, including along pipeline corridors as necessary (**HP Pipe clearing, and LSP Pipe clearing**).

2. Document review

The following documents were reviewed as part of this RTS review:

- AECOM (2016). Waste Characterisation and Water Quality Assessment - Bayswater Ash Dam. 29 June 2016
- AECOM (2016). Water Management Investigation - Bayswater Ash Dam - Bayswater and Liddell PRP. 29 June 2016
- AECOM (2016c). Waste Management Assessment - Bayswater Ash Dam - Bayswater and Liddell PRP. 29 June 2016
- AECOM (2016d). Water Balance Assessment - Bayswater and Liddell Ash Dams. 29 June 2016
- AECOM (2016e). Ravensworth Mining Operations Plan for Ravensworth Ash Disposal Area (Rehabilitation Management Plan). 20 June 2016.
- AECOM (2017). Bayswater Coal Handling - Plant Sediment Basin - Assessment of Water Quality and Water Management. 29 June 2017. Job No.: 60519036
- AECOM (2017). Bayswater and Liddell Ash Dam Discharges: Water Quality Analysis. 09-June-2017
- AECOM (2018). Groundwater Monitoring Report - Proposed Brine Concentrator Baking Plant (DRAFT). 14 December 2018.
- AECOM (2020). Water Management System Review - Select Sites at Liddell and Bayswater Power Stations. 31 August 2020. Job No.: 60623154
- AECOM (2020b). Water System Review - Sampling Plan. 25 February 2020
- Aurecon (2013). Ravensworth Void 4 Discharge Investigation, Macquarie Generation, October 2013.
- Aurecon (2019). Bayswater Ash Dam Augmentation Design Report.
- HLA (2004). Pikes Gulley ash dam - geophysical survey. Commissioned for Macquarie Generation. 24 August 2004.
- Jacobs (2020). Water and Other Associated Operational Works (WOAOW) Project – Environmental Impact Statement. Feb 2020.
- Jacobs (2020). Water and Other Associated Operational Works (WOAOW) Project - Surface Water, Groundwater and Flooding Technical Paper. Feb 2020.
- Jacobs (2020). Water and Other Associated Operational Works (WOAOW) Project – Water Balance Model Technical Paper. Feb 2020.
- Power Plant Engineering Group (1993). Bayswater Power Station/Hunter Ash Dam Seepage Control – Draft of Geotechnical Investigation. Prepared for Pacific Power in June 1993. Power Plant Engineering Group Civil and Geotechnical Services.

3. Environmental setting

3.1 Topography and drainage

The area of the Project elements is generally characterised by low hills with elevations ranging from 100 m Australian Height Datum (**AHD**) to 220 m AHD. The majority of the Project elements are situated between two large water bodies, Lake Liddell in the north east and Plashett Reservoir to the south west, both with an elevation of approximately 125 m AHD to 130 m AHD. Maximum slopes of natural land in the vicinity of Project elements are approximately 25% to 30% (14 to 17 degrees).

In the vicinity of the BWAD, there are two water bodies; Lake Liddell to the north east and Plashett Reservoir to the south west, both with an elevation of approximately 130m AHD. Bayswater lies on top of a small hill (approximately 210m AHD) sloping towards the water body with a 3% slope to the north towards Lake Liddell and a 2% slope south towards Plashett Reservoir. To the west, a steep hill drains towards Saltwater Creek which flows west out of the study area and then south into the reservoir. A low ridge runs along the eastern boundary of the study area.

Within the vicinity of the Project, there are a number of hydrological features, including:

- Tinkers Creek, running along the western boundary of the proposal area and draining to Lake Liddell;
- Lake Liddell located to the north east of Bayswater;
- Plashett Reservoir located about 300m to the west of the proposed borrow pits (Borrow Pit 4);
- Saltwater Creek located to the west of Bayswater, which drains to Plashett Reservoir. A tributary of the Saltwater Creek, referred to in this report as the Noname Creek, is located to the south of the proposed salt cake landfill facility location;
- Wisemans Creek, which runs from east to west across Bayswater, before discharging to Plashett Reservoir;
- Pikes Creek, located to the north of the proposal area, intersecting with the existing BWAD and running parallel to the proposed Ravensworth Ash Line;
- Eye Creek running from west to east, which is located south of the BWAD and is a tributary of Pikes Creek; and
- Bayswater Creek, draining from Lake Liddell before ultimately discharging to Hunter River.

3.2 Climate

The Project area is considered to have a Mediterranean climate with hot summers and cool to mild winters. Jacobs (2020) summarises the key points of the Project area climate as follows:

- The average long-term annual rainfall for the AGLM Bayswater rain gauge of 699 **mm**. Rainfall is generally greater in the late spring/summer months from November to February. Within the winter months, rainfall is relatively high in June;
- average Class A pan evaporation is 1,514 mm/year (based on data from 1920 to present);
- Rainfall surplus, defined as rainfall – evapotranspiration, is a description of the available water for recharge to groundwater. A positive rainfall surplus indicates a water surplus, which may manifest itself in increased potential for groundwater recharge. Conversely, a negative rainfall surplus indicates a water deficit and therefore is associated with reduced potential for groundwater recharge. Based on the Doyles Creek daily rainfall and the BOM Areal actual evapotranspiration (**AAET**) monthly averages (BOM, 2019c), there is a rainfall surplus in February and from April to September. Remaining months have a rainfall deficit.

3.3 Geology

The 1:100,000 Hunter Coalfield Regional Geology map (Department of Mineral Resources, 1993) indicates that surface geology in the Project area comprises sedimentary rock, with some limited areas mapped as Quaternary Alluvium.

The western two-thirds of the Project area is mapped as Mulbring Siltstone of the Maitland Group comprising siltstone, claystone and minor fine-grained sandstone. The remaining eastern third is mapped as the Saltwater Creek Formation of the Wittingham Coal Measures comprising sandstone, siltstone and minor coal seams. The Saltwater Creek Formation is younger than the Mulbring Siltstone. Both the formations are mapped as dipping to the east or south east at between 4 and 10 degrees.

The area of the proposed salt cake landfill and CHP is mapped as the Branxton Formation comprising conglomerate, sandstone and siltstone. There is no mapped alluvial immediately adjacent to the landfill with the nearest mapped alluvial material approximately 2.4 kilometres to the south west.

3.4 Hydrogeology

Groundwater is likely to be hosted in two primary formations: the porous sediments of the alluvium associated with the creeks in the Project area, and the fractured rock aquifer of the Permian sequences.

The creek lines may host a small amount of alluvium, which is considered to be sediment that has been transported by water movement and shows flow structure. The groundwater in the alluvium is likely to be unconfined. Groundwater flow in these systems generally flow parallel to the creek flow direction, and dependent on the stream size, whether it is ephemeral perennial etc.

Groundwater hosted in fractured rock systems are likely to be hosted either in the primary porosity of the rock or within the fractures, joints and bedding planes of the rock units. The key aquifers in the fractured rock systems are the coarse and weathered units and the coal seams. The coal seams host groundwater within the jointing and cleat network within the coal seams. The fractured rock groundwater systems can be confined or unconfined, and the shallow aquifer flow directions follow the general surface topography.

Discharge of groundwater from the fractured rock aquifers to the surface and to alluvium can occur at seepage points at the surface or in subcrop. Groundwater from the fractured rock aquifers in the area is generally considered to be brackish to saline. The alluvium is predominantly recharged by rainfall, with a small percentage of rainfall infiltrating to the water table. The alluvium in the area discharges eventually to the Hunter River alluvium or it contributes to the baseflow of the surface water bodies. The alluvium is most likely to be recharged by rainfall and discharge from the underlying fractured rock aquifers, except in areas where the fractured rock has been depressurised and/or dewatered by mining. In the areas of depressurisation, the hydraulic gradient may be the opposite and the alluvium may recharge the fractured rock aquifers. Interaction between the porous aquifers and the fractured rock aquifers is likely to be low where the environment is not disturbed.

Depths to groundwater vary considerably. In the alluvium, unconsolidated porous material (such as colluvium) and the weathered rock (all unconfined aquifers) the depth to groundwater is generally low – with depths to water between 0 m below ground level (**m BGL**) and approximately 10 m BGL. In the fractured rock aquifers, depth to water ranges from a few metres to tens of metres below ground level.

The water quality of the hydrogeological units is discussed in the following sections.

3.5 Sensitive receiving environments

No waterways within the Project footprint area have been classified as sensitive receiving environments. This conclusion has been made based on the following considerations:

3.5.1 Drinking water catchment

No waterways within the footprint area are part of the drinking water catchments for any of the surrounding townships.

3.5.2 Areas that contribute to aquaculture and commercial fishing

Commercial fishing is prohibited in waterways within the footprint area, and no waterways are classified as aquaculture areas.

3.5.3 Threatened aquatic species

Assessment of fish habitat values of waterways within the proposal area has been based on review of existing literature, desk-top searches and aerial photograph interpretation. The assessment has considered the Policy and Guidelines for Fish Habitat Conservation and Management (DPI, 2013) as well as current indicative distribution of the threatened species in NSW, modelled from past catchment data and environmental conditions as provided by the Department of Primary Industries (2018) and the Commonwealth *Environmental Protection and Biodiversity Act 1999* (**EPBC Act**) Protected Matters Search Tool.

According to the Protected Matters Search Tool (DAWE 2020 - https://www.environment.gov.au/epbc/protected-matters-search-tool) and the DPI NSW threatened species distribution maps (2018), no threatened fish listed under the *Environmental Protection and Biodiversity Conservation Act* 1999 (**EPBC Act**) or *Fisheries Management Act 1994* (**FM Act**) are likely to be present in any of the waterways located within the Project footprint area.

Lake Liddell, Plashett Reservoir and Bayswater Creek have been mapped as Key Fish Habitat (DPI, 2018), however, no threatened species are predicted to occur, and only minimal suitable aquatic habitat features appear to be present along the banks of the waterways. Considering this, all three waterways have been classified as Type 3 minimal key fish habitat (DPI, 2013). Furthermore, Bayswater Creek has been highly modified downstream including the construction of a diversion channel which has resulted in significantly altered aquatic and riparian habitat. In particular, the construction of a drop structure near the confluence of Bayswater Creek and the Hunter River prevents the migration of fish upstream.

No other waterways within the Project footprint have been mapped as Key Fish Habitat.

3.5.4 Groundwater dependent ecosystems (GDE)

Review of the Water Sharing Plan (**WSP**) Groundwater Dependant Ecosystem (**GDE**) maps for the North Coast Fractured and Porous Rock Groundwater Sources (NSW Government 2016) and the Hunter Unregulated and Alluvial Water Sources (NSW Government 2009) identified no high priority GDEs within the groundwater assessment study area boundary. The BOM's GDE Atlas (BOM, 2019b) was reviewed for potential GDEs within the study area. The atlas mapping is shown in Figure 4.13 and summarised as follows:

- 'Low potential terrestrial GDEs – from regional studies' are mapped over vast portions of the groundwater study area, most notably in the north western and south eastern portion of the study area;
- 'High potential terrestrial GDEs – from regional studies' are mapped over a narrow strip approximately 2 km long surrounding Davis Creek in the east of the groundwater study area. This same mapping category also occupies the southern boundary of the groundwater study area for a distance of approximately 200 m and surrounds an unnamed creek;

- ‘Moderate potential aquatic GDE – from national assessment’ is mapped in the very north eastern corner of the groundwater study area over a creek reach of approximately 1 km; and
- ‘High potential aquatic GDE – from national assessment’ is mapped in the south east of the groundwater study area over a reach of Parnells Creek which is approximately 4 km long.

3.5.5 Registered groundwater bores

Bore data provided by WaterNSW (2019a) was reviewed to investigate registered groundwater bores and associated groundwater level records in the groundwater study area. The review identified 35 registered groundwater bores within the study area (Jacobs 2020a) and the purposes of these bores can be summarised as follows:

- Water supply for manufacturing and industry (i.e. Commercial/industrial) – 2 bores
- Dewatering – 2 bores
- monitoring – 29 bores
- Unknown – 2 bores

The two commercial/industrial bores, GW053862 and GW060263, are both located approximately 3.6 km north-west of the closest Project elements (salt cake landfill and coal handling plant). The closest dewatering bore to the Project elements, GW20110, is located approximately 450 m north of the closest Project element (Ravensworth Ash Line). The closest monitoring bore to the Project elements, GW201061, is located approximately 500 m north of the closest Project element (Ravensworth Ash Line).

Standing water levels for the bores ranged from 3 m BGL to 43 m BGL (16 m AHD to 182 m AHD).

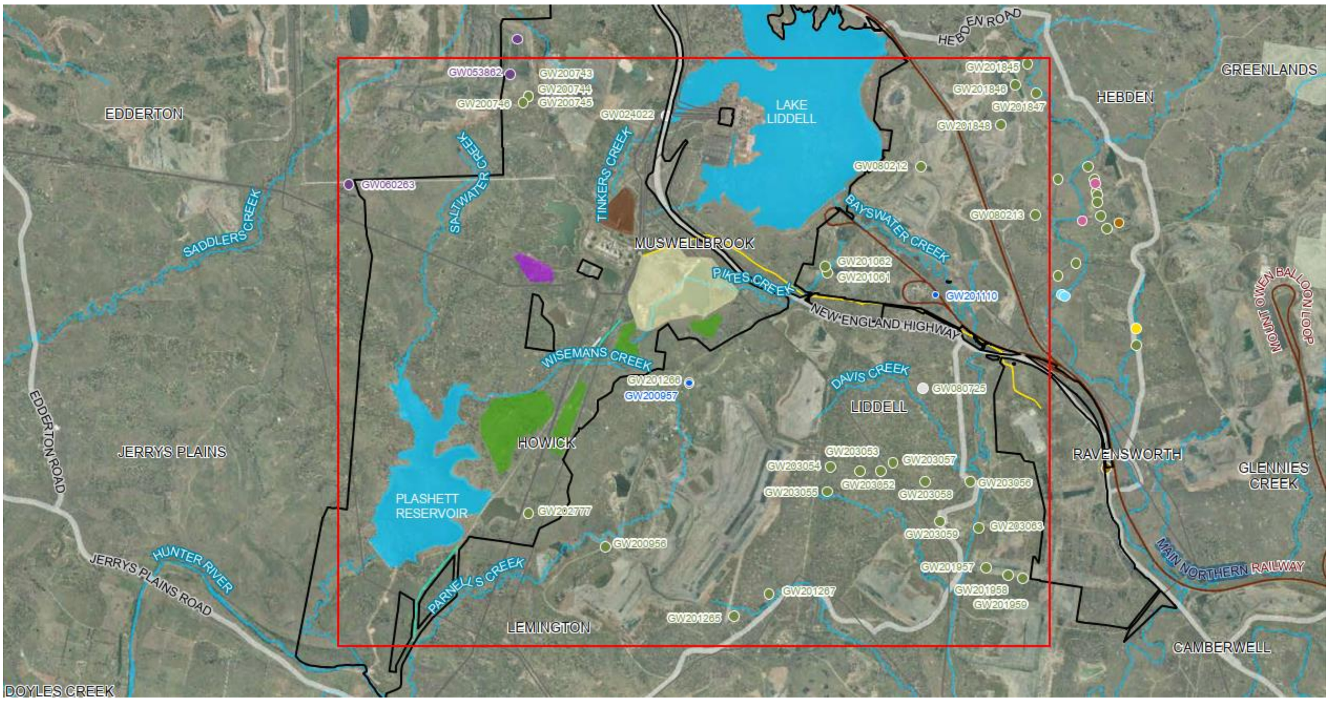

Figure 3.1: Registered water bores (source: Jacobs 2020a)

4. Water quality review

4.1 BWAD

4.1.1 Contaminants of potential concern (CoPCs)

AECOM (2016c) identified the principal contaminants of potential concern (**CoPCs**) for the ash dam as those potentially found in fly ash and bottom ash, which are the primary BWAD waste streams. Contributary sources of contaminants were also identified considering the additional waste streams that are co-disposed with the ash effluent. Table 4.1 presents a summary of the CoPCs that were identified for the ash dam.

Table 4.1: Summary of principal CoPC from the ash dam as listed in AECOM (2016c)

Waste Source Point	Matrix	Potential Contaminant
Sludge lagoons (a,b,c)	Sludge Effluent, (can include residue from lime softening plant)	Heavy metals, benzene, toluene, ethylbenzene and total xylenes (BTEX), petroleum hydrocarbons (total recoverable hydrocarbons TRH C6 to C40), polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH)
Fly ash	Fly ash effluent	Heavy metals, BTEX, TRH, PCB and PAH
Bottom ash transfer line	Bottom ash effluent, ChemClean effluent	Heavy metals, BTEX, TRH, PCB and PAH
Sewage effluent transfer	Sewage effluent	Heavy metals, TRH and microbacteria

The CoPC heavy metals include aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium and zinc.

4.1.2 Analysis results

AECOM (2016b) summarises groundwater and surface water results compared to the ANZECC (2000) Trigger Levels for fresh waters at the 95% protection level to provide an initial point of assessment and discussion against site assessment criteria (**SAC**) as at June 2016. The report states the following for samples collected from the BWAD:

- exceedances of the SAC
  - pH, EC, fluoride, total alkalinity, total suspended solids, total dissolved solids, major cations/anions and bicarbonate
  - Heavy metals (dissolved): aluminium, boron, barium, beryllium, copper, iron, nickel, lead, selenium, vanadium and zinc
  - Heavy metals (total): aluminium, boron, cadmium, copper, nickel, lead, selenium, vanadium and zinc
- The correlation between total and dissolved metals, and the notable presence of inorganics such as sulphur, suggests the potential for leaching of minerals from the solid ash entering the ash dam. (AECOM 2016b)

Table 4.2 summarises the results of BWAD decant water analysis for metals and the exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria of the results in the AECOM waste assessment report (2016c). The exceedances can be summarised thus:

- BWAD waste stream and decant water – aluminium, arsenic, boron, chromium, molybdenum, nickel, selenium, vanadium and zinc.

Figure 4.1 shows the locations of the AECOM (2016c) sample points.

A more recent water sampling campaign was undertaken as part of the BWAD Southern Seepage assessment by Jacobs on 12 October 2020. Table 4.3 summarises the BWAD waste stream and decant water results (for physico-chemical, major cation/anions, metals and cyanide/nitrogen compounds) and exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria that include:

- BWAD waste stream and decant water – aluminium, cadmium, boron, chromium, copper, molybdenum, nickel, selenium, vanadium, iron and total nitrogen

No detects above limits of reporting were recorded in the BWAD for polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), total recoverable hydrocarbons (TRHs), benzene/toluene/ethylbenzene/xylene/naphthalene (BTEXN), polychlorinated biphenyls (PCBs), lead, mercury or cyanide.

A comparison of the 2016 against the 2020 metals exceedances shows that in 2020 there were no exceedances for arsenic and zinc, and there were additional exceedances for cadmium copper iron and total nitrogen. Also, of these exceedances, concentrations for aluminium and boron and nickel was almost double in 2020 compared to 2016, and molybdenum was greater than double the concentration of 2016. That said, chromium, copper, vanadium and selenium concentrations were similar between 2016 and 2020.

Additionally, the pH of the BWAD decant water was slightly alkaline (Jacobs 2020) and the EC has been consistently between 4500 and 5000 µS/cm (AECOM 2016c, AECOM 2017b, Jacobs 2020).

Figure 4.2 shows the locations of the Jacobs 2020 sample points.

Table 4.2: Metals analysis results and exceedances (AECOM 2016c)

Analyte	Unit	ANZECC criteria#	BW_SW08	BW_SW08	BW_SW09	BW_SW09	BW_SW10	BW_SW17
			19/08/2015	23/10/2015	19/08/2015	23/10/2015	19/08/2015	23/10/2015
			BWAD Decant	BWAD Decant	BWAD Decant	BWAD Decant	BWAD Decant up-stream	west of BWAD
Aluminium	mg/L	0.055	0.050	0.070	0.040	0.060	0.040	0.030
Barium	mg/L	-	0.082	0.086	0.083	0.079	0.048	0.070
Arsenic	mg/L	0.024	0.029	0.034	0.029	0.036	0.014	0.027
Beryllium	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	2.860	2.920	2.840	2.730	2.800	2.890
Cadmium	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.0033	0.004	0.010	0.004	0.010	0.001	0.003
Cobalt	mg/L	0.0014	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Copper	mg/L	0.0014	0.001	0.001	0.001	<0.001	0.001	<0.001
Iron	mg/L	0.00007	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.0034	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.9	0.013	0.002	0.014	0.002	0.008	0.014
Mercury	mg/L	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.0034	0.252	0.316	0.256	0.312	0.236	0.295
Nickel	mg/L	0.011	0.009	0.006	0.009	0.006	0.014	0.010
Selenium	mg/L	0.005	0.030	0.050	0.020	0.040	0.010	0.030
Vanadium	mg/L	0.006	0.040	0.080	0.040	0.080	0.010	0.040
Zinc	mg/L	0.008	0.012	<0.005	<0.005	0.008	0.014	0.005

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

Table 4.3: Key BWAD water analysis results - 12 October 2020 (Jacobs)

Analyte	Unit	ANZECC criteria#	12/10/2020 BWADSW010 BWAD decant water	12/10/2020 BWADSW011 BWAD decant water	12/10/2020 BWADSW016 BWAD inflow ash slurry	12/10/2020 BWADSW019 BWAD inflow decant water
Physico-chemical properties						
pH Value	pH Unit	6.5 – 8.5	7.77	7.74	7.84	7.89
Electrical Conductivity	µS/cm		4920	4900	4750	4980
Sulfate	mg/L		1950	1960	1900	2000
Chloride	mg/L		618	622	604	631
Calcium	mg/L		374	378	364	391
Magnesium	mg/L		119	121	119	122
Sodium	mg/L		572	576	559	575
Potassium	mg/L		23	22	22	23
Total Alkalinity as CaCO3	mg/L		82	86	86	65
Dissolved Metals						
Aluminium	mg/L	0.055	0.140	0.140	0.090	0.150
Arsenic	mg/L	0.024	0.018	0.019	0.017	0.024
Beryllium	mg/L	-	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	-	0.078	0.081	0.081	0.101
Cadmium	mg/L	0.0002	0.0004	0.0004	0.0004	0.001
Chromium	mg/L	0.0033	0.004	0.004	0.004	0.003
Cobalt	mg/L	0.0014	<0.001	<0.001	<0.001	0.001
Copper	mg/L	0.0014	0.002	0.002	0.002	0.002
Lead	mg/L	0.0034	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.9	0.034	0.032	0.043	0.059
Molybdenum	mg/L	0.0034	0.747	0.771	0.726	0.869
Nickel	mg/L	0.011	0.015	0.015	0.015	0.018
Selenium	mg/L	0.005	0.050	0.050	0.050	0.060
Vanadium	mg/L	0.006	0.070	0.060	0.060	0.030
Zinc	mg/L	0.008	<0.005	<0.005	<0.005	<0.005
Boron	mg/L	0.37	5.320	5.450	5.190	5.430
Iron	mg/L	0.00007	<0.05	<0.05	<0.05	0.140
Mercury	mg/L	0.00006	<0.0001	<0.0001	<0.0001	<0.0001
Other						
Total Cyanide	mg/L	0.024	<0.004	<0.004	<0.004	<0.004
Ammonia as N	mg/L	-	0.48	0.39	0.17	0.01
Nitrite + Nitrate as N	mg/L		1.36	1.08	1.16	0.65
Total Kjeldahl Nitrogen as N	mg/L		0.5	0.500	0.300	<0.2
Total Nitrogen as N	mg/L	0.35	1.9	1.6	1.5	0.6

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

Figure 4.1: 2015 Bayswater sample locations (AECOM 2016c)

Figure 4.2: Sample locations - 12 October 2020 (Jacobs)

4.2 Seepage

Seepage from the BWAD has been known to occur for some time. An investigation by Power Plant Engineering Group in 1993 identified seepage from the right abutment of the Main Embankment (Power Plant Engineering Group 1993). Seepage also occurs via the Saddle Dam and potentially the hillside to the south of the BWAD. Currently, a seepage collection system exists only down-gradient of the Main Embankment; whereas, seepage from the Saddle Dam flows to Lake Liddell, via Chilcotts Creek (AECOM 2016c), and the potential seepage to the south of the BWAD flows via Eye Creek to Pikes Creek and ultimately to Bayswater Creek. Bayswater Creek is the receiving water for discharge from Lake Liddell.

A seepage return system was initially installed at the toe of the main dam wall and commissioned in 1987 (Seepage return water pond No. 1). A second seepage return water system was installed in the creek (Seepage return water pond No. 2) approximately 300 m downstream from the dam in 1994 (Aurecon 2011).

Seepage, that flows through the dam filter system, is monitored at a v-notch at the toe of the dam. Seepage flow through the right abutment (adjacent to the toe of the embankment) is controlled through a system of relief wells and gravel intercept drainage system. The seepage from the upper right abutment is monitored through drainage pipes, with the total flow being measured at a second v-notch weir. Seepage through the lower right abutment is measured through a drainage pipe at the toe of the dam. All this seepage flow is collected by Seepage return water pond No. 1 from where it is pumped back to the dam. The seepage from the main dam and abutments that bypass this first pond is collected and monitored at a separate V-notch weir at Seepage return water pond No. 2, from where it is pumped back to Seepage return water pond No.1 and subsequently to the ash dam (Aurecon 2011).

The seepage below the saddle dam wall flows through the filter system and is measured at a pipe outlet at the dam toe. The total overall seepage through the foundation and abutments is monitored at a v-notch weir installed about 200 m downstream from the dam toe (Aurecon 2011).

Monitoring and reporting of the seepage flow rates is undertaken as part of the dam monitoring and surveillance reporting required by the Dams Safety NSW (**DS NSW**) approvals. Seepage from both ponds is returned via a pump and pipeline and discharged back into the ash dam (Aurecon 2011).

A range of seepage rates for the Main Embankment have been estimated in previous investigations, including 0.28 ML/day [190 L/min] (AECOM 2017) and 0.58 ML/day [400 L/min] (Power Plant Engineering Group 1993). Jacobs (2020c), via a water balance model, predicted that losses from the BWAD (primarily via the Main Embankment and southern hillside areas) were more likely to be in the order of 9.2 ML/day, of which approximately 0.56 ML/day is expected to be pumped back to the BWAD via the upgraded seepage collection system (to be upgraded as part of the WAOAW project). This seepage volume predicted in the Jacobs (2020c), that is greater than previous estimates, is not due to the project. The water balance modelling results (Jacobs 2020c) indicate that daily seepage flows from the BWAD bypassing the BWAD seepage collection system are similar for existing and post-BWAD augmentation conditions for varying rainfall scenarios; that is, the net incremental change to the seepage due to the project is not significant. Additionally, the predicted Saddle Dam seepage rate (Jacobs 2020c) accounts for between 0.05 ML/ day [35 L/min] and 0.14 ML/ day [95L/min] that are lost as seepage to Chilcotts Creek (AECOM 2016d). This leaves approximately 8.5 ML/day that is lost as seepage from the BWAD (predominantly from the right abutment) that circumvents the Main Embankment collection system or that seeps to the south to Eye Creek. Regular dam safety inspections are undertaken as part of the site maintenance program.

AGLM has committed to upgrading the BWAD seepage collection system to maximise the volume of BWAD seepage loss flows that are captured by the seepage pond collection and pumped back to BWAD. The proposed upgrades to the seepage pond collection system and return water system include:

- Installing a seepage collection system below the Saddle Dam wall;
- Enlargement and deepening (and potential lining) of the existing seepage collection ponds;

- Installation of larger capacity pumps to increase the maximum volume of seepage water that can be pumped back to the BWAD following large storm events; and
- Increasing the duration of pumping from the seepage collection ponds to the ash dam.

Table 4.4 is a summary of the results of the Jacobs (2020c) water balance model (refer green highlighting). The table shows that the proposed improvement works will improve seepage collection at the ponds, with only a minor increase to seepage to Bayswater Creek. Additionally, the Project also includes works to recover seepage at the Saddle Dam wall. The AECOM (2016b) water balance modelling suggests that improvements to the Main Embankment Seepage Pond no. 2, seepage to Pikes Gully and the Saddle Dam could reduce seepage by 123 ML/yr to 155 ML/yr, 88 ML/yr and 42 ML/yr, respectively (refer Table 4.5**Error! Reference source not found.**), for a total reduction of 284 ML/yr.

Therefore, the proposed upgrades to the seepage collection are expected to result in a reduction of the volume of the BWAD water that discharges to the receiving environment. This is likely to have a positive impact on the water quality of Pikes Creek and other downstream receiving water bodies (Jacobs 2020).

Table 4.4: BWAD water balance summary (source Jacobs 2020c)

	Dry Scenario (5th Percentile)		Average Scenario (Mean)		Wet Scenario (95th Percentile)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
ASH DAM WATER STORAGE VOLUME (ML)	1,626	65	2,109	65	2,487	65
INPUTS (ML/d)						
Rainfall	0.000	0.000	0.663	0.070	4.140	0.439
Runoff	0.000	0.000	0.822	0.822	2.183	2.183
Seepage Collection Pond 1	0.239	0.000	0.264	0.178	0.270	0.254
Seepage Collection Pond 2	0.239	0.000	0.264	0.178	0.270	0.254
Brine Holding Pond overflow	0.000	0.000	0.000	0.000	0.000	0.000
Boiler and Mills Cleanout	0.000	0.000	0.000	0.000	0.000	0.000
Demineralisation Effluent	0.787	0.787	0.787	0.787	0.787	0.787
Treated Sewage Effluent	0.000	0.000	0.000	0.000	0.000	0.000
Ash Plant	8.216	8.216	8.216	8.216	8.216	8.216
OUTPUTS (ML/d)						
Overflow	0.000	0.000	0.000	0.000	0.050	2.042
Evaporation	0.822	0.114	1.089	0.115	1.295	0.115
Seepage to Collection Ponds	0.478	0.000	0.528	0.356	0.540	0.508
Seepage to Lake Liddell	0.094	0.094	0.094	0.094	0.094	0.094
Seepage to Bayswater Creek	8.702	8.733	8.715	8.886	8.757	9.241

Table 4.5: AECOM (2016a) water balance results summary

Description	Destination	Average Scenario (50%ile)	Wet Scenario (99%ile)	Priority
		ML / year	ML / year	
Bayswater Ash Dam spillway	Lake Liddell	410	857	Medium
Bayswater Ash Dam Seepage Collection Pond 2 spillway	Bayswater Creek (Hunter River)	123	154	Medium
Bayswater main dam seepage via Pikes Gully	Bayswater Creek (Hunter River)	88	88	Low
Bayswater Ash Dam saddle dam wall seepage	Lake Liddell	42	42	Low

Furthermore, AGLM have reviewed the feasibility of using a liner in the Main Embankment Seepage Ponds and are currently assessing the potential seepage south toward Eye Creek.

The seepage water has been the subject of numerous assessments. Table 4.6 summarises the exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria of the Main Embankment Seepage Pond 1 sample results in the AECOM waste assessment report (2016c). The exceedances can be summarised thus:

- Boron, molybdenum, nickel and zinc.

Figure 4.1 shows the locations of the AECOM (2016c) sample points.

A more recent water sampling campaign was undertaken as part of the BWAD Southern Seepage assessment by Jacobs on 12 October 2020. Table 4.7 summarises the exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria that include:

- Main Embankment seepage samples collected from:
  - Seepage Pond 1 – molybdenum, nickel and boron
  - Seepage Pond 2 – molybdenum and boron
- Saddle dam discharge point to Chilcotts Creek – aluminium, cadmium, cobalt, boron, chromium, copper, nickel, zinc, iron and total nitrogen

No detects above limits of reporting were recorded in the BWAD for PAHs, TPHs, TRHs, BTEXN, PCBs, lead, mercury or cyanide.

Figure 4.2 shows the locations of the Jacobs (2020) sample points.

Also, the pH of the BWAD seepage has had a wide range of pH values ranging from 6.8 (Jacobs 2020) to 8.5 (AECOM 2017b). BWAD seepage EC also has been measured over a large range of values from 2130 µS/cm (AECOM 2017b) to 11550 µS/cm at Seepage Pond No.1 (Jacobs 2020) (refer Table 4.7). It appears as though the Saddle Dam EC values tend to be within the lower EC ranges and in line with the EC of the BWAD decant water, and tend to have higher dissolved metals concentrations. Conversely, the Main Embankment seepage samples tend to a higher EC value and lower metals concentrations

Table 4.6: Water analysis results (AECOM 2016c)

Analyte	Unit	ANZECC criteria#	BW_SW13	
			Seepage pond 1	
			19/08/2015	23/10/2015
Aluminium	mg/L	0.055	0.020	<0.01
Barium	mg/L	-	0.012	0.011
Arsenic	mg/L	0.024	<0.001	<0.001
Beryllium	mg/L	-	<0.001	<0.001
Boron	mg/L	0.37	2.300	2.110
Cadmium	mg/L	0.0002	<0.0001	<0.0001
Chromium	mg/L	0.0033	<0.001	<0.001
Cobalt	mg/L	0.0014	<0.001	<0.001
Copper	mg/L	0.0014	<0.001	<0.001
Iron	mg/L	0.00007	<0.05	<0.05
Lead	mg/L	0.0034	<0.001	<0.001
Manganese	mg/L	1.9	0.120	0.021
Mercury	mg/L	0.00006	<0.0001	<0.0001
Molybdenum	mg/L	0.0034	0.034	0.041
Nickel	mg/L	0.011	0.013	0.010
Selenium	mg/L	0.005	<0.01	<0.01
Vanadium	mg/L	0.006	<0.01	<0.01
Zinc	mg/L	0.008	0.015	<0.005

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

Table 4.7: Water analysis results - 12 October 2020 (Jacobs)

Analyte	Unit	ANZECC criteria#	12/10/2020	12/10/2020	12/10/2020
			BWADSW007	BWADSW008	BWADSW009
			Seepage pond 2	Seepage Pond 1	Saddle Dam seepage
Physico-chemical properties					
pH Value	pH Unit	6.5 – 8.5	8.02	7.82	6.8
Electrical Conductivity	µS/cm		6920	11500	5600
Sulfate	mg/L		2930	2930	1890
Chloride	mg/L		802	1940	842
Calcium	mg/L		397	466	210
Magnesium	mg/L		256	369	130
Sodium	mg/L		894	1620	828
Potassium	mg/L		9	11	13
Total Alkalinity as CaCO3	mg/L		299	576	21
Dissolved Metals					
Aluminium	mg/L	0.055	<0.01	<0.01	0.340
Arsenic	mg/L	0.024	<0.001	<0.001	<0.001
Beryllium	mg/L	-	<0.001	<0.001	0.002
Barium	mg/L	-	0.015	0.027	0.017
Cadmium	mg/L	0.0002	<0.0001	<0.0001	0.0004
Chromium	mg/L	0.0033	<0.001	<0.001	<0.001
Cobalt	mg/L	0.0014	<0.001	<0.001	0.039
Copper	mg/L	0.0014	<0.001	<0.001	<0.001
Lead	mg/L	0.0034	<0.001	<0.001	<0.001
Manganese	mg/L	1.9	0.213	0.014	0.467
Molybdenum	mg/L	0.0034	0.007	0.008	<0.001

Analyte	Unit	ANZECC criteria#	12/10/2020 BWADSW007 Seepage pond 2	12/10/2020 BWADSW008 Seepage Pond 1	12/10/2020 BWADSW009 Saddle Dam seepage
Nickel	mg/L	0.011	0.007	0.023	0.091
Selenium	mg/L	0.005	<0.01	<0.01	<0.01
Vanadium	mg/L	0.006	<0.01	<0.01	<0.01
Zinc	mg/L	0.008	<0.005	<0.005	0.085
Boron	mg/L	0.37	2.650	1.790	2.340
Iron	mg/L	0.00007	<0.05	<0.05	0.700
Mercury	mg/L	0.00006	<0.0001	<0.0001	<0.0001
Other					
Total Cyanide	mg/L	0.024	<0.004	<0.004	<0.004
Ammonia as N	mg/L	-	0.02	0.04	<0.01
Nitrite + Nitrate as N	mg/L	-	<0.01	0.04	1.12
Total Kjeldahl Nitrogen as N	mg/L	-	<0.1	<0.1	0.2
Total Nitrogen as N	mg/L	0.35	<0.1	<0.1	1.3

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

4.3 Surface water

Surface water bodies that are the likely receiving environments for seepage from the BWAD are Pikes Creek - east and south of the BWAD Main Embankment; Eye Creek - south of BWAD (Jacobs 2020) and Chilcotts Creek - north of BWAD and is the BWAD spillway discharge point flowing to Lake Liddell (AECOM 2017). Secondary receptors include Bayswater Creek, into which Lake Liddell and Pikes Creek discharge.

Salinity of water courses within the Hunter River catchment are naturally elevated, with sources of salt related heavily to rainfall and weathering products which enter streams via surface runoff pathways and groundwater sources, particularly from the underground geology of the Permian coal measures. Of the surface water salinity observations from across the Hunter region (including Bayswater Creek), median electrical conductivities exceeded 5,500 µS/cm for areas in proximity to the AGLM power station facilities (Bioregional Assessments, 2019).

The date ranges of surface water quality data available for review is summarised in Table 4.8.

Table 4.8: Available surface water quality monitoring data

Site name	Project Site code*	Waterway	Data source	Monitoring timeframe/period	Description and relevance
Hunter River Low Pressure Pumping Station	HR1	Hunter River	Ravensworth Void 4 Discharge Investigation (Aurecon, 2013)	2005 – 2013	Water quality data collected by Macquarie Generation for the Hunter River (at the low-pressure pumping station). Approximately 170 metres downstream of the confluence of Saltwater Creek and Hunter River.
Plashett Reservoir Monitoring Site	PR1	Plashett Reservoir	Monitoring data acquired from AGL Macquarie (2019)	2015 – 2019	Monitoring site located at Plashett Reservoir dam wall. Indicative water quality within in Plashett Reservoir.

Site name	Project Site code*	Waterway	Data source	Monitoring timeframe/period	Description and relevance
Bayswater Creek Sampling Site 1	BC1	Bayswater Creek	Ravensworth Void 4 Discharge Investigation (Aurecon, 2013)	December 2010	Aurecon (2013) monitoring site within Bayswater Creek approximately 300 metres upstream of the confluence of Bayswater Creek and Hunter River.
Bayswater Creek Sampling Site 2	BC2	Bayswater Creek	Ravensworth Void 4 Discharge Investigation (Aurecon, 2013)	December 2010	Aurecon (2013) monitoring site within Bayswater Creek approximately 900 metres downstream of the confluence of Bayswater Creek and Emu Creek.
Bayswater Creek Sampling Site 3	BC3	Bayswater Creek	Ravensworth Void 4 Discharge Investigation (Aurecon, 2013)	December 2010	Aurecon (2013) monitoring site within Bayswater Creek approximately 250 metres downstream of the confluence of Davis Creek.
Bayswater Creek Sampling Site 4	BC4	Bayswater Creek	Ravensworth Void 4 Discharge Investigation (Aurecon, 2013)	December 2010	Aurecon (2013) monitoring site within Bayswater Creek immediately downstream of the confluence of Davis Creek.
Discharge Point 07 (EPL 7)	LDP07	Tinkers Creek	Monitoring data required under EPL 779 (AGL Macquarie, 2019)	2015 – 2019	Monitoring site located at the licensed discharge point from cooling towers to Tinkers Creek via an under-over weir.
Discharge Point 08 (EPL 8)	LDP08	Lake Liddell	Monitoring data required under EPL 779 (AGL Macquarie data, 2019)	2015 – 2019	Monitoring site located at the discharge pipe from Lake Liddell dam wall. Indicative water quality in Lake Liddell.
Coal Handling Plant 03	CHP03	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located within the upstream tributary of Tinkers Creek that is influenced by the freshwater dam, which is located within an external catchment.
Coal Handling Plant 04	CHP04	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located at the confluence of external catchment areas and Tinkers Creek, upstream of LDP07.
Coal Handling Plant 05	CHP05	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located downstream of the confluence of LDP07 and Tinkers Creek.

Site name	Project Site code*	Waterway	Data source	Monitoring timeframe/period	Description and relevance
Coal Handling Plant 09	CHP09	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located at the overflow outlet weir that discharges into Tinkers Creek.
Coal Handling Plant 10	CHP10	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located downstream of the confluence of discharge points into Tinkers Creek.
Coal Handling Plant 11	CHP11	Tinkers Creek	Bayswater Coal Handling Plant Sediment Basin – Assessment of Water Quality and Water Management (AECOM, 2017b)	November 2016 – January 2017	Monitoring site located at the confluence of Tinkers Creek and Lake Liddell.
MGW10	PC1	Pikes Creek (Pikes Gully)	Monitoring data acquired from AGL Macquarie (2019)	2005 – 2011	Monitoring site at BWAD spill way.

** The Project site codes will here-in be used to describe results of analysis*

4.3.1 Bayswater Creek

Bayswater Creek is the main transfer channel linking Lake Liddell and the Hunter River, with Lake Liddell receiving runoff from the upper portion of the Bayswater Creek catchment and discharge from the AGLM power station facilities (Jacobs 2020). Bayswater Creek also receives a small proportion of its flow from Pikes Creek.

There was no contemporary water quality data for pH, electrical conductivity, or toxicant indicators for Bayswater Creek, however water sampling at locations along Bayswater Creek was undertaken by Aurecon (2013) in December 2010. Results were extracted from Aurecon (2013), analysed and compared to the ANZECC/ARMCANZ (2000) guidelines for the protection of lowland river aquatic ecosystems, or ANZG (2018) guidelines for either the protection of aquatic ecosystems or primary industry (irrigation and general water use and livestock drinking water).

pH and electrical conductivity

The quality of water within Bayswater Creek at the time of sampling was characterised by high electrical conductivity, with all samples above the ANZECC/ARMCANZ (2000) guidelines, however all samples were below the stated median EC value for water courses in the area (5500 µS/cm) (Bioregional Assessments, 2019). pH levels remained within the ANZECC/ARMCANZ (2000) guidelines values on all four sampling occasions. Summary data is provided in Table 4.9.

Table 4.9: Bayswater Creek water quality data at sampling points downstream of the dam wall (Source: Aurecon, 2013)

Parameter		ANZG (2018) Guidelines	BC 1	BC 2	BC 3	BC 4
Electrical conductivity	(EC)	125 – 2,200	**2,864**	**3,452**	**3,130**	**2,907**
pH	(pH)	6.5 – 8.5	8.13	7.82	8.12	7.91

Toxicant concentrations

Based on data for toxicant concentrations, a large portion of the analysed trace metals and ions had concentrations below detection limits or below recommended upper limits stated in the ANZG (2018) guidelines for either the protection of aquatic ecosystems (greater than 80% species protection) or primary industry (irrigation and general water use and livestock drinking water). The exceptions were aluminium, chloride, chromium, copper, fluoride, iron, sodium and zinc which were above the guideline level at a minimum of one sampling site. Results are provided in

Table 4.10. Results outside the recommended guidelines are shown in bold.

Table 4.10: Bayswater Creek trace metal and ion concentration data at sampling points downstream of the dam wall (Source: Aurecon, 2013)

Parameter		ANZG (2018) Guideline level of protection				BC 1	BC 2	BC 3	BC 4
		99%	95%[1]	90%	80%				
Aluminum (mg/L)	(Al)	0.027	0.055[4]	0.08	0.15	<0.1	**0.2**	<0.1	<0.1
Barium (mg/L)	(Ba)	No guideline				0.1	0.07	0.09	0.09
Arsenic (III) (mg/L)	(As)	0.001	0.024	0.094	0.36	0.002	0.002	0.002	0.002
Beryllium (mg/L)	(Be)	0.1[2]				<0.01	<0.01	<0.01	<0.01
Boron (mg/L)	(B)	0.09	0.37	0.68	1.3	<1	<1	<1	<1
Cadmium (mg/L)	(Cd)	0.00006	0.0002	0.0004	0.0008	<0.0002	<0.0002	<0.0002	<0.0002
Calcium (mg/L)	(Ca)	1,000[3]				140	94	150	150
Chloride (mg/L)	(Cl)	350[2]				**510**	**620**	**540**	**510**
Chromium (VI) (mg/L)	(Cr)	0.00001	0.001	0.006	0.04	<0.001	0.002	0.005	0.002
Cobalt (mg/L)	(Co)	0.05[2]				<0.01	<0.01	<0.01	<0.01
Copper (mg/L)	(Cu)	0.001	0.0014	0.0018	0.0025	0.002	0.001	<0.001	<0.001
Fluoride (mg/L)	(F)	2[2]				**2**	1	**2**	1
Iron (mg/L)	(Fe)	0.2[2]				<0.001	0.002	0.005	0.002
Lead (mg/L)	(Pb)	0.001	0.0034	0.0056	0.0094	<0.001	<0.001	<0.001	<0.001
Magnesium (mg/L)	(Mg)	No guideline				110	80	120	110
Manganese (mg/L)	(Mn)	1.2	1.9	2.5	3.6	<0.01	0.02	0.06	0.03
Mercury (mg/L)	(Hg)	0.00006	0.00006	0.0019	0.0054	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum (mg/L)	(Mo)	0.01[2] 0.034[1]				<0.1	<0.1	<0.1	<0.1
Nickel (mg/L)	(Ni)	0.008	0.011[6]	0.013	0.017	0.002	0.004	0.008	0.004
Potassium (mg/L)	(K)	No guideline				18	14	17	16

Parameter		ANZG (2018) Guideline level of protection				BC 1	BC 2	BC 3	BC 4
		99%	95%[1]	90%	80%				
Selenium (mg/L)	(Se)	0.005	0.011	0.018	0.034	0.002	0.005	0.002	<0.002
Silver (mg/L)	(Ag)	0.00002	0.00005	0.0001	0.0002	<0.001	<0.001	<0.001	<0.001
Sodium (mg/L)	(Na)	230[2]				**440**	**650**	**480**	**430**
Strontium (mg/L)	(Sr)	No guideline				2.4	1.9	2.6	2.5
Titanium (mg/L)	(Ti)	No guideline				<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	(V)	0.1[1]				<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	(Zn)	0.0024	0.008	0.015	0.031	<0.01	**0.06**	<0.01	<0.01

[1] – Trigger values for slightly-moderately disturbed ecosystems in south-east Australia (Lowland river)

[2] – Trigger values for primary industry (irrigation and general water use – long term use)

[3] – Trigger values for primary industry (livestock drinking water)

[4] – for pH > 6.5

4.3.2 Pikes Creek

Pikes Creek is a highly disturbed, ephemeral water way with approximately 950 m of its 5000 m length occupied by the BWAD, and the lower 1700 m having been diverted through old open cut mine workings. The Jacobs (2020) water impact assessment as part of the EIS for the Project concluded that Pikes Creek was not a sensitive receiving environment. There are no potential sensitive groundwater receptors until approximately 1.4km downgradient (measured in a straight-line distance) from the current ash dam wall, where low potential GDEs are mapped (Jacobs 2020).

Water samples were collected by AECOM in 2015 and the lab analysis results are summarised in Table 4.11. The data shows only minor exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria for boron for one sampling round and for molybdenum for the two sampling rounds.

Table 4.11: Pikes Creek water analysis results (AECOM 2016c)

Analyte	Unit	ANZECC criteria#	BW_SW12 Pikes Creek agricultural dam	
			19/08/2015	23/10/2015
Aluminium	mg/L	0.055	<0.01	<0.01
Barium	mg/L	-	0.045	0.068
Arsenic	mg/L	0.024	0.002	0.003
Beryllium	mg/L	-	<0.001	<0.001
Boron	mg/L	0.37	0.380	0.310
Cadmium	mg/L	0.0002	<0.0001	<0.0001
Chromium	mg/L	0.0033	<0.001	<0.001
Cobalt	mg/L	0.0014	<0.001	<0.001
Copper	mg/L	0.0014	<0.001	<0.001
Iron	mg/L	0.00007	<0.05	<0.05
Lead	mg/L	0.0034	<0.001	<0.001
Manganese	mg/L	1.9	0.030	0.027
Mercury	mg/L	0.00006	<0.0001	<0.0001
Molybdenum	mg/L	0.0034	0.007	0.004
Nickel	mg/L	0.011	0.003	0.002
Selenium	mg/L	0.005	<0.01	<0.01
Vanadium	mg/L	0.006	<0.01	<0.01
Zinc	mg/L	0.008	<0.005	<0.005

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

Jacobs (2020) states that limited data was available for toxicant indicators for water in Pikes Gully, with the majority of the toxicants (antimony, arsenic, barium, cadmium, fluoride, lead, lithium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, strontium, vanadium, zinc) only analysed once, on 24 November 2010. Concentrations of the remaining indicators (aluminium, boron, chloride, hexavalent chromium, copper, iron, sodium) are based on median values of 28 sampling events between 2005 and 2011. Results are provided in Table 4.12. Some of the toxicants had median concentrations that were above the ANZG (2018) recommended guidelines for either the protection of aquatic ecosystems (greater than 80% species protection) or primary industry (irrigation and general water use and livestock drinking water). These included aluminium, boron, cadmium, chloride, chromium, copper, fluoride, molybdenum, nickel, selenium, sodium and zinc. Results outside the recommended guidelines are shown in bold.

Table 4.12: Trace metals and ions data collected for the discharge into Pikes Creek (Jacobs 2020)

Parameter		ANZG (2018) Guideline level of protection				Pikes Gully (MGW10)
		99%	95%[1]	90%	80%	
Aluminium (mg/L)	(Al)	0.027	0.055[4]	0.08	0.15	**0.2**[6]
Antimony (mg/L)	(Sb)	0.009				0.008[7]
Arsenic (mg/L)	(As)	0.001	0.024	0.094	0.36	0.015[7]
Barium (mg/L)	(Ba)	No guideline				0.09[7]
Boron (mg/L)	(B)	0.09	0.37	0.68	1.3	**3**
Cadmium (mg/L)	(Cd)	0.00006	0.0002	0.0004	0.0008	<0.01[7]
Chloride (mg/L)	(Cl)	350[2]				**785**[6]
Chromium (VI) (mg/L)	(Cr)	0.00001	0.001	0.006	0.04	<0.01[10]
Copper (mg/L)	(Cu)	0.001	0.0014	0.0018	0.0025	**0.005**[9]
Fluoride (mg/L)	(F)	1[2]				**3.7**[7]
Iron (mg/L)	(Fe)	0.2[2]				0.0656
Lead (mg/L)	(Pb)	0.0034[6]				0.01[7]
Lithium (mg/L)	(Li)	No guideline				0.69[7]
Manganese (mg/L)	(Mn)	1.2	1.9	2.5	3.6	0.06[7]
Mercury (mg/L)	(Hg)	0.00006	0.00006	0.0019	0.0054	0.00005[7]
Molybdenum (mg/L)	(Mo)	0.01[2] 0.034[5]				0.3[7]
Nickel (mg/L)	(Ni)	0.008	0.011	0.013	0.017	**0.49**[7]
Potassium (mg/L)	(K)	No guideline				31[7]
Selenium (mg/L)	(Se)	0.005	0.011	0.018	0.034	**0.019**[7]
Silver (mg/L)	(Ag)	0.00002	0.00005[6]	0.0001	0.0002	<0.001[7]
Sodium (mg/L)	(Na)	230[2]				**789**[6]
Strontium (mg/L)	(Sr)	No guideline				3[7]
Vanadium (mg/L)	(V)	0.006[1]				0.04[7]
Zinc (mg/L)	(Zn)	0.0024	0.008	0.015	0.031	**0.01**[7]

[1] – Trigger values for slightly-moderately disturbed ecosystems in south-east Australia (Lowland river)

[2] – Trigger values for primary industry (irrigation and general water use – long term use)

[3] – Trigger values for primary industry (livestock drinking water)

[4] – for pH > 6.5

[5] – Trigger value for freshwater (Unknown)

[6] – For the purpose of estimating medians (n=28), when concentrations were below the detection limit (DL), a value of half the DL was used.

[7] – Only 1 sampling event undertaken on 24/11/2010

A more recent water sampling campaign was undertaken as part of the BWAD Southern Seepage assessment by Jacobs on 12 October 2020. The water was collected from a pool that is considered to be groundwater as the creek was dry after a prolonged dry spell and the pool was in particularly deep section of the creek. Therefore, the water is considered daylighting groundwater that is likely representative of the alluvium groundwater quality at this location. The water quality of the alluvium in Pikes Creek is likely to be a combination of surface water runoff, water seepage from the BWAD and discharge from coal seams in the area.

Table 4.13 summarises the exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria that include boron, copper, molybdenum and total nitrogen. Two of the four exceedances are the same as for the AECOM (2015) rounds.

The pH (8.2) and EC (24,300 µS/cm) values for the Pikes Creek sample, however, were the highest of the October 2020 sampling campaign. The EC in the creek pool is considerably higher than the water from the

BWAD and the concentration is likely due to a combination of discharge of brackish/saline water from adjacent seam subcrops and concentration due to evapotranspiration.

No detects above limits of reporting were recorded in the BWAD for PAHs, TPHs, TRHs, BTEXN, PCBs, lead, mercury or cyanide.

Figure 4.2 shows the locations of the Jacobs (2020) sample points.

Table 4.13: Pikes Creek water analysis results - 12 October 2020 (Jacobs)

Analyte	Unit	ANZECC criteria#	12/10/2020
			BWADSW006
			Pikes Creek - lower
Physico-chemical properties			
pH Value	pH Unit	6.5 – 8.5	8.23
Electrical Conductivity	µS/cm		24300
Sulfate	mg/L		9300
Chloride	mg/L		4220
Calcium	mg/L		426
Magnesium	mg/L		1050
Sodium	mg/L		4440
Potassium	mg/L		14
Total Alkalinity as CaCO3	mg/L		652
Dissolved Metals			
Aluminium	mg/L	0.055	<0.01
Arsenic	mg/L	0.024	0.002
Beryllium	mg/L	-	<0.001
Barium	mg/L	-	0.038
Cadmium	mg/L	0.0002	<0.0001
Chromium	mg/L	0.0033	<0.001
Cobalt	mg/L	0.0014	<0.001
Copper	mg/L	0.0014	0.003
Lead	mg/L	0.0034	<0.001
Manganese	mg/L	1.9	0.018
Molybdenum	mg/L	0.0034	0.009
Nickel	mg/L	0.011	0.006
Selenium	mg/L	0.005	<0.01
Vanadium	mg/L	0.006	<0.01
Zinc	mg/L	0.008	0.007
Boron	mg/L	0.37	0.530
Iron	mg/L	0.00007	<0.05
Mercury	mg/L	0.00006	<0.0001
Other			
Total Cyanide	mg/L	0.024	<0.004
Ammonia as N	mg/L	-	0.29
Nitrite + Nitrate as N	mg/L		<0.01
Total Kjeldahl Nitrogen as N	mg/L		1.5
Total Nitrogen as N	mg/L	0.35	1.5

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

4.3.3 Eye Creek

Eye Creek is a fourth order (also referred to as Cye Creek), ephemeral stream located south of the BWAD. The creek flows in an easterly direction and joins Pikes Creek just prior to Pikes Creek flowing under the New England Highway. Eye Creek receives the majority of its flow from runoff during wet periods, potentially with a portion of seepage from the BWAD via seepage through the hillside between the BWAD and Eye Creek (HLA 2004). There is currently no formal collection point for this seepage volume and the only available water quality data is from a recent campaign that has yet to be finalised (see below).

The recent sampling campaign targeted sampling points in the Eye Creek catchment, including agricultural dams, seepage points and creek pools. A total of ten samples were collected in the Eye Creek catchment, of which six samples were collected from pools within the creek and four from the agricultural dams.

The water collected from the pools is considered to be groundwater as the creek was dry after a prolonged dry spell and the pools were in particularly deep section of the creek. Therefore, the water is considered daylighting groundwater that is likely representative of the alluvium groundwater quality at those locations. The water quality of the alluvium in Eye Creek is likely to be a combination of surface water runoff, water seepage from the BWAD and discharge from coal seams in the area. Figure 4.2 shows the locations of the Jacobs (2020) sample points.

The samples were analysed for a range of parameters including pH, EC, cation/anions, metals, PAH, TPH, TRH, BTEXN, PCB, and nitrogen compounds (nitrate/nitrite/TKN/ammonia/cyanide).

The water quality of the four agricultural dams (four samples), even close to the recognised seepage point, are of relatively good quality. The pH range for the dams is 7.3 to 7.8, with an average of 7.3, and the EC ranges from 229 µS/cm to 735 µS/cm, with an average of 373 µS/cm. The pH and EC are within the ranges (6.5 – 8.5 and 125–2200 µS/cm, respectively) for slightly disturbed ecosystems in south-east Australia (ANZECC 2000). Key EyeCreek lab data is summarised in Table 4.14.

The quality of the water sampled from the pools in the creek line is considered representative of Eye Creek alluvium. The pH range for this water is 6.7 to 8.1, with an average of 7.7, and the EC ranges from 1000 µS/cm to 21500 µS/cm, with an average of 9685 µS/cm. The pH is within the range (6.5 – 8.5) for slightly disturbed ecosystems in south-east Australia (ANZECC 2000), whereas, the EC is in the upper ranges or exceeds the criteria. Key Eye Creek lab data is summarised in Table 4.14.

Table 4.14 also summarises the metals exceedances when compared to the ANZECC (2018) criteria for slightly to moderately disturbed freshwater aquatic ecosystems. Both the agricultural dams and the creek pools identified exceedances of aluminium, cobalt, copper, molybdenum, zinc, boron and iron. Sample location BWADSW018 (which is closest to the presumed seepage point to Eye Creek) also exceeded criteria for nickel and vanadium.

No detects above limits of reporting were recorded in the Eye Creek catchment for PAHs, TPHs, TRHs, BTEXN, PCBs, beryllium, cadmium, chromium, mercury and cyanide.

The above water analysis data appears to indicate that the seepage from BWAD and from the coal seams does not daylight until the pools in Eye Creek. The EC in the creek pools is considerably higher than the water from the BWAD and the concentrations are likely due to a combination of discharge of brackish/saline water from adjacent seam subcrops and concentration due to evapotranspiration.

Table 4.14: Eye Creek water quality results (12 October 2020)

Analyte	Unit	ANZECC criteria#	BWADSW001	BWADSW003	BWADSW004	BWADSW005	BWADSW012	BWADSW013	BWADSW014	BWADSW015	BWADSW017	BWADSW018
			Ag. dam	Eye Creek Lower	Ag. dam	Eye Creek Lower	Ag. dam	Seepage point at Eye ck	Seepage point at Eye ck	Ag. dam	Eye Creek Lower	Seepage point at Eye ck
Physico-chemical properties												
pH Value	pH Unit	6.5 – 8.5	7.3	7.79	7.79	7.75	7.49	8.07	7.98	7.83	7.95	6.71
EC	µS/cm		245	1320	284	1000	229	21500	14400	735	2090	17800
Dissolved Metals												
Aluminium	mg/L	0.055	1.21	0.16	0.050	0.47	10.6	<0.01	<0.01	0.4	0.020	0.07
Arsenic	mg/L	0.024	<0.001	0.003	0.002	0.004	0.002	0.001	<0.001	<0.001	<0.001	0.011
Beryllium	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	-	0.063	0.056	0.064	0.104	0.073	0.076	0.022	0.040	0.164	0.064
Cadmium	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.0033	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Cobalt	mg/L	0.0014	0.001	0.003	<0.001	0.003	0.001	0.001	<0.001	<0.001	0.002	0.182
Copper	mg/L	0.0014	0.004	0.001	<0.001	0.005	0.003	<0.001	<0.001	0.003	<0.001	<0.001
Lead	mg/L	0.0034	<0.001	<0.001	<0.001	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.9	0.144	0.219	0.060	0.646	0.136	0.341	0.061	0.055	0.230	21.2
Molybdenum	mg/L	0.0034	<0.001	0.002	0.003	0.001	0.007	0.010	0.003	0.002	0.008	0.003
Nickel	mg/L	0.011	0.003	0.004	0.003	0.003	0.003	0.003	0.005	0.003	0.004	0.039
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.006	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Zinc	mg/L	0.008	<0.005	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.007
Boron	mg/L	0.37	<0.05	0.250	<0.05	0.150	0.190	0.200	0.4	0.100	0.290	0.59
Iron	mg/L	0.00007	0.42	0.78	0.41	7.3	1.68	<0.05	<0.05	0.37	0.19	251
Mercury	mg/L	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

4.3.4 Chilcotts Creek and Lake Liddell

Chilcotts Creek and Lake Liddell are located to the north and northeast of the BWAD. Chilcotts Creek is an ephemeral water way that leads from the BWAD Saddle Dam to Lake Liddell, which is a distance of approximately 1200 m. The BWAD spillway is constructed to flow into a tributary of Chillcotts Creek approximately 400 m downstream of the Saddle Dam.

Water quality data for Chilcotts Creek is limited to a small number of incomplete references in AECOM (2016b). One location on Chilcotts Creek SW16 (BWAD Spillway) (refer Figure 4.1) was sampled twice in 2015 and the key observations can be summarised as follows:

- pH and EC at SW16 (refer Figure 4.1) was in line with water from the BWAD, with a pH of 8 and an EC of 4760 µs/cm
- results for TPH, BTEX, PAH/Phenols were below limits of reporting
- dissolved metals concentrations that exceeded slightly disturbed ecosystems in south-east Australia (ANZECC 2000) were cobalt, boron, molybdenum and nickel (refer Table 4.16)

Table 4.15: SW16 field water quality results (AECOM 2017b)

Site	Sample Type	Date	pH	EC (µs/cm)	Temp (ºC)	DO (mg/L)	Redox (mV)
BW_SW16	Surface Water	19/08/2015	-	-	-	-	-
BW_SW16	Surface Water	23/10/2015	7.96	4,760	17.2	5.33	95

Table 4.16: Chillcotts Creek/BWAD Spillway water quality results (AECOM 2017b)

Analyte	Unit	ANZECC criteria#	BW_SW16 Chilcotts Creek (BWAD Spillway)	
			19/08/2015	23/10/2015
Aluminium	mg/L	0.055	<0.01	<0.01
Barium	mg/L	-	0.020	0.020
Arsenic	mg/L	0.024	<0.001	0.001
Beryllium	mg/L	-	<0.001	<0.001
Boron	mg/L	0.37	3.080	3.080
Cadmium	mg/L	0.0002	<0.0001	<0.0001
Chromium	mg/L	0.0033	<0.001	<0.001
Cobalt	mg/L	0.0014	0.003	0.002
Copper	mg/L	0.0014	<0.001	<0.001
Iron	mg/L	0.00007	<0.05	<0.05
Lead	mg/L	0.0034	<0.001	<0.001
Manganese	mg/L	1.9	0.009	0.065
Mercury	mg/L	0.00006	<0.0001	<0.0001
Molybdenum	mg/L	0.0034	0.082	0.114
Nickel	mg/L	0.011	0.046	0.042
Selenium	mg/L	0.005	<0.01	<0.01
Vanadium	mg/L	0.006	<0.01	<0.01
Zinc	mg/L	0.008	<0.005	<0.005

- ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria – highlighting shows exceedances

Lake Liddell is an artificial waterbody that was constructed in the 1960's for use of supplying cooling water to Bayswater and Liddell power stations by damming Bayswater Creek. The water quality of the lake is influenced by a number of sources as it collects runoff from the upper portion of the Bayswater Creek catchment (Bioregional Assessments, 2019), as well as from licensed discharges released from Bayswater and Liddell Power Stations at Tinkers Creek, Chilcotts Creek and directly into the lake. The water quality of Lake Liddell is monitored at LDP08 (now EPL Point 23), which is located at the pipe at the dam wall used to release water to Bayswater Creek (Jacobs 2020).

In 2017, as part of a water quality assessment of the Bayswater and Liddell Ash Dam Discharges, AECOM (2017b) estimated that the BWAD emergency spillway (that spills to Chillcotts Creek and Lake Liddell) would discharge 410 ML per year under average climatic conditions and 857 ML per year under wet conditions. That said, no discharges occurred from the BWAD between AGL's acquisition of the site in September 2014 and the publication of the report in mid-2017. AECOM (2017b) also summarises water quality data for five general water source locations (refer Table 4.17)

Based on the Lake Liddell outlet monitoring data, the ash dam discharges do not appear to be impacting the quality of water exiting Lake Liddell. The TSS and pH values at the lake outlet were within the required EPL limits, even though the ash dam samples showed TSS and pH values higher than the EPL limits at EPL Point 8 (now EPL Point 23) for comparison. For the other analytes, the lake outlet average values were typically the lowest out of the sample locations. Based on the data analysed as part of this study, it appears that the ash dam discharges are diluted by the lake prior to reaching the lake outlet, thus meeting water quality requirements at the lake discharge location (AECOM 2017b).

Jacobs (2020) summarises water quality monitoring data was collected at LDP08 (now EPL Point 23) between July 2015 and July 2019 (refer Table 4.18). The pH values complied with the requirements specified in EPL779 for LDP08 (now EPL Point 23) monitoring site at all times (6.5-8.5), however median pH was outside the ANZECC/ARMCANZ (2000) recommended pH range of 6.5 – 8.0 for lakes and reservoirs (Table 4-11).

Based on the median (n=48) values for all toxicants provided in Table 4.19, a large portion of the trace metals and ions had concentrations below detection limits or below ANZG (2018) guidelines for either the protection of aquatic ecosystems (greater than 80% species protection) or primary industry (irrigation and general water use and livestock drinking water). The exceptions were boron, cadmium, chloride, copper, fluoride and molybdenum. Results outside the recommended guidelines are shown in bold.

The Project proposes to increase the BWAD Emergency Spillway from the current elevation of 172 m AHD to 173.7 m AHD. This change to the spillway elevation will increase the BWAD decant pond storage capacity by some 380 ML. This will reduce the risk of overflow, and will reduce the discharge to Chilcotts Creek and Lake Liddell (Jacobs 2020a).

Table 4.17: Bayswater and Liddell Ash Dam Discharges: Water Quality Analysis (AECOM 2017)

Analyte	Value	LD Ash Dam	LD Skimmer Dam	BW Ash Dam	Lake Liddell PRP	Lake Liddell Outlet
pH	Min	8.00	8.10	8.33	7.43	7.70
	Average	8.54	8.41	8.77	7.88	8.16
	Max	9.07	8.64	9.10	8.33	8.50
Electrical Conductivity (µs/cm)	Min	1798	1835	3078	1962	2130
	Average	2262	2183	3686	1982	2287
	Max	3390	2600	4350	2001	2520
Total Suspended Solids (mg/L)	Min	7	6	15		1
	Average	10	124	33		4
	Max	15	242	50		16
Total Dissolved Solids (mg/L)	Min	1770	1800	3350		1240
	Average	2050	1805	3355		1485
	Max	2570	1810	3360		1640
Total Aluminum (mg/L)	Min	0.03	0.10	0.16	0.05	0.01
	Average	0.21	1.95	0.46	0.86	0.03
	Max	0.46	7.32	1.55	2.44	0.08
Total Manganese (mg/L)	Min	0.008	0.018	0.006	0.009	0.003
	Average	0.018	0.096	0.021	0.202	0.029
	Max	0.025	0.312	0.049	0.577	0.096
Total Arsenic (mg/L)	Min	0.018	0.047	0.015	0.005	0.003
	Average	0.117	0.057	0.031	0.013	0.004
	Max	0.169	0.083	0.042	0.019	0.006
Total Nickel (mg/L)	Min	0.003	0.003	0.006	0.004	0.003
	Average	0.005	0.006	0.009	0.010	0.004
	Max	0.007	0.013	0.014	0.020	0.006
Total Iron (mg/L)	Min	0.025	0.060	0.060	0.050	0.005
	Average	0.095	1.178	0.216	1.520	0.036
	Max	0.200	4.350	0.700	4.420	0.080
Total Copper (mg/L)	Min	0.001	0.001	0.001	0.005	0.001
	Average	0.003	0.007	0.001	0.046	0.002
	Max	0.005	0.025	0.003	0.117	0.003
Alkalinity (Bicarbonate as CaCO3) (mg/L)	Min	110	132	54	100	
	Average	129	136	88	138	
	Max	149	142	141	158	
Chloride (mg/L)	Min	306	309	499	299	
	Average	337	332	531	342	
	Max	368	356	559	365	
Fluoride (mg/L)	Min	1.9	2.6	4.1	1.0	
	Average	3.7	2.6	4.3	1.6	
	Max	4.6	2.6	4.4	1.8	
Sulphur (Total Oxidised as SO4) (Filtered) (µg/L)	Min	586,000	668,000	1,610,000	452,000	
	Average	767,333	700,750	1,682,000	581,750	
	Max	906,000	742,000	1,790,000	728,000	
Calcium (mg/L)	Min	128	144	250	110	
	Average	189	167	269	122	
	Max	231	189	286	136	
Magnesium (mg/L)	Min	71	70	112	72	
	Average	79	75	129	84	
	Max	92	79	154	107	
Potassium (mg/L)	Min	15	15	19	13	
	Average	19	17	21	13	
	Max	21	18	22	14	
Sodium (mg/L)	Min	261	266	582	233	
	Average	282	272	612	252	
	Max	302	276	641	288	

Table 4.18: Summary statistics at site EPL 8, within Lake Liddell (Source: AGL Macquarie, 2019)

Indicator	Minimum	20th percentile	Median	80th percentile	Maximum
pH	7.7	7.9	8.2	8.4	8.5
Electrical conductivity (µS/cm)	**2160**	**2246**	**2310**	**2614**	**2860**

Table 4.19: Toxicant and ion concentration data at EPL 8 (Source AGL Macquarie, 2019)

Parameter		ANZG (2018) Guideline level of protection				Lake Liddell Dam Wall (LDP08)
		99%	95%[1]	90%	80%	
Aluminum (mg/L)	(Al)	0.027[4]	0.055[4]	0.08[4]	0.15[4]	0.0235[5]
Antimony (mg/L)	(Sn)	0.009				0.006
Arsenic (mg/L)	(Ar)	0.001	0.024	0.094	0.36	0.005
Beryllium (mg/L)	(Be)	0.1[2]				<0.001
Boron (mg/L)	(B)	0.09	0.37	0.68	1.3	1.185
Cadmium (mg/L)	(Cd)	0.00006	0.0002	0.0004	0.0008	0.0005[5]
Calcium (mg/L)	(Ca)	1,000[3]				139
Chloride (mg/L)	(Cl)	350[2]				**437[5]**
Chromium (VI) (mg/L)	(Cr)	0.00001	0.001	0.006	0.04	0.0005
Copper (mg/L)	(Cu)	0.001	0.0014	0.0018	0.0025	**0.003[5]**
Fluoride (mg/L)	(F)	2[2]				1.8
Iron (mg/L)	(Fe)	0.2[2]				0.04[5]
Lead (mg/L)	(Pb)	0.001	0.0034	0.0056	0.0094	<0.001
Magnesium (mg/L)	(Mg)	No guideline				81.8
Manganese (mg/L)	(Mn)	1.2	1.9	2.5	3.6	0.0155
Mercury (mg/L)	(Hg)	0.00006	0.00006	0.0019	0.0054	<0.0001
Molybdenum (mg/L)	(Mo)	0.01[2] 0.034[6]				**0.101**
Nickel (mg/L)	(No)	0.008	0.011	0.013	0.017	0.004
Potassium (mg/L)	(K)	No guideline				18.25
Selenium (mg/L)	(Se)	0.005	0.011	0.018	0.034	<0.01
Silver (mg/L)	(Ag)	0.00002	0.00005	0.0001	0.0002	<0.001
Sodium (mg/L)	(Na)	230[2]				315.5
Vanadium (mg/L)	(V)	0.1[1]				0.0091
Zinc (mg/L)	(Zn)	0.0024	0.008	0.015	0.031	0.0025[5]

[1] – Trigger values for slightly-moderately disturbed ecosystems in south-east Australia (Lowland river)
[2] – Trigger values for primary industry (irrigation and general water use – long term use)
[3] – Trigger values for primary industry (livestock drinking water)
[4] – for pH > 6.5
[5] – For the purpose of estimating medians, when concentrations were below the detection limit (DL), a value of half the DL was used.
[6] – Trigger values for freshwater (Unknown)

4.4 Groundwater quality

Existing groundwater quality data is available for Project assessment groundwater monitoring bores. The bores were sampled during multiple rounds and field tested (field parameters only) and laboratory tested for the range of analytes. There are 27 groundwater monitoring bores across four key Project elements (refer Figure 4.3), including the ash dam augmentation, salt cake landfill, periphery of the north eastern potential borrow pit area and the Ravensworth Ash Line:

- Between three to eleven records of manual groundwater level measurements from November 2016 to April 2019; and
- Groundwater quality analytical records from November 2016 to April 2019. Analytes tested included:
  - Heavy metals;
  - TRH;
  - BTEXN;
  - PAHs;
  - PCBs;
  - Ammonia;
  - Nutrients;
  - Major anions and cations; and
  - Field parameters: pH, EC, TDS, DO and Redox potential.

Details of these bores and results are summarised in Jacobs (2020b).

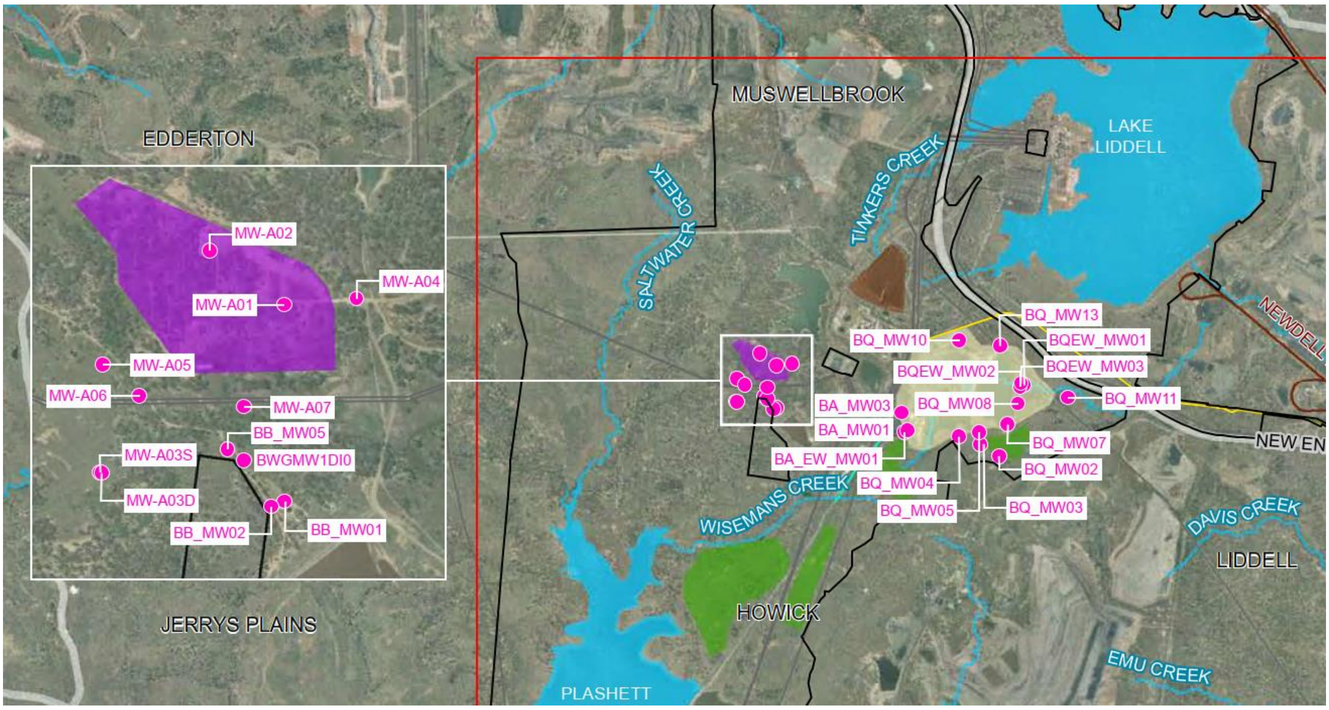

Figure 4.3: AGL Bayswater groundwater monitoring locations (sourced: Jacobs 2020b)

Historical groundwater quality results were compared to ANZECC 2000 freshwater 95% level of protection, ANZECC 2000 trigger values for lowland rivers, and ANZECC 2000 freshwater 99% level of protection (used only for bioaccumulate Mercury and Selenium) (Jacobs 2020b). A summary of groundwater exceedances is shown in Table 4.20 and the complete data set is included Jacobs (2020b).

The following general key points are noted as related to the groundwater quality data:

- aluminium, boron, copper, cadmium, iron, manganese, molybdenum, nickel, silver and zinc concentrations were above ANZECC 2000 GW 95% guideline levels on at least one occasion
- The LOR for vanadium for all samples was above the criteria.
- Reactive phosphorous, nitrate and total nitrogen were at times above the ANZECC 2000 guideline levels for lowland rivers
- The pH values at BA_MW01, BA_MW03 BQ_MW04 and BA_ BQ_MW10 were above the ANZECC 2000 guideline levels for lowland rivers
- There were no detects for TRH, BTEXN, PAHs and PCBs in any sample

In order to characterise the existing groundwater quality, the major and minor ions are presented in a piper plot in Figure 4.4. The piper plot indicates the groundwater of the Project monitoring bores is generally split between sodium chloride and calcium chloride water types. MW_A04 (middle samples in diamond portion of plot) associated with the Salt cake landfill, has a distinct groundwater quality signature compared to other Project bores (refer Figure 4.4). This location is characterised by no dominant water type (Jacobs 2020b).

The average TDS concentration, excluding MW_A04, was 11,556 mg/L, with a maximum concentration of 20,600 mg/L, which is considered saline (Freeze and Cherry, 1979). The mean and median monitored TDS concentrations for the salt cake landfill bores is 7,277 mg/L and 7,753 mg/L, respectively, which corresponds to 'brackish' water quality (Freeze and Cherry, 1979) (Jacobs 2020b).

The Project is expected to generate negligible impacts to groundwater and risks to groundwater are assessed as low. This conclusion is based on a detailed review of background groundwater level and quality data, along with an analysis of the existing environmental setting and an assessment of the Project elements. With regards to the salt cake landfill, saline/briny water may migrate to underlying and surrounding groundwater systems, if the salt cake landfill liner were to leak.

Table 4.20: Summary of groundwater quality exceedances (Jacobs 2020b)

Bore ID	Key Area	Sampled Date	Aluminium (Filtered)	Boron (Filtered)	Cadmium (Filtered)	Copper (Filtered)	Iron (Filtered)	Manganese (Filtered)	Molybdenum (Filtered)	Nickel (Filtered)	Silver	Vanadium (Filtered)	Zinc (Filtered)	Nitrate (as N)	Nitrogen (Total)	Reactive Phosphorus as P	pH (Field)	Total Dissolved Solids
			µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	pH Units	mg/L
ANZECC 2000 FW 95%			55	370	0.2	1.4	0.07	1900	3.4	11	0.05	6	8	0.1581				
ANZECC (2000) trigger values for lowland rivers															0.5	0.02	6.5 - 8	
BA_EW_MW01	Ash dam augmentation zone	1/12/2016	80	2290	0.1	<1	<0.05	1730	2	49	-	<10	15	0.04	0.3	0.05	6.3	8100
BA_EW_MW01	Ash dam augmentation zone	27/02/2017	80	3020	0.1	<1	<0.05	1790	<1	44	-	<10	14	0.08	0.5	0.1	6.5	7870
BA_EW_MW01	Ash dam augmentation zone	28/06/2017	100	2970	<0.1	<1	<0.05	2130	2	34	-	<10	13	0.02	0.3	0.05	6.5	7560
BA_EW_MW01	Ash dam augmentation zone	6/09/2017	60	2490	<0.1	<1	<0.05	2210	<1	33	-	<10	8	0.05	0.2	0.06	6.5	7520
BA_EW_MW01	Ash dam augmentation zone	29/11/2017	<10	2830	0.1	<1	<0.05	2810	<1	27	-	<10	<5	<0.01	0.2	0.06	6.5	7630
BA_EW_MW01	Ash dam augmentation zone	28/02/2018	<10	2830	0.1	<1	0.22	2850	2	31	-	<10	<5	0.06	0.3	0.02	6.6	7520
BA_EW_MW01	Ash dam augmentation zone	30/05/2018	<10	2600	0.2	<1	0.11	2200	1	34	-	<10	<5	0.02	0.2	0.06	6.4	5600
BA_EW_MW01	Ash dam augmentation zone	23/08/2018	<10	2900	0.3	<1	<0.05	2020	<1	30	-	<10	<5	<0.01	0.3	0.08	6.6	5940
BA_EW_MW01	Ash dam augmentation zone	4/12/2018	<10	3160	0.8	<1	<0.05	1850	2	36	-	<10	6	0.83	1.5	0.05	6.6	7060
BA_EW_MW01	Ash dam augmentation zone	28/03/2019	<10	3220	0.5	<1	<0.05	719	<1	50	-	<10	8	0.46	0.8	0.04	6.7	7320
BA_MW01	Ash dam augmentation zone	30/11/2016	120	2360	2	<1	<0.05	3180	<1	138	-	<10	46	0.02	0.2	0.18	5.5	9950
BA_MW01	Ash dam augmentation zone	27/02/2017	110	2360	2	<1	<0.05	3200	<1	130	-	<10	45	0.04	0.3	0.21	5.6	9500
BA_MW01	Ash dam augmentation zone	28/06/2017	100	2330	1.8	<1	<0.05	3090	<1	118	-	<10	40	0.02	<0.2	0.19	5.7	9370
BA_MW01	Ash dam augmentation zone	6/09/2017	80	2250	1.6	<1	<0.05	2630	<1	119	-	<10	39	0.03	<0.2	0.2	5.6	9100
BA_MW01	Ash dam augmentation zone	29/11/2017	90	2230	1.9	<1	<0.05	2920	<1	119	-	<10	42	<0.01	0.3	0.17	5.6	8610
BA_MW01	Ash dam augmentation zone	28/02/2018	90	2430	1.8	<1	<0.05	2990	<1	119	-	<10	41	0.04	0.1	0.19	5.6	8930
BA_MW01	Ash dam augmentation zone	30/05/2018	80	1950	1.8	<1	<0.05	3270	<1	126	-	<10	42	0.04	0.2	0.16	5.5	8400
BA_MW01	Ash dam augmentation zone	17/08/2018	60	2040	1.4	<1	<0.05	2900	<1	110	-	<10	35	<0.01	<0.2	0.17	5.8	6000
BA_MW01	Ash dam augmentation zone	4/12/2018	70	2450	1.7	<1	<0.05	3150	<1	120	-	<10	41	0.2	0.4	0.17	5.6	9430
BA_MW01	Ash dam augmentation zone	28/03/2019	60	1920	1.8	<1	<0.05	2920	<1	121	-	<10	39	<0.01	0.1	0.18	5.7	7790
BA_MW03	Ash dam augmentation zone	23/11/2016	280	1130	2.8	<1	<0.05	3330	<1	283	-	<10	114	0.02	0.3	0.06	5.5	9760
BA_MW03	Ash dam augmentation zone	23/02/2017	290	1350	2.6	<1	<0.05	3500	<1	274	-	<10	108	0.07	<0.2	0.04	5.4	9550
BA_MW03	Ash dam augmentation zone	28/06/2017	340	1600	2.4	<1	<0.05	3700	<1	270	-	<10	114	0.02	<0.1	0.06	5.6	9240
BA_MW03	Ash dam augmentation zone	6/09/2017	300	1570	2.2	<1	<0.05	3090	<1	275	-	<10	113	0.05	<0.2	0.06	5.6	8980
BA_MW03	Ash dam augmentation zone	29/11/2017	340	1660	2.3	<1	<0.05	3540	<1	274	-	<10	112	<0.01	0.2	0.05	5.5	9260
BA_MW03	Ash dam augmentation zone	27/02/2018	330	1870	2.2	<1	<0.05	3300	<1	242	-	<10	99	0.04	0.1	0.02	5.5	8750
BA_MW03	Ash dam augmentation zone	30/05/2018	250	1530	2.2	<1	<0.05	3710	<1	254	-	<10	95	0.02	0.1	0.05	5.5	6140
BA_MW03	Ash dam augmentation zone	14/08/2018	280	1540	2.4	<1	<0.05	3840	<1	270	-	<10	103	<0.01	0.1	0.05	5.5	7610
BA_MW03	Ash dam augmentation zone	4/12/2018	310	1580	2.6	<1	<0.05	3500	<1	284	-	<10	112	<0.01	<0.1	0.07	5.4	8820
BA_MW03	Ash dam augmentation zone	28/03/2019	270	1300	2.5	<1	<0.05	3240	<1	274	-	<10	108	<0.01	<0.1	0.07	5.6	6430
BQ_MW04	Ash dam augmentation zone	29/11/2016	<10	200	<0.1	<1	<0.05	12	3	4	-	<10	6	0.02	<0.2	0.03	6.8	7910
BQ_MW04	Ash dam augmentation zone	24/02/2017	<10	220	0.1	<1	<0.05	207	2	6	-	<10	<5	0.09	<0.5	<0.01	7.2	8660
BQ_MW04	Ash dam augmentation zone	15/06/2017	<10	170	<0.1	<1	0.08	45	3	4	-	<10	<5	<0.01	<0.2	<0.01	7	7880
BQ_MW04	Ash dam augmentation zone	6/09/2017	<10	190	<0.1	<1	<0.05	15	2	3	-	<10	<5	0.05	0.4	<0.01	7	7620
BQ_MW04	Ash dam augmentation zone	16/11/2017	<10	370	0.4	<1	<0.05	3	3	3	-	<10	<5	0.03	<0.5	<0.01	6.9	8060
BQ_MW04	Ash dam augmentation zone	22/02/2018	<10	320	<0.1	<1	<0.05	3	2	3	-	<10	<5	0.03	<0.2	<0.01	7	7630
BQ_MW04	Ash dam augmentation zone	29/05/2018	<10	190	<0.1	<1	<0.05	3	2	6	-	<10	<5	0.01	0.3	0.01	7.2	7400
BQ_MW04	Ash dam augmentation zone	14/08/2018	<10	250	<0.1	<1	<0.05	514	2	6	-	<10	<5	0.04	<0.5	<0.01	7.3	6450
BQ_MW04	Ash dam augmentation zone	20/11/2018	<10	300	<0.1	<1	<0.05	30	2	4	-	<10	<5	0.04	<0.1	<0.01	7.3	6370
BQ_MW04	Ash dam augmentation zone	28/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BQ_MW05	Ash dam augmentation zone	25/11/2016	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BQ_MW07	Ash dam augmentation zone	25/11/2016	<10	1090	0.2	<1	<0.05	12	2	10	-	<10	<5	0.2	0.2	0.05	6.7	8240
BQ_MW07	Ash dam augmentation zone	24/02/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.6	-
BQ_MW07	Ash dam augmentation zone	15/06/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	-
BQ_MW07	Ash dam augmentation zone	6/09/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
BQ_MW07	Ash dam augmentation zone	16/11/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
BQ_MW07	Ash dam augmentation zone	28/02/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-

Bore ID	Key Area	Sampled Date	Aluminium (Filtered)	Boron (Filtered)	Cadmium (Filtered)	Copper (Filtered)	Iron (Filtered)	Manganese (Filtered)	Molybdenum (Filtered)	Nickel (Filtered)	Silver	Vanadium (Filtered)	Zinc (Filtered)	Nitrate (as N)	Nitrogen (Total)	Reactive Phosphorus as P	pH (Field)	Total Dissolved Solids
			µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	pH Units	mg/L
ANZECC 2000 FW 95%			55	370	0.2	1.4	0.07	1900	3.4	11	0.05	6	8	0.1581				
ANZECC (2000) trigger values for lowland rivers															0.5	0.02	6.5 - 8	
BQ_MW07	Ash dam augmentation zone	20/11/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BQ_MW07	Ash dam augmentation zone	22/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BQ_MW08	Ash dam augmentation zone	25/11/2016	<10	3100	<0.1	<1	<0.05	108	1	7	-	<10	<5	0.02	<0.1	<0.01	6.6	4780
BQ_MW08	Ash dam augmentation zone	24/02/2017	<10	3100	<0.1	3	<0.05	139	<1	7	-	<10	<5	0.08	0.3	0.01	6.6	4780
BQ_MW08	Ash dam augmentation zone	16/06/2017	<10	3590	<0.1	<1	<0.05	138	<1	8	-	<10	<5	<0.01	<0.1	<0.01	6.7	4390
BQ_MW08	Ash dam augmentation zone	5/09/2017	<10	3330	<0.1	<1	<0.05	99	<1	7	-	<10	<5	0.03	0.1	<0.01	6.7	4520
BQ_MW08	Ash dam augmentation zone	15/11/2017	<10	3590	0.1	<1	<0.05	133	<1	9	-	<10	<5	<0.01	<0.1	<0.01	6.8	3760
BQ_MW08	Ash dam augmentation zone	23/02/2018	<10	3250	<0.1	<1	<0.05	126	<1	7	-	<10	<5	0.01	<0.2	<0.01	6.7	3570
BQ_MW08	Ash dam augmentation zone	29/05/2018	<10	3730	<0.1	12	<0.05	134	<1	9	-	<10	<5	<0.01	0.3	0.01	6.7	2850
BQ_MW08	Ash dam augmentation zone	2/08/2018	<10	3460	0.1	<1	<0.05	129	<1	8	-	<10	<5	<0.01	0.2	<0.01	6.8	4040
BQ_MW08	Ash dam augmentation zone	26/11/2018	<10	3580	<0.1	<1	<0.05	145	<1	8	-	<10	<5	<0.01	<0.1	<0.01	6.8	3960
BQ_MW08	Ash dam augmentation zone	27/03/2019	<10	3380	<0.1	<1	<0.05	132	<1	9	-	<10	<5	<0.01	<0.1	<0.01	6.8	2980
BQ_MW10	Ash dam augmentation zone	24/11/2016	6370	3650	0.4	<1	0.23	586	<1	196	-	<10	259	<0.01	0.7	<0.01	4	3800
BQ_MW10	Ash dam augmentation zone	1/06/2017	4800	2720	0.4	2	0.18	528	<1	149	-	<10	192	<0.01	0.6	<0.01	4	3210
BQ_MW10	Ash dam augmentation zone	5/09/2017	7150	3510	0.3	3	0.25	645	2	179	-	<10	266	0.03	0.6	<0.01	4	2980
BQ_MW10	Ash dam augmentation zone	14/11/2017	7050	3510	0.5	2	0.26	689	<1	180	-	<10	262	<0.01	0.6	<0.01	3.9	3880
BQ_MW10	Ash dam augmentation zone	22/02/2018	6900	3780	0.5	3	0.24	637	<1	183	-	<10	255	<0.01	0.4	<0.01	3.9	3310
BQ_MW10	Ash dam augmentation zone	28/05/2018	6830	3380	0.5	3	0.26	646	<1	181	-	<10	266	<0.01	0.6	<0.01	4	4000
BQ_MW10	Ash dam augmentation zone	14/08/2018	6810	3480	0.5	3	0.25	606	<1	182	-	<10	259	<0.01	0.7	<0.01	3.9	3010
BQ_MW10	Ash dam augmentation zone	27/11/2018	7180	3470	0.5	3	0.25	662	<1	182	-	<10	252	<0.01	0.6	0.02	4.1	2820
BQ_MW10	Ash dam augmentation zone	26/03/2019	6820	3380	0.5	3	0.26	646	<1	185	-	<10	268	<0.01	0.6	<0.01	4.1	3530
BQ_MW11	Ash dam augmentation zone	25/11/2016	<10	360	0.2	<1	<0.05	14	2	4	-	<10	<5	0.04	<0.1	<0.01	7.1	9440
BQ_MW11	Ash dam augmentation zone	24/02/2017	<10	520	<0.1	<1	<0.05	88	2	4	-	<10	<5	0.08	0.3	0.02	7.2	9090
BQ_MW11	Ash dam augmentation zone	15/06/2017	<10	450	<0.1	<1	<0.05	40	3	4	-	<10	<5	<0.01	0.2	<0.01	7.2	8700
BQ_MW11	Ash dam augmentation zone	5/09/2017	<10	350	<0.1	<1	<0.05	41	2	3	-	<10	<5	0.07	<0.2	0.02	7.3	8850
BQ_MW11	Ash dam augmentation zone	15/11/2017	<10	380	<0.1	<1	<0.05	35	2	3	-	<10	<5	<0.01	0.2	0.02	7.3	8130
BQ_MW11	Ash dam augmentation zone	23/02/2018	<10	690	<0.1	<1	<0.05	38	1	3	-	<10	<5	0.04	<0.2	0.01	7.3	9240
BQ_MW11	Ash dam augmentation zone	28/05/2018	<10	450	<0.1	<1	<0.05	65	2	4	-	<10	<5	0.03	<0.1	0.04	7.2	7550
BQ_MW11	Ash dam augmentation zone	14/08/2018	10	400	<0.1	<1	<0.05	15	1	4	-	<10	<5	0.02	<0.5	<0.01	7.2	6130
BQ_MW11	Ash dam augmentation zone	26/11/2018	<10	430	<0.1	<1	<0.05	41	2	4	-	<10	<5	0.01	<0.1	0.01	7.3	8510
BQ_MW11	Ash dam augmentation zone	26/03/2019	<10	400	<0.1	<1	<0.05	34	2	4	-	<10	<5	<0.01	<0.1	<0.01	7.3	8910
BQ_MW13	Ash dam augmentation zone	24/11/2016	<10	2450	<0.1	<1	<0.05	77	<1	8	-	<10	<5	0.02	0.2	0.01	6.8	4130
BQ_MW13	Ash dam augmentation zone	23/02/2017	<10	2170	<0.1	<1	<0.05	111	<1	8	-	<10	<5	0.08	<0.2	<0.01	6.7	3780
BQ_MW13	Ash dam augmentation zone	1/06/2017	<10	1820	<0.1	<1	<0.05	82	<1	6	-	<10	<5	0.06	<0.1	0.03	6.8	3880
BQ_MW13	Ash dam augmentation zone	4/09/2017	<10	1910	<0.1	<1	<0.05	99	<1	7	-	<10	<5	<0.01	0.1	0.02	6.8	3980
BQ_MW13	Ash dam augmentation zone	24/11/2017	<10	1800	<0.1	<1	<0.05	122	<1	7	-	<10	<5	0.03	<0.1	0.01	7	3590
BQ_MW13	Ash dam augmentation zone	23/02/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BQ_MW13	Ash dam augmentation zone	31/05/2018	<10	2160	<0.1	1	<0.05	80	<1	6	-	<10	<5	0.4	0.4	0.02	6.8	3910
BQ_MW13	Ash dam augmentation zone	2/08/2018	<10	2340	<0.1	1	<0.05	120	<1	8	-	<10	<5	0.03	0.2	0.02	6.8	3700
BQ_MW13	Ash dam augmentation zone	26/11/2018	<10	2110	<0.1	<1	<0.05	138	<1	6	-	<10	<5	0.03	<0.1	0.12	6.9	4000
BQ_MW13	Ash dam augmentation zone	27/03/2019	<10	2150	<0.1	<1	<0.05	128	<1	6	-	<10	<5	0.01	0.2	0.01	7	3590
BQEW_MW01	Ash dam augmentation zone	29/11/2016	<10	1920	<0.1	<1	<0.05	88	4	13	-	<10	<5	<0.01	<0.1	0.03	7	5580
BQEW_MW01	Ash dam augmentation zone	28/02/2017	<10	2060	<0.1	<1	0.07	105	2	14	-	<10	<5	0.03	<0.1	0.02	7.2	6210
BQEW_MW01	Ash dam augmentation zone	16/06/2017	<10	2190	<0.1	<1	<0.05	67	4	12	-	<10	<5	<0.01	<0.1	0.02	7.1	5490
BQEW_MW01	Ash dam augmentation zone	5/09/2017	<10	2130	<0.1	<1	<0.05	51	3	12	-	<10	<5	0.02	<0.1	0.01	7.2	5580
BQEW_MW01	Ash dam augmentation zone	15/11/2017	<10	1730	<0.1	<1	0.07	89	3	12	-	<10	<5	<0.01	<0.1	<0.01	7.2	4760
BQEW_MW01	Ash dam augmentation zone	23/02/2018	<10	1980	<0.1	<1	<0.05	74	3	12	-	<10	<5	0.01	0.1	0.01	7.1	6250
BQEW_MW01	Ash dam augmentation zone	31/05/2018	<10	2040	<0.1	<1	<0.05	58	2	13	-	<10	<5	0.06	<0.1	0.01	7.2	3820
BQEW_MW01	Ash dam augmentation zone	13/08/2018	<10	1980	<0.1	<1	<0.05	74	3	11	-	<10	<5	<0.01	<0.1	0.01	7.2	5390

Bore ID	Key Area	Sampled Date	Aluminium (Filtered)	Boron (Filtered)	Cadmium (Filtered)	Copper (Filtered)	Iron (Filtered)	Manganese (Filtered)	Molybdenum (Filtered)	Nickel (Filtered)	Silver	Vanadium (Filtered)	Zinc (Filtered)	Nitrate (as N)	Nitrogen (Total)	Reactive Phosphorus as P	pH (Field)	Total Dissolved Solids
			µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	pH Units	mg/L
ANZECC 2000 FW 95%			55	370	0.2	1.4	0.07	1900	3.4	11	0.05	6	8	0.1581				
ANZECC (2000) trigger values for lowland rivers															0.5	0.02	6.5 - 8	
BQEW_MW01	Ash dam augmentation zone	27/11/2018	<10	2200	<0.1	<1	0.07	95	3	13	-	<10	38	<0.01	<0.1	0.01	7.3	5680
BQEW_MW01	Ash dam augmentation zone	26/03/2019	<10	2040	<0.1	<1	0.06	102	3	13	-	<10	<5	<0.01	<0.1	0.01	7.2	6150
BQEW_MW02	Ash dam augmentation zone	29/11/2016	<10	2990	<0.1	<1	<0.05	26	14	10	-	<10	<5	<0.01	0.1	0.01	7.1	3580
BQEW_MW02	Ash dam augmentation zone	28/02/2017	<10	3310	<0.1	<1	<0.05	19	13	10	-	<10	<5	0.05	<0.5	0.01	7.3	4360
BQEW_MW02	Ash dam augmentation zone	16/06/2017	<10	3320	<0.1	<1	<0.05	15	17	10	-	<10	<5	0.04	<0.1	0.02	7.3	4120
BQEW_MW02	Ash dam augmentation zone	5/09/2017	<10	3200	<0.1	<1	<0.05	12	15	8	-	<10	<5	0.03	<0.1	<0.01	7.4	4140
BQEW_MW02	Ash dam augmentation zone	15/11/2017	70	2760	<0.1	1	<0.05	17	13	8	-	<10	<5	<0.01	<0.5	<0.01	7.3	3640
BQEW_MW02	Ash dam augmentation zone	27/02/2018	<10	3190	<0.1	<1	<0.05	16	13	10	-	<10	<5	0.02	<0.2	<0.01	7.4	4130
BQEW_MW02	Ash dam augmentation zone	31/05/2018	<10	3220	<0.1	<1	<0.05	14	12	10	-	<10	<5	0.07	0.4	0.02	7.3	2880
BQEW_MW02	Ash dam augmentation zone	2/08/2018	<10	3240	<0.1	<1	<0.05	16	22	9	-	<10	<5	0.01	0.9	0.01	7.3	3290
BQEW_MW02	Ash dam augmentation zone	27/11/2018	<10	3270	<0.1	<1	<0.05	17	17	10	-	<10	6	<0.01	<0.1	0.01	7.4	4350
BQEW_MW02	Ash dam augmentation zone	26/03/2019	<10	3280	<0.1	<1	<0.05	41	16	10	-	<10	<5	<0.01	0.2	0.01	7.4	4450
BQEW_MW03	Ash dam augmentation zone	30/11/2016	<10	310	<0.1	<1	3.66	214	5	10	-	<10	<5	<0.01	0.2	<0.01	6.8	6290
BQEW_MW03	Ash dam augmentation zone	28/02/2017	<10	530	<0.1	<1	2.68	254	4	15	-	<10	<5	0.04	<0.1	<0.01	6.8	10,000
BQEW_MW03	Ash dam augmentation zone	16/06/2017	<10	330	<0.1	<1	1.83	203	5	14	-	<10	<5	<0.01	<0.1	<0.01	6.7	6760
BQEW_MW03	Ash dam augmentation zone	5/09/2017	<10	250	<0.1	<1	0.21	81	3	13	-	<10	<5	0.02	<0.2	<0.01	6.7	8390
BQEW_MW03	Ash dam augmentation zone	28/11/2017	<10	360	<0.1	<1	0.73	231	4	16	-	<10	<5	0.04	1.7	<0.01	6.7	10,600
BQEW_MW03	Ash dam augmentation zone	23/02/2018	<10	550	<0.1	<1	1.23	193	2	11	-	<10	<5	<0.01	<0.2	<0.01	6.8	10,200
BQEW_MW03	Ash dam augmentation zone	31/05/2018	<10	380	<0.1	<1	0.1	45	2	15	-	<10	<5	0.08	<0.2	<0.01	6.7	5780
BQEW_MW03	Ash dam augmentation zone	13/08/2018	<10	360	<0.1	<1	0.06	22	2	14	-	<10	<5	0.01	<0.5	<0.01	6.7	7890
BQEW_MW03	Ash dam augmentation zone	27/11/2018	<10	350	<0.1	<1	0.36	36	3	13	-	<10	<5	0.01	<0.1	<0.01	6.8	9520
BQEW_MW03	Ash dam augmentation zone	26/03/2019	<10	390	<0.1	<1	0.19	125	3	14	-	<10	<5	0.02	<0.2	<0.01	6.9	8950
BQ_MW02	NE borrow pit zone	24/11/2016	<10	220	<0.1	<1	<0.05	643	1	14	-	<10	<5	0.04	0.7	0.01	6.8	19,000
BQ_MW02	NE borrow pit zone	23/02/2017	<10	220	0.5	2	<0.05	689	2	10	-	<10	<5	0.14	<1	<0.01	-	19,800
BQ_MW02	NE borrow pit zone	28/02/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	-
BQ_MW02	NE borrow pit zone	1/06/2017	<10	220	<0.1	<1	<0.05	574	<1	8	-	<10	<5	0.02	0.7	0.01	6.6	13,700
BQ_MW02	NE borrow pit zone	6/09/2017	<10	270	0.2	<1	<0.05	502	2	10	-	<10	<5	0.38	<0.5	<0.01	6.7	18,600
BQ_MW02	NE borrow pit zone	16/11/2017	<10	280	0.2	<1	<0.05	664	2	11	-	<10	<5	0.43	<0.5	<0.01	6.6	20,600
BQ_MW02	NE borrow pit zone	22/02/2018	<10	290	0.2	<1	<0.05	524	2	10	-	<10	<5	0.3	<0.5	0.01	6.8	19,100
BQ_MW02	NE borrow pit zone	29/05/2018	10	320	0.4	2	<0.05	711	2	10	-	<10	<5	0.35	0.6	0.01	6.8	18,000
BQ_MW02	NE borrow pit zone	14/08/2018	<10	240	0.3	<1	<0.05	622	2	10	-	<10	<5	0.41	0.4	<0.01	6.7	19,300
BQ_MW02	NE borrow pit zone	20/11/2018	<10	240	0.2	<1	<0.05	636	2	10	-	<10	<5	0.44	<0.5	<0.01	6.8	19,000
BQ_MW02	NE borrow pit zone	27/03/2019	<10	250	0.3	1	<0.05	708	2	11	-	<10	<5	0.35	<0.5	<0.01	6.7	18,900
BQ_MW03	NE borrow pit zone	24/11/2016	<10	2030	<0.1	<1	<0.05	72	<1	8	-	<10	<5	<0.01	<0.1	0.07	6.3	5980
BQ_MW03	NE borrow pit zone	23/02/2017	<10	1920	<0.1	<1	0.34	192	<1	9	-	<10	<5	0.08	0.5	0.07	6.3	4460
BQ_MW03	NE borrow pit zone	1/06/2017	<10	1580	<0.1	<1	0.13	107	<1	6	-	<10	<5	0.02	<0.5	0.07	6.4	4290
BQ_MW03	NE borrow pit zone	4/09/2017	<10	1650	<0.1	<1	0.12	110	<1	8	-	<10	<5	<0.01	0.1	0.06	6.3	5780
BQ_MW03	NE borrow pit zone	16/11/2017	<10	2230	<0.1	<1	0.09	104	<1	7	-	<10	<5	0.03	<0.2	0.07	6.4	6220
BQ_MW03	NE borrow pit zone	22/02/2018	<10	2020	<0.1	<1	0.1	113	<1	9	-	<10	<5	0.03	<0.5	0.07	6.4	5880
BQ_MW03	NE borrow pit zone	28/05/2018	<10	1960	<0.1	<1	0.3	217	<1	8	-	<10	<5	0.13	0.3	0.12	6.3	5720
BQ_MW03	NE borrow pit zone	13/08/2018	<10	2040	<0.1	<1	0.12	103	<1	8	-	<10	<5	0.02	<0.5	0.06	6.3	5520
BQ_MW03	NE borrow pit zone	20/11/2018	<10	2230	<0.1	<1	0.06	123	<1	9	-	<10	<5	<0.01	<0.1	0.05	6.5	5300
BQ_MW03	NE borrow pit zone	27/03/2019	<10	2100	0.1	<1	0.13	124	<1	9	-	<10	<5	<0.01	<0.2	0.04	6.6	4560
BB_MW01	Salt cake landfill zone	18/04/2018	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.6	-
BB_MW01	Salt cake landfill zone	20/07/2018	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.5	-
BB_MW01	Salt cake landfill zone	30/10/2018	-	-	-	-	-	-	-	-	0.8	-	-	-	-	-	6.6	-
BB_MW01	Salt cake landfill zone	18/02/2019	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.6	-
BB_MW01	Salt cake landfill zone	17/04/2019	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.5	-
BB_MW02	Salt cake landfill zone	18/04/2018	-	-	-	-	-	-	-	-	0.9	-	-	-	-	-	6.6	-

Bore ID	Key Area	Sampled Date	Aluminium (Filtered)	Boron (Filtered)	Cadmium (Filtered)	Copper (Filtered)	Iron (Filtered)	Manganese (Filtered)	Molybdenum (Filtered)	Nickel (Filtered)	Silver	Vanadium (Filtered)	Zinc (Filtered)	Nitrate (as N)	Nitrogen (Total)	Reactive Phosphorus as P	pH (Field)	Total Dissolved Solids
			µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	pH Units	mg/L
ANZECC 2000 FW 95%			55	370	0.2	1.4	0.07	1900	3.4	11	0.05	6	8	0.1581				
ANZECC (2000) trigger values for lowland rivers															0.5	0.02	6.5 - 8	
BB_MW02	Salt cake landfill zone	19/07/2018	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.4	-
BB_MW02	Salt cake landfill zone	29/10/2018	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	6.5	-
BB_MW02	Salt cake landfill zone	18/02/2019	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.6	-
BB_MW02	Salt cake landfill zone	17/04/2019	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	6.6	-
BB_MW05	Salt cake landfill zone	17/04/2018	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-	7	-
BB_MW05	Salt cake landfill zone	19/07/2018	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-	7.2	-
BB_MW05	Salt cake landfill zone	29/10/2018	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-	7.2	-
BB_MW05	Salt cake landfill zone	18/02/2019	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-	7.2	-
BB_MW05	Salt cake landfill zone	17/04/2019	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	7.1	-
MW-A01	Salt cake landfill zone	7/08/2018	-	200	<0.1	<1	-	68	-	12	-	<10	<5	-	-	-	6.8	4371
MW-A01	Salt cake landfill zone	20/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	4064
MW-A01	Salt cake landfill zone	18/10/2018	-	160	<0.1	<1	-	102	-	9	-	<10	<5	-	-	-	6.8	5380
MW-A01	Salt cake landfill zone	15/11/2018	-	200	<0.1	<1	-	210	-	17	-	<10	<5	-	-	-	6.7	5370
MW-A02	Salt cake landfill zone	21/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	7475
MW-A02	Salt cake landfill zone	19/10/2018	-	180	<0.1	<1	-	247	-	14	-	<10	12	-	-	-	6.7	8019
MW-A02	Salt cake landfill zone	16/11/2018	-	270	<0.1	1	-	657	-	43	-	<10	16	-	-	-	6.6	9216
MW-A03D	Salt cake landfill zone	19/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	7821
MW-A03D	Salt cake landfill zone	17/10/2018	-	200	<0.1	<1	-	112	-	2	-	<10	<5	-	-	-	6.9	8403
MW-A03D	Salt cake landfill zone	14/11/2018	-	250	<0.1	<1	-	134	-	3	-	<10	<5	-	-	-	6.8	8384
MW-A03S	Salt cake landfill zone	19/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.1	10112
MW-A03S	Salt cake landfill zone	17/10/2018	-	80	<0.1	<1	-	408	-	10	-	<10	<5	-	-	-	7.1	11130
MW-A03S	Salt cake landfill zone	14/11/2018	-	180	<0.1	2	-	596	-	15	-	<10	<5	-	-	-	7	11168
MW-A04	Salt cake landfill zone	6/08/2018	-	<50	<0.1	<1	-	6	-	<1	-	<10	<5	-	-	-	7.7	340
MW-A04	Salt cake landfill zone	20/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.8	402
MW-A04	Salt cake landfill zone	18/10/2018	-	<50	<0.1	<1	-	2	-	<1	-	<10	<5	-	-	-	7.9	360
MW-A04	Salt cake landfill zone	15/11/2018	-	<50	<0.1	1	-	3	-	<1	-	<10	<5	-	-	-	7.8	440
MW-A05	Salt cake landfill zone	19/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	6669
MW-A05	Salt cake landfill zone	17/10/2018	-	170	<0.1	<1	-	32	-	4	-	<10	<5	-	-	-	6.9	7226
MW-A05	Salt cake landfill zone	14/11/2018	-	160	<0.1	<1	-	39	-	4	-	<10	<5	-	-	-	6.8	7194
MW-A06	Salt cake landfill zone	19/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	7744
MW-A06	Salt cake landfill zone	17/10/2018	-	180	<0.1	<1	-	77	-	9	-	<10	<5	-	-	-	6.8	8422
MW-A06	Salt cake landfill zone	14/11/2018	-	230	<0.1	<1	-	90	-	11	-	<10	<5	-	-	-	6.7	8403
MW-A07	Salt cake landfill zone	21/09/2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	13760
MW-A07	Salt cake landfill zone	19/10/2018	-	320	<0.1	<1	-	24	-	5	-	<10	<5	-	-	-	6.8	13696
MW-A07	Salt cake landfill zone	16/11/2018	-	410	<0.1	2	-	30	-	6	-	<10	6	-	-	-	6.7	13632

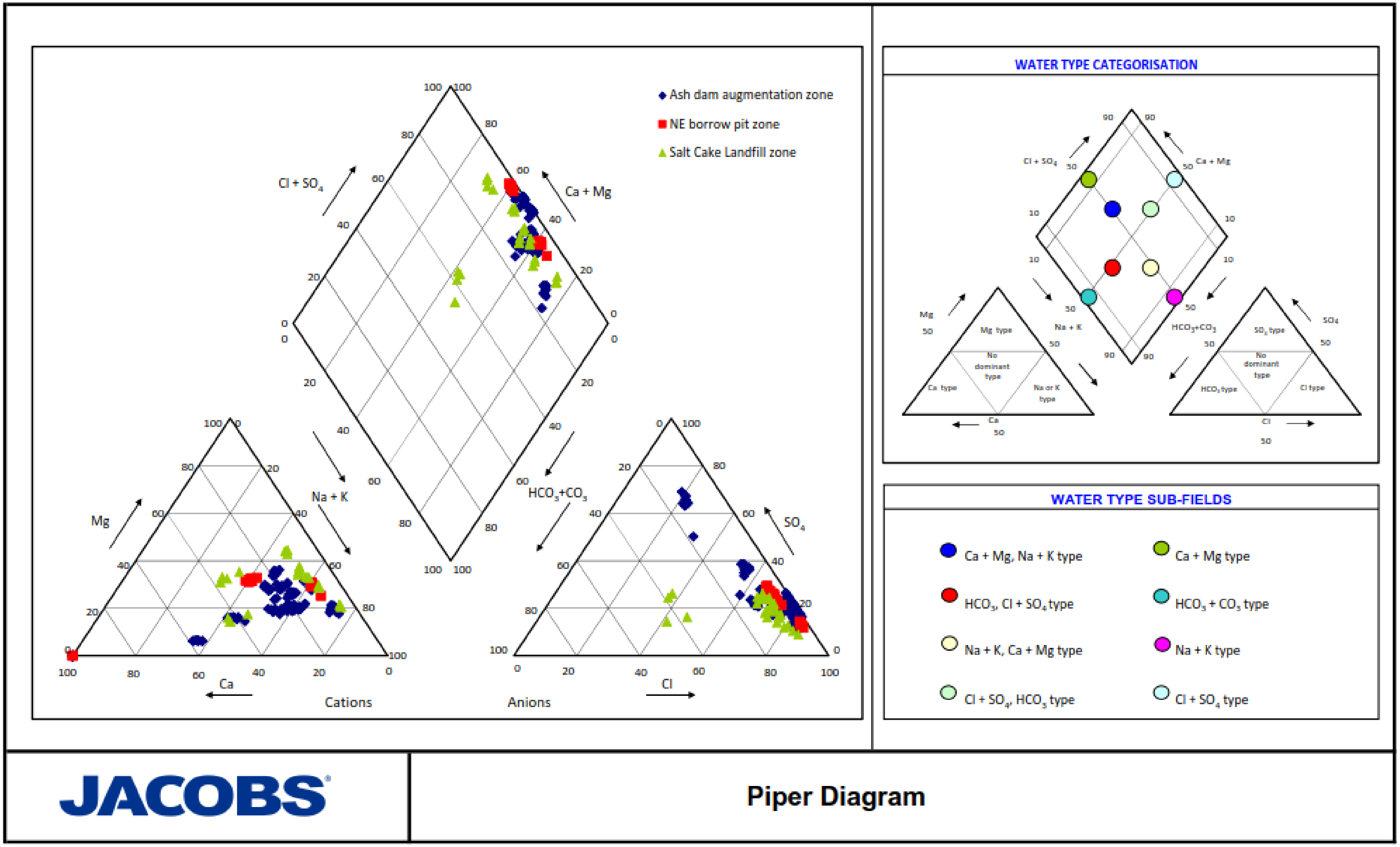

Figure 4.4: Piper plot of major cations and anions - historic data (Jacobs 2020a)

4.5 Water ways

Increasing the size of the BWAD may result in an increased volume of dam seepage to the seepage collection ponds and to other surface water ways, including Chilcotts Creek and Lake Liddell, Pikes Creek and Bayswater Creek. The Project proposes to upgrade the dam drainage and seepage collection systems and return as much water as is feasible to the BWAD.

No waterways within the Project footprint area have been classified as sensitive receiving environments; therefore, the risk of negatively impacting the surrounding environment is low.

4.6 Conceptual model

Groundwater is hosted in two main geological units: the porous alluvial deposits and weathered regolith that hosts the unconfined water table aquifer, and the fractured rock units of the Permian aged rock units that can host unconfined, semi-confined and confined aquifers. The groundwater flow of the alluvium is generally parallel to the orientation of the surface water flow and the flow within the weathered regolith aquifer generally follows the topography.

In undisturbed conditions, groundwater recharge occurs from rainfall runoff and seepage or surface water to the underlying geology. A small proportion is recharged to the porous media aquifers which in turn recharge a yet smaller proportion to the fractured rock aquifers. At the site, seepage from the BWAD also contribute an additional amount of seepage and the groundwater in the alluvium is likely to be a combination of rainfall run-off, BWAD seepage and discharge from the fractured rock units (including the coal seams).

Currently, seepage from the BWAD appears to occur predominantly at the Main Embankment and the Saddle Dam. Seepage from the Main Embankment is collected at Seepage Collection Ponds 1 and 2, with a larger proportion of seepage that is lost to the surrounding environment, including Pikes Creek, which flows into Bayswater Creek. Seepage from the Saddle Dam is discharged to Chilcotts Creek and subsequently Lake Liddell. Discharge from Lake Liddell meets the required criteria for discharge. A small amount of discharge also appears to occur south of the BWAD (to EyeCreek). Eye Creek is a tributary of Pikes Creek and it discharges ultimately to Bayswater Creek.

The water quality of the BWAD decant and waste stream water has a pH ranging from 7 to 8 and an EC of between 4500 and 5000 µS/cm. Dissolved metals concentrations are elevated with exceedances of the ANZECC (2018) - slightly to moderately disturbed freshwater aquatic criteria for aluminium, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, molybdenum, nickel, lead, selenium, vanadium, zinc and total nitrogen. No detects above limits of reporting were recorded in the BWAD for PAHs, TPHs, TRHs, BTEXN, PCBs, lead, mercury or cyanide. The correlation between total and dissolved metals, and the notable presence of inorganics such as sulphur, suggests the potential for leaching of minerals from the solid ash entering the ash dam.

Dissolved metals concentrations decrease with increasing distance from the BWAD. Dissolved metals concentrations and exceedances in the lower reaches of Pikes Creek were significantly lower than water samples at the Main Embankment seepage point. This is likely due to negatively charged clays in the ground at site having high surface to volume ratio enabling positively charged heavy metals to bind/sorb on its surface. Additionally, brackish and saline water can cause fine particles to settle out considerably faster than in fresh water (4-200 times, depending on particle size) (Flemming, Burghard & Delafontaine, 2016, and Ugwu and Igbokwe, 2019).

The range of pH of surface water is greater with increasing distance from the BWAD but remains within the criteria for ANZECC (2018) - slightly to moderately disturbed freshwater aquatic ecosystems. EC also increases with distance from the BWAD. This is likely due to a combination of discharge of brackish/saline water from adjacent seam subcrops and concentration due to evapotranspiration.

The contribution of metals due to rainfall run off is likely to be low. Water samples from four agricultural dams located adjacent to the BWAD showed that collected run off is of neutral pH, low EC and low in metals concentrations.

Generally, pH and many trace metals were below recommended guideline values for protection of aquatic ecosystems and other nominated environmental values. There were however some trace metals that were above recommended ANZECC (2018) water quality guidelines at numerous sites and included chloride, copper, fluoride nickel, sodium, zinc. No waterways within the Project footprint area have been classified as sensitive receiving environments; therefore, the risk of negatively impacting the surrounding environment is low.

With the exception of potential salinisation associated with the proposed salt cake landfill, the Project is expected to generate negligible impacts to groundwater and risks to groundwater are assessed as low. This conclusion is based on a detailed review of background groundwater level and quality data, along with an analysis of the existing environmental setting and an assessment of the Project elements. Saline/briny water may migrate to underlying and surrounding groundwater systems, if the salt cake landfill liner were to leak.

Additionally, the seepage control upgrades associated with the Main Embankment and Saddle Dam walls will improve seepage recovery. It is proposed that a seepage collection system will be installed at the Saddle Dam seepage and that will return the loss, which is estimated to be between 0.05 ML/ day [35 L/min] and 0.14 ML/ day [95L/min]. Also, seepage control upgrades at the Main Embankment area will double the estimated lower limit of the water return to 26 L/min for the 3 hr daily pumping time.

5. Dam and pond liners

Historically and more recently, liners have been considered as an option to reduce seepage from the BWAD and from the Main Embankment Seepage Ponds. Liner options include lining of containment cells within the BWAD and lining the BWAD with a clay liner or a HDPE liner. These options are not considered feasible from a practical and a financial point of view. The area of the BWAD is in the order of 1.5 square kilometres and the cost of lining a similar structure would be considerable, especially considering that it is an operational site and waste would need to be managed around any works. In terms of practicality, a liner would not reduce seepage from the BWAD because the material emplaced is saturated and would constitute an ongoing source of seepage water, despite the liner reducing the contribution of any subsequent waste emplacement. Hence, no detailed planning of lining the BWAD has been undertaken.

The Bayswater Ash Dam Pollution Reduction Program (**PRP**) (AECOM 2016b) recommends that the BWAD Main Embankment Seepage Ponds be upgraded and/or have new seepage cut-off / collection ponds constructed (AECOM 2016b). The existing ponds and any additional ponds that are constructed will be lined if it is considered necessary at the time of design.

6. BWAD post-closure and rehabilitation

The Bayswater Ash Dam Augmentation Design Report (Aurecon, 2019) provides a number of options and a recommended concept schematic for the rehabilitation of the site. This rehabilitation option is a basic rehabilitation that conforms with the industry standard approach of:

- Capping ash surfaces with an appropriately low permeability layer (minimum 0.5 m thick)
- Provision of adequate cross fall over capped surfaces to avoid ponding above ash deposits
- Grading of the dam and storage to remove the dam walls ability to detain a ‘free’ water pond
- Upgrade of flood spillways (i.e. increasing the spillway elevation from 172 m AHD to 173.7m AHD) to enable safe discharge of the Probable Maximum Flood event
- Provision of a growth medium to allow for light vegetation that would assist in the prevention of erosion.

The Jacobs (2020a) EIS outlines a proposed BWAD closure and rehabilitation plan. The EIS states that once the augmented BWAD has reached capacity, rehabilitation would be undertaken to integrate the BWAD within the existing landform, as far as possible. Rehabilitation would be undertaken in accordance with the approved Rehabilitation Management Plan and would include capping, measures to prevent any ponding or disruption to water flows, stabilisation and revegetation.

Post closure, AGLM would look at alternative land uses for the site and where these are not appropriate, limit land use to either grazing or native pasture. Any more intensive land use or development would most likely require separate approval.

Decommissioning would occur over an agreed timeframe and would be followed by rehabilitation monitoring and management until such time as a safe, sustainable and non-polluting landform is confirmed. Assuming currently modelled ash generation rates, the final landform would consist of a generally flat but free draining landform sloping from west to east. At its western extent, the landform would have a maximum height of approximately 186 m AHD, to incorporate a minimum 0.5 metre capping layer, and be graded to 173 m AHD at the northern abutment of the main embankment and 172 m AHD at the southern abutment. The area would be vegetated with grass species. The concrete parapet along the main embankment would be removed and the ponded water allowed to evaporate, drained or otherwise managed in accordance with its water quality at the time. The landform would be re-graded to provide free drainage to the south. A new spillway would be provided around the main embankment wall to the south to allow surface flows to be returned to Pikes Gully post rehabilitation.

Additionally, the capping of the BWAD will define the end of water input into the BWAD cycle, and ultimately lead to a decline in seepage from the structure. That is, peak seepage rates should coincide with the closure and rehabilitation of the BWAD.

It is expected that AGLM will undertake the works in collaboration with the EPA and other relevant agencies.

7. Ash disposal

The comment by the EPA on ash disposal requests "*Further information on the underground ash disposal*". It should be stated for clarity that AGLM does not currently, nor does AGL intend to, dispose of ash to any underground voids. When Bayswater was constructed, it envisaged that ash would be disposed of into the Ravensworth open cut voids. The Ravensworth No.2 Mine, was operated by Peabody Resources Ltd under contract to Pacific Power up until 1993 when extraction of the coal resource was completed. In accordance with commitments made in the EIS for the Bayswater Fly Ash Disposal in Ravensworth No. 2 Mine Void and Mine Rehabilitation Project and development consent 144/93, Pacific Power proposed to complete rehabilitation of the site by filling the final void left after completion of mining with fly ash from Bayswater. Filling of the void was predicted to take around 30 years from the time of commencement of filling (AECOM 2016e). Approximately 1.3 million tonnes of fly ash per annum are currently pumped to the Void 5 in Ravensworth South via a designated ash slurry pipeline from Bayswater.

In November 1993, the then Department of Mineral Resources (**DMR**) approved the Ravensworth No. 2 Mine Fly Ash Disposal and Rehabilitation Environmental Management Plan Volume 1 and 2 (**No.2 EMP**) which describes the rehabilitation standard to which the site is to be returned and the rehabilitation methodology to be employed (AECOM 2016e). An EIS for the ash disposal project and ongoing rehabilitation was subsequently developed with approval subsequently received from Muswellbrook and Singleton Councils under the EPA& Act who at the time were the determining authorities.

In 1996, the Ravensworth South Mine Final Void Rehabilitation Plan (**South EMP**) was first approved. The South EMP was subsequently amended and approved by DRE on 20 December 2012.

Voids 1 and 2 have been completely filled with ash, capped and rehabilitated. Void 3 was completely filled with ash and capped by 2014.

Due to the localised low point in the underlying bedrock, Void 4 was, during the mine life and continues to be, used as a water storage dam. This usage will continue until the Ravensworth South Mine void (Void 5) is filled, with the water storage capability of Void 4 being used to manage the water for the ash transport system in an effective and efficient manner, following which the final rehabilitation of Void 4 would be completed. Void 4 also includes provision to discharge in accordance with the Hunter River Salinity Trading Scheme (**HRSTS**) and subject to EPL 779

Ravensworth South Mine (development consent 86/51, ML 1484 and ML 1485) includes final Void 5 and the surrounding formerly rehabilitated areas. Deposition of ash into Void 5 commenced in 2014 and is expected to be completed in 2032. A dividing wall has been constructed within the Ravensworth South final void to separate the AGLM and Glencore emplacement areas. The western ramp of the final void, on land owned and operated by Glencore Ravensworth Underground Mine (**RUM**) under ML 1349 is currently being used for tailings emplacements prior to being rehabilitated. AGLM is currently working on an application to modify DA 86/51.

8. Salt Cake landfill review

The Project includes a proposal to construct and operate a salt cake landfill facility to dispose of salt cake waste from the approved salt caking plant to be constructed at the Bayswater water treatment plant. The landfill has been designed to include ten individual cells and each cell would be able to hold more than three years of salt cake. The salt cake landfill would have capacity to hold approximately 600,000 tonnes of salt cake over its operational life (Jacobs 2020b).

In accordance with the *EPA Environmental Guidelines for solid waste landfills* (Second Edition, 2016), the landfill has been designed to include:

- a compacted sub-base 200mm thick to provide a firm, stable, smooth surface of high bearing strength on which to install the liner (will not be required where in hard rock)
- a liner equivalent to 1000 mm of compacted clay liner, with an in situ hydraulic conductivity of less than 1 x 10^{-9} m/sec[1].
- a leachate barrier system to contain leachate and prevent the contamination of surface water and groundwater over the life of the landfill.
- turkey's nest style construction, no natural stormwater runoff would enter these cells except for direct rainfall.
- diversion structures would be constructed to prevent stormwater entering the cells. (Jacobs 2020b)

Final capping of each Salt cake landfill cell would be in accordance with the EPA Environmental Guidelines (EPA, 2016), and would comprise of a compacted clay layer (or other suitable material) at least 600 millimetres thick, and then a one metre thick revegetation layer comprising of clean soils, top soil and vegetation. Clay materials for construction, decommissioning and rehabilitation would be sourced from the proposed Borrow Pits, and clean soils and topsoil would be utilised. When constructing the final capping, consideration would be given to grading the final surface in such a direction so as not to impede on future landfill cells. As more cells are constructed, filled and then capped, this final landform may be amended to suit the topography where required. Final decommissioning of the Salt cake landfill disposal area would be followed by rehabilitation monitoring and management until such time as a safe sustainable and non-polluting landform is confirmed (Jacobs 2020b).

In 2018, AECOM undertook an investigation of groundwater conditions at the location of the proposed Salt Cake Landfill. The investigation showed that the site was an area that was not impacted by adjacent site activities and that all parameters tested were below limits of reporting or below the relevant guideline criteria (AECOM 2018).

The Jacobs (2020b) assessment of the salt cake landfill stated that the key risks were to surface water quality from the operation of the landfill facility are related to contaminated leachate from the landfill site or by uncontrolled stormwater flows containing sediments and contaminants entering downstream waterways. Additionally, the storage and transport of the wastes to the facility presents a risk to water quality. To reduce the risk of leachate and waste entering the surrounding environment, the landfill facility would be designed in accordance with EPA (2016) requirements which would include a liner system (whereby compacted clay or a geosynthetic liner is laid within the cell) to contain the waste within the system.

In the event of a liner failure, saline/briny water was modelled to migrate from the landfill beyond a distance of 40 m. The concentrations associated with the saline/briny water are such that the beneficial use category of the groundwater source may be lowered. Therefore, the Project is assessed to not meet the NSW Aquifer Interference Policy (DPI, 2012) minimal impact consideration with regards to groundwater quality. Further consideration needs to be given to the selection of an appropriate salt cake landfill liner. This will be undertaken at the design stage of the landfill.

[1] As an alternative to compacted clay, a geosynthetic clay liner may be used, provided it is used in composite with an overlying geomembrane liner. Depending on the outcome of geotechnical investigations, this option may need to be explored if sufficient suitable clay cannot be found on site.

Also, without appropriate erosion and sediment controls and stormwater diversions, uncontrolled stormwater flows along drainage lines, through disturbed areas and soil stockpiles could transport sediments and contaminants to downstream waterways. The storage and transport of wastes to the landfill facility presents a risk to water quality if the waste is not appropriately covered during transportation or due to accidental spills from incidents.

A groundwater monitoring plan is proposed to be established prior to construction to monitor the construction, operation and closure phases of the landfill. The existing groundwater monitoring locations at the proposed landfill site were sampled by AECOM in 2018 (AECOM 2018). The location details are summarised in Table 8.1 and shown on Figure 8.1. Six of the eight monitoring bores are positioned suitably to undertake pre-construction, construction, operation and post-closure phase monitoring, and will provide a long-term data set that can be used to assess for potential leakage from the landfill. The AECOM (2018) report constitutes the initial data for a baseline.

Monitoring and reporting would be undertaken at regular intervals (likely on an annual basis). The management of water quality issues will be undertaken in collaboration with the EPA.

Table 8.1: Salt cake landfill groundwater monitoring locations and location rationale (source AECOM 2018)

Well ID	Easting (GDA94z56)	Northing (GDA94z56)	Location	Rationale	Targeted Formation
MW_A01	305816.63	6413458.77	The proposed waste salt cake storage site	Obtain baseline groundwater information within the proposed waste salt cake storage. It is particularly important to know how deep the water table is at this location. These monitoring wells will be destroyed during the construction of the waste salt cake storage.	Siltstone aquifer
MW_A02	305587.76	6413623.26			
MW_A03S	305253.77	6412946.96	Down-gradient of the proposed waste salt cake storage site. Nested with MW_A03D	Obtain baseline groundwater information down-gradient of the proposed waste salt cake storage site. Only down-gradient location where groundwater was evident in the shallow unconsolidated aquifer.	Unconsolidated alluvial aquifer
MW_A03D	305257.63	6412945.30	Down-gradient of the proposed waste salt cake storage site. MW_A03D is nested with MW_A03S.	Obtain baseline groundwater information down-gradient of the proposed waste salt cake storage site, at varying distances and down-gradient directions from the site.	Siltstone aquifer
MW_A05	305261.62	6413275.29	Upgradient of the proposed waste salt cake storage site.	Obtain baseline groundwater information up-gradient (north-east) of the proposed waste salt cake storage site.	Siltstone aquifer
MW_A06	305374.61	6413180.21			
MW_A07	305691.99	6413146.82			
MW_A04	306038.09	6413476.95			

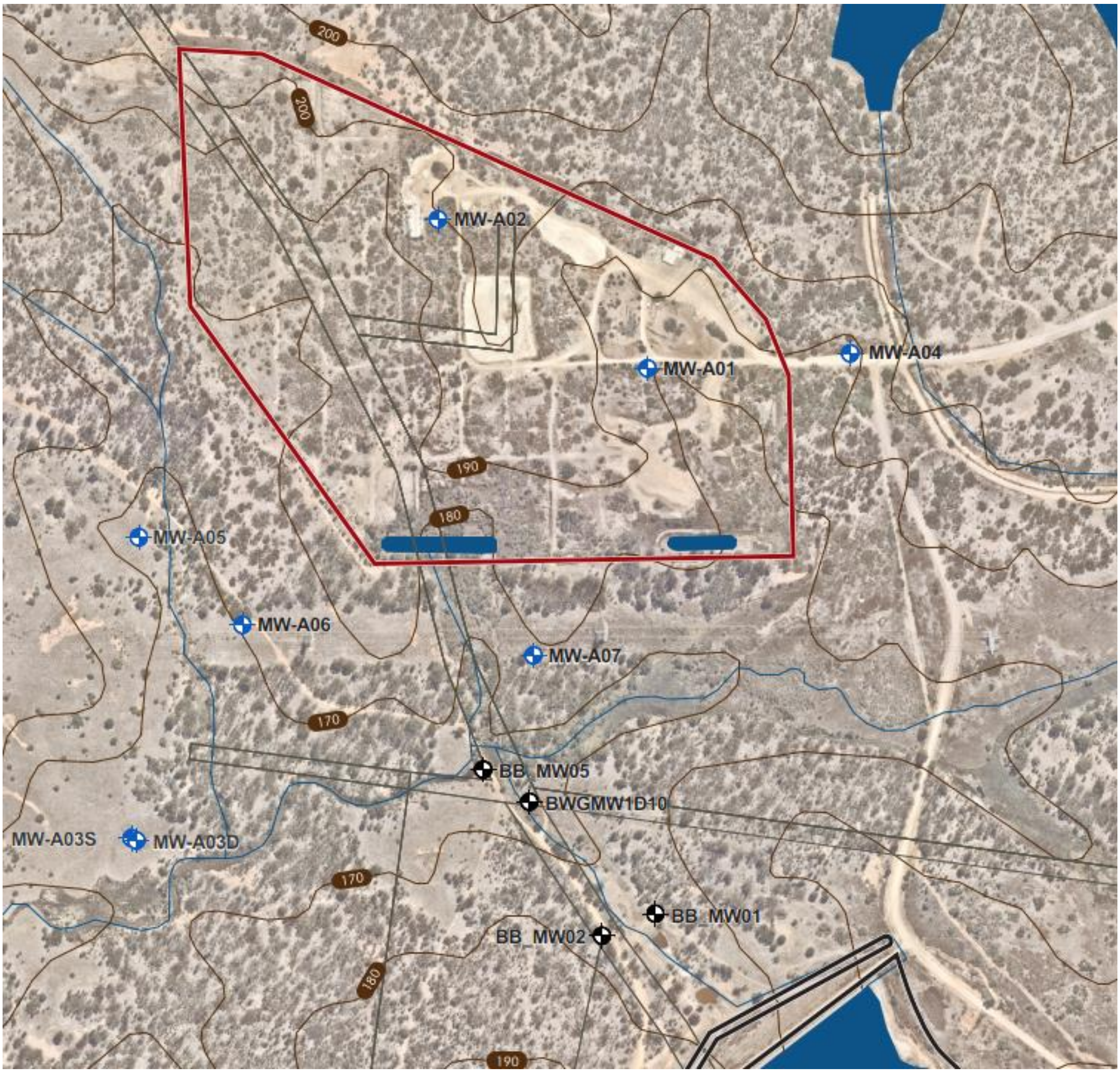

Figure 8.1: Salt cake landfill groundwater monitoring locations (source AECOM 2018)

9. Coal handling plant

Discharges (overflows) to Tinkers Creek currently occur on a daily basis from the CHP sediment basin. CHP water and wastewater infrastructure upgrades are proposed as part of an environmental improvement program (**EIP**) at Bayswater to reduce the quantity of discharges to Tinkers Creek from the sediment basin and associated drainage systems (Jacobs 2020a).

In 2017, AECOM undertook an assessment of the Bayswater CHP (AECOM 2017a). The assessment found the following:

- surface water from the CHP flowing into Tinkers Creek does not appear to be increasing the levels of contaminants in Tinkers Creek or Lake Liddell.
- Field measurements such as pH, EC, turbidity and DO did not show any anomalous results at 'background', 'source area' or 'downstream' locations. Whilst exceedances were noted, these appeared to be associated with natural processes and were not indicative of surface water contamination from the site.
- The sampling undertaken as part of this assessment identified concentrations of heavy metals above the SAC. However, the 'background' concentrations reported the highest levels of metals, primarily copper, nickel and zinc, indicating background concentrations of dissolved metals may be higher than concentrations being derived from the Site. Sampling of 'source area' and 'downstream' showed similar levels of copper, nickel and zinc.
- Boron was present at concentrations exceeding the SAC at one location 'downstream' of the Site. The source of this boron has not been identified.
- TPH / TRH were detected intermittently in both 'background' and 'source area' samples. Whilst no SAC was used to compare the concentrations of TPH/TRH, the lack of BTEX, usually associated with petroleum hydrocarbons, suggests the source could be either a transient source of heavy end petroleum hydrocarbons or a natural source of hydrocarbons.
- Previous groundwater and surface water monitoring suggests surface water may be influenced by other background sources (possibly naturally occurring and/or other nearby or historical activities).
- The full analytical suite that was undertaken showed mostly non-detects (AECOM 2017a).

Jacobs (2020a) reviewed lab analysis results for the CHP and found that they were within the range specified in EPL 779. When considering water quality in relation to the recommended ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems, or guidelines for either the protection of aquatic ecosystems (greater than 80% species protection) or primary industry (irrigation and general water use and livestock drinking water) (ANZG, 2018) there were instances of some toxicants exceeding the recommended guidelines. In particular, electrical conductivity was found to be outside either the ANZECC/ARMCANZ (2000) recommended range of 125 – 2250 µS/cm within Tinkers Creek, Lake Liddell, Plashett Reservoir and Pikes Creek. However, median electrical conductivities are suggested to exceed 5500µS/cm in water sources within the Hunter River Catchment (Jacobs 2020a). Therefore, the values recorded are considered consistent with regional water quality issues, and in some instances (for example within Tinkers Creek) low in comparison. In addition, other toxicants were either below detection limits or below recommended upper limits stated in the appropriate guidelines (Jacobs 2020a).

The water management upgrades as part of the Project are anticipated to improve water quality and quantity discharged from the CHP. The upgrades to the CHP water and wastewater infrastructure, whilst presenting a minimal risk to water quality during the construction of the upgrade, is expected to result in better water quality of Tinkers Creek and Lake Liddell during operation (Jacobs 2020a). AECOM (2017a) states that water from the following sources was collected and treated in the CHP sediment basin:

- Runoff from coal stockpiles as a result of direct rainfall on the CHP
- Wash down / process water from the CHP
- Catchment runoff from surrounding roads and batter slopes

- Discharge from the treated process water pond located to the south of the CHP
- Overflows / excess from water treatment processes i.e. oil water separator system and process water pond located to the south of the CHP (AECOM 2017a).

The CHP sediment basin currently overflows daily to Tinkers Creek.

AECOM (2017a) made a number of recommendations to address the water quality and quantity issues associated with the current CHP infrastructure, including:

- Construction of clean water diversions to reduce stormwater inflows to the CHP sediment basin; that is, the separation of "clean" stormwater from the CHP waste stream will reduce the volume of discharge to Tinkers Creek from the CHP, and consequently reduce the risk of increased volumes and concentrations of contaminant discharge.
- Reuse of water within the coal plant water system, where possible, for operational purposes which could include water treatment. This action will reduce the need to import water to site for operations, which in turn will facilitate the management of water on site specially during wetter periods.
- Changes to the water management structures, including the enlargement/reconfiguration of the CHP sediment basin to allow for a larger volume of water to be stored with increased detention time and improved settlement of coal fines to better enable the treatment of water (Jacobs 2020a).

These actions will result in better treatment and management of water prior to discharge through increased detention time. Overall, with the implementation of the proposal mitigation measures, the Project is expected to have minimal impacts on existing water quality during the construction phase. Whilst some potential risks to water quality have been identified during the operational phase, there would also be an improvement to water quality associated with the upgrade of the CHP and seepage management measures associated with BWAD (Jacobs 2020a).

For the purposes of this assessment it is assumed that the volume and frequency of water discharged to Tinkers Creek would not change. The aim of the water management improvement works is to improve the water quality of discharges from the system. It is assumed that water quality in Tinkers Creek would be improved in accordance with the requirements of EPL 779.

The above actions are likely to be part of the CHP EIP, which has not been validated to date and is due for submission by AGL in March 2021 (delayed due to COVID-19). Any work that is deemed feasible will be undertaken with regards to these projects will be done in collaboration with the EPA.

10. Water balance modelling

Jacobs (2020c) describes the water balance modelling undertaken for the EIS of the Project. The model included a daily stress period and data inputs (such as rainfall and discharges) were applied at daily intervals, despite the results being presented as monthly averages. This methodology was intended to provide a representative simulation of daily influences on site conditions.

11. Water pollution risks mitigation measures

Bayswater Ash Dam Pollution Reduction Program (PRP) (AECOM 2016b) summarises the options assessment results that reviewed measures to mitigate water pollution risks to waterways. The options assessment report describes the process used to identify potential options and the criteria applied to qualitatively compare a range of alternative solutions associated with the Bayswater Power Station PRP.

The options that were shortlisted include:

- Seepage collection and return options
  - Increase seepage water return at existing seepage collection ponds by lowering the pumping level.
  - Construction of new seepage cut-off / collection ponds.
  - Construction of bunds/diversion drains around existing seepage collection ponds to reduce surface water inflows.
- Increased Evaporation
  - Increase evaporation through mechanical evaporation to reduce volume / frequency of overflows.
  - Increase transfer of water to Ravensworth Voids, and increase rate of evaporation via increased dust suppression of haul roads.

These options have been translated into AGLM's Project tasks of:

- Augmentation of the existing BWAD to provide additional ash storage capacity (Ash Dam augmentation) – this will allow the BWAD to gain capacity and reduce the risk of overflow. Additionally, the Project proposes to increase the BWAD Emergency Spillway from the current elevation of 172 m AHD to 173.7 m AHD. This change to the spillway elevation will increase the BWAD decant pond storage capacity by some 380 ML. This will reduce the risk of overflow, and will reduce the discharge to Chilcotts Creek and Lake Liddell (Jacobs 2020a).
- Improvements to water management structures and systems to ensure continued collection and reuse of process water and return waters from the BWAD (Ash Dam augmentation) – this task will improve seepage containment reducing impact to the down gradient environment. The improvements are also aimed at reducing discharge of seepage to Lake Liddell.
- Construction and operation of a new coal ash pipeline to Ravensworth Void No. 3 for ash emplacement (Ravensworth ash line) – an improved connection to Ravensworth will allow better management of water and ash.
- Changes to the CHP water use and coal basin will reduce the quantity of water discharged and improve the quality.

Additionally, AGLM has an ongoing program of surface water and groundwater monitoring, which will continue to be implemented and reviewed regularly to assess its suitability for a long term monitoring programme at the site to meet the PRP requirements. The surface water and groundwater monitoring program was informed by a Waste Characterisation and Water Quality Assessment (AECOM 2016a).

All water quality management issues will be managed in collaboration with the EPA.

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