Appendix E

Water Impact Assessment Report
– Main report

Hume Coal Project

Environmental Impact Statement | Appendix E |Water Impact Assessment Report

Prepared for Hume Coal Pty Limited | 3 March 2017

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Environmental Impact Statement | Appendix E

|Water Impact Assessment Report

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Hume Coal Project

Final

Report J12055RP1 | Prepared for Hume Coal Pty Limited |3 March 2017

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Executive Summary

ES1 Assessment overview

Hume Coal Pty Limited (Hume Coal) proposes to develop and operate an underground coal mine and associated mine infrastructure (the 'project’) in the Southern Coalfield of New South Wales (NSW). This water assessment report forms part of the *Hume Coal Project EIS* (EMM 2017a), and is required for approval of the Hume Coal Project under the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The report documents the groundwater and surface water assessment methods and results, the initiatives built into the project design to avoid and minimise water associated impacts, and the additional mitigation and management measures proposed to address residual effects unable to be avoided. The assessment has been made in accordance with relevant NSW and Commonwealth guidelines and the Environmental Assessment Requirements (SEARs) issued by the Secretary of the NSW Department of Planning and Environment (DPE) for the Hume Coal Project (the project) and supplementary SEARs both issued on 20 August 2015.

The water assessment was undertaken by a team of leading specialists and a number of technical reports that have been appended for reference to this document, namely:

- Water Balance WSP PB (2016a);
- Surface Water Quality Assessment (WSP PB 2016b);
- Surface Water Flow and Geomorphology Assessment (WSP PB 2016c);
- Flooding Assessment (WSP PB 2016d);
- Groundwater Assessment, Volume 1: Data Analysis, (Coffey 2016a);
- Groundwater Assessment, Volume 2: Numerical modelling and Impact (Coffey 2016b); and
- Hydrogeochemical Assessment (Geosyntec 2016).

The proposed project life is 23 years, with active mining occurring over 19 years. Hume Coal has adopted a number of leading practices in mine design such that it will minimise impacts to water assets. Extensive technical investigations have taken place over several years to develop and refine the project, and arrive at the proposed design. The key leading practices adopted to minimise impacts to water resources and related assets are:

- innovative and tailored first workings mine design (resulting in imperceptible levels of subsidence or damage to the overlying Hawkesbury Sandstone);
- underground emplacement of reject (which removes the need for permanent surface stockpiles); and
- sealing mined panels, and filling with water (which allows groundwater to recover more rapidly).

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement Works and Inghams Berrima Feed Mill, some extractive industry and major transport infrastructure such as the Hume Highway.

There is a long history of mining in the Southern Coalfield, including mining for coal, iron ore, bauxite, gold, diamonds, shale, sand, clay and kerosene shale. There is also a history of hard rock quarrying in the area, including basalt quarries at Exeter and Mount Gingenbullen as well as the heritage-listed dimension stone quarry at Mount Gibraltar. Mining still occurs at various locations within Wingecarribee Shire local government area (LGA), including the Dendrobium longwall coal mine in the shire's north-east. Deposits of potentially commercial bauxite are known to occur in the south of the shire.

The project is within the Southern Coalfield of the sedimentary Permo-Triassic Sydney Basin. The Triassic Ashfield Shale outcrops over much of the eastern part of the project area while the Triassic Hawkesbury Sandstone outcrops over much of the western part (Moffit 1999). Mining is proposed in the Wongawilli Coal Seam of the Permian Illawarra Coal Measures which directly and unconformably underlie the Hawkesbury Sandstone in the project area.

ES2 Water resources

The surface water and groundwater near the project area have begun water sharing plans and therefore most aspects of project water management come under the *Water Management Act 2000*. However, licensing monitoring bores is regulated under the *Water Act 1912*.

The project area and A349 are mostly within the Wingecarribee River catchment of the Upper Nepean and Upstream Warragamba Water Source, which is managed under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011*. A small portion of the south-east corner of A349 is within the Bundanoon Creek catchment, a sub-catchment of the Shoalhaven River catchment (WSP PB 2016c), and this is still managed under the same water sharing plan.

The groundwater resources of the project area are within Nepean Management Zone 1 of the Sydney Basin Nepean Groundwater Source, which is managed under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*.

The project area is traversed by several drainage lines all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream of the project area. The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean River catchments, which supply water to Sydney. Most local drainage lines are classified as 'confined valley setting with occasional floodplain', under the River Styles Framework.

The groundwater units within the project area are defined as:

- localised low permeability groundwater systems associated with the Robertson Basalt and Wianamatta Group shales;
- regional porous fractured rock groundwater system located in the Hawkesbury Sandstone; and
- localised water bearing zones associated with the Illawarra Coal Measures and the Shoalhaven Group.

The Hawkesbury Sandstone is the main groundwater bearing unit used for water resources in the project area. Groundwater within the Hawkesbury Sandstone is generally fresh with varying bore yields (the median bore yield of registered bores in the area is 2 L/sec).

Streams in the area are all 'gaining' streams with groundwater providing stream baseflows. Recharge to the groundwater system is via rainfall infiltration. Lateral groundwater flow dominates with regional flow influenced by the regional topography (ie incised streams to the north-west) and the general dip of the strata to the east. Faults and igneous intrusions can operate as both barriers and conduits to flow on a local scale; however, they do not appear to influence groundwater flow on a regional scale.

Water quality is mostly good in both groundwater and surface water systems. Surface water is generally fresh, but has elevated salinity when associated with the shale geology. Elevated nutrients are associated with agricultural practices and town effluent discharges, and elevated metals are associated with the geology, which is naturally high in some metals such as iron and manganese. Medway Dam is prone to algal blooms as a result of the high nutrient loads. Groundwater is relatively fresh in the Hawkesbury Sandstone and Illawarra Coal Measures and mostly comparable to surface water. The shale geology hosts brackish groundwater remnant from the marine depositional setting.

ES3 Mining methods and water management

A non-caving, first workings mining layout will be adopted, with mining occurring sequentially in panels that are separated from each other by solid barriers of unmined coal. The proposed method is low impact with negligible surface and subsurface subsidence impacts, and minimal overburden fracturing. Once mined, the open voids will be used for the emplacement of reject materials left over from washing raw coal.

After mining is complete, each panel will be sealed with an impermeable bulkhead and water will be allowed to flow into the sealed panels, resulting in a decreased volume of groundwater inflow to the workings and faster recovery post-mining. Once mining ceases (end of year 19) groundwater inflow to the void is expected to continue for three years (ie until all panels are full at the end of year 22) (Coffey 2016b). Water in the void will be part of the greater groundwater source and will be available for others to use.

The water management objectives are to minimise disturbance to water resources; runoff will be diverted from undisturbed areas, collected and reused, and releases minimised. This will be achieved via a series of mine water dams and stormwater basins. Water supply for the project will be fully self-contained by using:

- rainfall-runoff stored in the mine water dams;
- groundwater collected in the underground mine sump (where groundwater inflow to underground workings will be captured); and
- when required, groundwater will be extracted from behind the sealed mine void bulkheads.

The volume of water required to be licensed for the project is defined as the groundwater inflow to the sump that is physically extracted, plus the groundwater inflow to the void, even though the majority of the groundwater in the void remains physically within the groundwater source.

Based on the numerical groundwater model (Coffey 2016b) and the water balance model (WSP PB 2016a) results, the maximum volume required for licensing is 2,290.5 ML/yr in year 15. Hume Coal has already secured in excess of 60% of the total licence requirement for the project, and has a clear pathway for how the remaining licence volume will be secured so that all water taken is adequately licensed.

ES4 Monitoring network

A comprehensive water monitoring network has been designed and implemented to establish comprehensive baseline data for the project. The surface water monitoring network measures hydrologic conditions in the project area, providing over four years of baseline data (2012–2016, inclusive) across 11 streamflow gauging locations and 24 water quality monitoring locations.

Up to four years of baseline hydrogeological data have been collected at 54 groundwater monitoring bores at 22 locations, 11 vibrating wire piezometer sensors at three locations, and three landholder bores. The network was developed in consultation with the NSW Department of Primary Industries (DPI) Water (formerly NSW Office of Water) and documented in the Groundwater Monitoring and Modelling Plan (EMM 2017b).

A diverse range of hydraulic tests have been made to provide site-specific information on the hydraulic properties of the groundwater systems, including rising and falling head tests (slug tests), packer tests, laboratory core permeability tests and constant rate pumping tests (WSP PB 2016e).

There are no identified high-priority groundwater dependent ecosystems (GDEs) within or proximate to the project area. Stygofauna sampling assessed 19 groundwater monitoring bores (eight within the project area and 11 outside of the project area) in 2013 and 2014 (EMM 2017c), and no rare or significant stygofauna was found. Stygofauna are the animals that live in underground water. They are mainly crustaceans but include worms, snails, insects, other invertebrate groups, and, in Australia, two species of blind fish. Most species spend their entire lives in groundwater and are found nowhere else.

ES5 Assessment and findings

Numerical modelling and analytical techniques have been used in this assessment to develop the site water balance, investigate potential changes in the extent of flooding, and predict quantity and quality changes in groundwater and surface water resources.

Assessment of the project considers the NSW Aquifer Interference Policy, the Commonwealth Department of Environment *Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources* (DoE 2013) and the *Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals (*IESC 2015). In addition the principles of Neutral or Beneficial (NorBE) impact on water quality have been adopted.

The possible predicted effects and assessed significance are:

- flow and yield changes for users and the environment – **insignificant;**
- stream bank erosion and geomorphology changes –**insignificant;**
- surface water changes – **insignificant**;
- flooding – **insignificant**;
- **no impacts** predicted for GDEs;

- effects on ecosystems that potentially use groundwater – **insignificant**;
- reductions to baseflow – **insignificant**;
- water quality changes for private landholder bores – **insignificant**; and
- drawdown on private landholder bores – **significant.**

ES6 Mitigation, avoidance, management and monitoring

The primary mitigation strategy to protect water resources has been the mine design (non-caving first workings) and operation of the mine (progressively sealing panels and injecting water following mining). Other mitigation strategies include efficient and optimised water management practices, underground reject emplacement, and use of limestone.

Two overarching and adaptive Water Management Plans (WMPs) will be prepared for the project in consultation with NSW Government agencies: one for the construction phase (CWMP) and one for the operational phase (OWMP).

A range of make good provisions for landholder bores that could experience a drawdown greater than 2 m have been proposed. The actual provisions that will be applied will be identified following case-by-case assessments and will depend on the existing infrastructure, the degree of drawdown at each site and the outcome of consultation with the relevant landholder. Strategies could include compensation for increased pumping costs, repositioning pumps to unaffected strata, or relocating bores.

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1 Introduction

This chapter describes the context of the project and outlines the purpose, scope and outcomes of this water assessment.

1.1 Overview

Hume Coal Pty Limited (Hume Coal) proposes to develop and operate an underground coal mine and associated mine infrastructure (the 'Hume Coal Project' or 'the project') in the Southern Coalfield of New South Wales (NSW) (Figure 1.3). Hume Coal holds exploration Authorisation 349 (A349) to the west of Moss Vale, in the Wingecarribee local government area (LGA). The project area boundary is illustrated in Figure 1.4. The underground mine will be developed within A349 and associated surface infrastructure facilities will be developed within and north of A349.

Approval for the project is being sought under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). An environmental impact statement (EIS) is a requirement of the approval processes. This water assessment report forms part of the *Hume Coal Project Environmental Impact Statement* (EMM 2017a). It documents the groundwater and surface water assessment methods and results, the initiatives built into the project design to avoid and minimise water associated impacts, and the additional mitigation and management measures proposed to address residual impacts unable to be avoided. Specialist technical studies are included in this document's appendices.

1.2 Key terms

A glossary of terms is included at the back of this report. Commonly used terms are defined in Table 1.1 for ease of reference.

Table 1.1 Key terms

Term	Definition and description
Active mining area	The part of the underground mine where mining and reject emplacement taking place as well as other parts of the mine that are used for personnel and materials access, conveying coal, and ventilation. These areas have not been sealed off by bulkheads or seals.
Bulkhead	Following mining and co-disposal of coal rejects into each active panel, a permanent seal (bulkhead) will be installed near the entrance of the panel in each roadway. Each bulkhead will be designed to sustain anticipated groundwater pressures at an appropriate level of safety (nominally larger by a factor of four). The area behind the bulkheads then becomes an inactive part of the mine.
Cumulative impacts	Impacts from existing and future projects that may have an impact in combination with the predicted impacts from the project. These projects may already exist, be under construction, are confirmed, or are at various stages of the development application process.
Drawdown	The change in the groundwater head (level) as measured in a bore. The groundwater level in a bore reflects the pressure of the natural groundwater in the aquifer at the depth where the bore is open/screened. Drawdown refers to the change (lowering) in the groundwater level over time. Note that adjacent monitoring bores with different screen depths would be subject to different drawdown (see Figure 1.1).

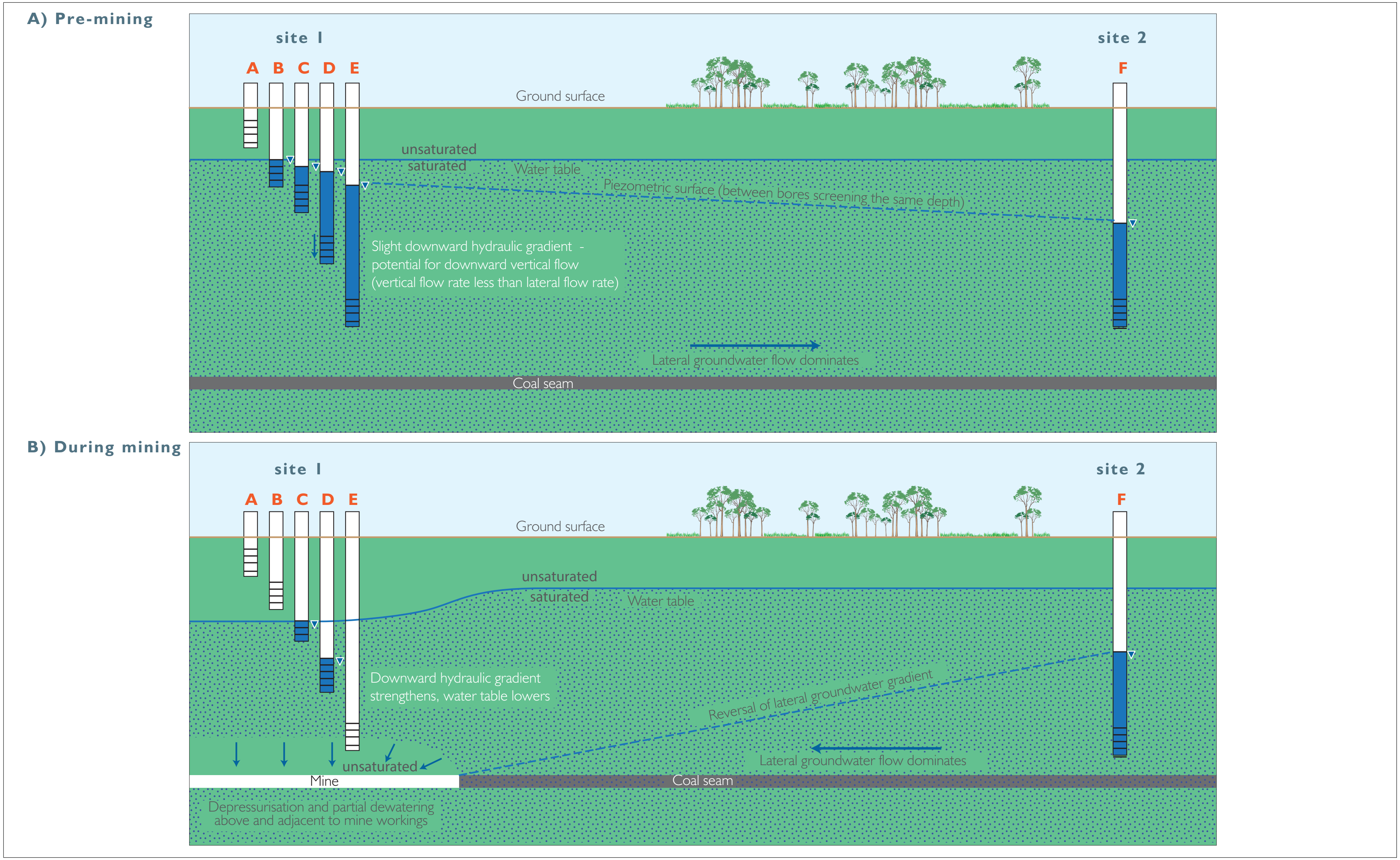
Table 1.1 Key terms

Term	Definition and description
Mine water dam	Structures designed to store and manage water at the surface during mining operations.
Model domain or groundwater model domain	The area that has been included in the groundwater model. This extends beyond the project area and is defined by hydrogeological or other boundaries.
Panel	A distinct part of the underground mine where coal is actively mined and removed. Each panel has its own separate ventilation circuit. The project consists of about 50 panels, which will be mined sequentially. The panels are generally separated from one another by solid coal barrier pillars 50 m wide.
Potentiometric surface/ level	An imaginary surface representing the static head of groundwater and defined by the level to which water will rise in a bore. In an unconfined groundwater system, this will generally be the same as the water table. If a bore is installed and screened below the water table, the groundwater level in the bore will rise up to the height of the potentiometric surface at the depth of the bore screens.
Reject co-disposal emplacement	The mixture of crushed rock and fines that have been separated from the coal during processing, along with limestone and water that will be emplaced underground into the void spaces in the mining panels prior to them being sealed with a bulkhead.
Reject co-disposal make-up water	The water that is mixed with the crushed rock rejects and limestone and which will be co-disposed in completed mining panels.
Sediment dam	Temporary structures that are constructed and used during construction of the surface infrastructure area to prevent sediment-laden runoff entering the local catchment. Water from dams will be released to the local catchment (as they are designed to do) once sediment is settled and separated. Once construction of the infrastructure area is finished, sediment dams will generally be decommissioned and will not remain part of the operations phase water management system.
Stormwater basin	Structures designed to collect and temporarily store water that falls within the mine surface infrastructure area during large rainfall events. These basins will contain mainly clean run-off water in high rainfall events, and water that enters them will have limited, if any, direct contact with coal.
Sump	An underground water storage where water is pumped to/from, or collects. For the project, the sump is where water from various parts of the mine is collected. This water is then either pumped to the surface for use in mine operations or is injected into the void.
Void	The open volume remaining following coal extraction.
Volume of licensable water	The volume of water required to be licensed for the project is defined as the groundwater inflow to the sump that is physically taken, plus the groundwater inflow to the void, even though the majority of the groundwater in the void remains physically within the groundwater source
Water flow to void	Water that flows in to the sealed void remains within the groundwater system. It will not flow into the active mining area or the sump. Water in the void is natural inflow to the void and/or injected excess water from the sump or mine water dams. Water in the void may be extracted for use in the mine operations during times of deficit; the volumes extracted will be licensed.
Water table	The depth, or level, below which the ground is fully saturated with groundwater.

To provide context for the key terms in the above table, two figures are presented to illustrate the conceptual changes in the groundwater resource from pre-mining to mining.

Figure 1.1 shows a conceptualisation of groundwater systems and hydraulic head in bores during pre-mining (A) and during mining (B) conditions. Two bore sites are shown: one situated in groundwater systems above a mine (site 1) and the other at distance from a mine (site 2). The response to depressurisation from mining in each bore depends on the depth and location of the bore.

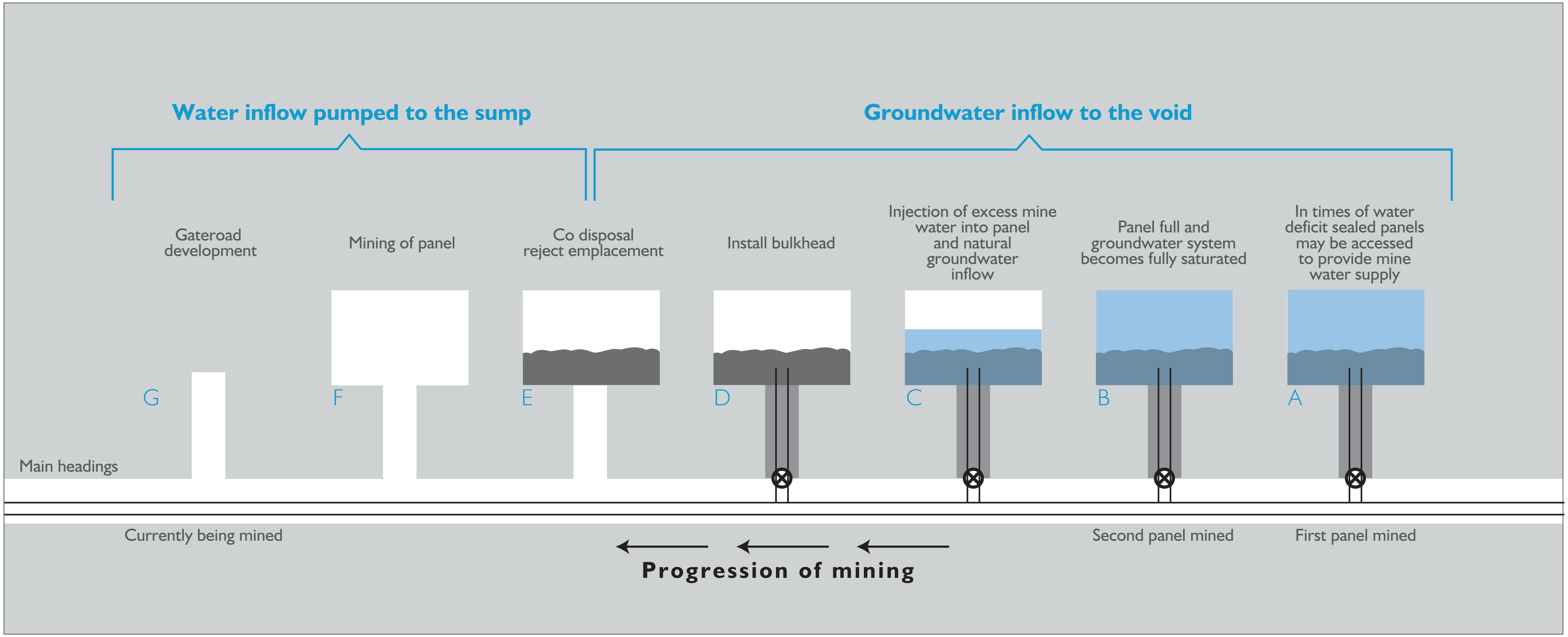
Figure 1.2 shows a schematic representation of progression of mining in adjacent panels from active mining (panel G), co-disposal reject emplacement, bulkhead installation, injection of excess mine water, and groundwater inflows. Panel A was mined first, followed by Panel B, and so on.



Hydraulic head in bores schematic — pre-mining and mining

Hume Coal Project
Water Assessment

Figure 1.1



Panel A was mined first, then panel B and so on.
Panel G is in the first stages of mining.

Water inflows into sequential panels during mining
Hume Coal Project
Water Assessment
Figure 1.2

1.3 Project description

The proponent will develop and operate an underground coal mine and associated infrastructure over a total estimated project life of 23 years. Indicative mine and surface infrastructure plans are provided in Figure 1.5 and Figure 1.6. A full description of the project is provided in Chapter 2 of the EIS (EMM 2017a).

In summary the project involves:

- Ongoing resource definition activities, along with geotechnical and engineering testing, and other fieldwork to facilitate detailed design.
- Establishment of a temporary construction accommodation village.
- Development and operation of an underground coal mine, comprising about two years of construction and 19 years of mining, followed by a closure and rehabilitation phase of up to two years, leading to a total project life of 23 years. Some coal extraction will begin during the second year of construction during installing the drifts, and hence there will be some overlap between the construction and operational phases.
- Extraction of about 50 million tonnes (Mt) of run-of-mine (ROM) coal from the Wongawilli Seam, at a rate of up to 3.5 million tonnes per annum (Mtpa). Low impact mining methods will be used, which will have negligible subsidence effects.
- After ROM coal is processed in the coal preparation plant (CPP), up to 3 Mtpa of metallurgical and thermal coal will be produced for sale to international and domestic markets.
- Construction and operation of associated mine infrastructure, mostly on cleared land, including:
    - one personnel and materials drift access and one conveyor drift access from the surface to the coal seam;
    - ventilation shafts, comprising one upcast ventilation shaft and fans, and up to two downcast shafts installed over the life of the mine, depending on ventilation requirements as the mine progresses;
    - a surface infrastructure area, including administration, bathhouse, wash down and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities. The surface infrastructure area will also contain the CPP and ROM coal, product coal and emergency reject stockpiles;
    - surface and groundwater management and treatment facilities, including storage, pipelines, pumps and associated infrastructure;
    - overland conveyors;
    - rail load-out facilities;
    - explosives magazine;
    - ancillary facilities, including fences, access roads, car parking areas, helipad and communications infrastructure; and

- environmental management and monitoring equipment.

- Establishment of site access from Mereworth Road, and minor internal road modifications and relocation of some existing utilities.

- Coal reject emplacement underground in the mined-out voids.

- Peak workforces of about 414 full-time equivalent employees during construction and about 300 full-time equivalent employees and contractors during operations.

- Decommissioning mine infrastructure and rehabilitating the area once mining is complete, so that it can support land uses similar to current land uses.

The project area, shown in Figure 1.4, occupies some 5,051 hectares (ha). Surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on Figure 1.6, though will include some other areas above the underground mine, such as drill pads and access tracks. The project area generally comprises direct surface disturbance areas of up to about 117 ha, and an underground mining area of about 3,472 ha, where negligible subsidence within the associated geological units is anticipated.

A construction buffer zone will be provided around the direct disturbance areas. The buffer zone will provide an area for construction vehicle and equipment movements, minor stockpiling and equipment laydown, as well as allowing for minor realignments of surface infrastructure. Ground disturbance will generally be minor and associated with temporary vehicle tracks and sediment controls as well as minor works such as backfilled trenches associated with realigning existing services. Despite this, environmental features identified in the relevant technical assessments will be marked as avoidance zones so that activities in these areas will not have an environmental effect.

Product coal will be transported by rail, mainly to Port Kembla terminal for shipment to international markets, and to domestic markets depending on market conditions applying at the time. Rail works and use are the subject of a separate EIS and State significant development application for the Berrima Rail Project.

1.4 Assessment requirements

This water assessment has been prepared following the appropriate guidelines, policies and industry requirements, and in consultation with relevant government agencies.

The main guidelines, legislation and policies relevant to the project are discussed in Chapter 3. Of particular note for the groundwater assessment are the requirements of the NSW Government Aquifer Interference Policy (AIP) (NOW 2012a).

This assessment has been prepared in accordance with requirements of the Commonwealth Department of the Environment (DoE) (now the Department of Environment and Energy (DoEE)) and NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the project and supplementary SEARs both issued on 20 August 2015. The SEARs identify matters that must be addressed in the EIS and essentially form its terms of reference. The complete SEARs are included in the *Hume Coal Project EIS* as Appendix B (EMM 2017a), while Table 1.2 lists individual requirements relevant to this water assessment and where they are addressed in this report.

Table 1.2 Water-related SEARs

Requirement	Chapter where addressed in this document
An assessment of the likely effects of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the EPA's[1], DPI's[2] and Water NSW requirements and recommendations.	10, 11
An assessment of the likely effects of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users.	10, 11
An assessment of the potential flooding effects of the development.	10.3
A water management strategy, having regard to the EPA's, DPI's and WaterNSW's requirements	13

Notes: 1. EPA = Environment Protection Authority.
2. DPI = Department of Primary Industries.

To inform the preparation of the SEARs, the DPE invited other government agencies to recommend matters to be addressed in the *Hume Coal Project EIS* (EMM 2017a). These matters were taken into account by the Secretary for the DP&E when preparing the SEARs. Copies of the government agencies' advice to DP&E were attached to the SEARs.

A number of agencies, including the Department of Primary Industries, Water (DPI Water), WaterNSW, Environment Protection Authority (EPA), Office of Environment and Heritage (OEH), and the DoEE raised matters relevant to the water assessment. These were mainly their standard requirements for projects of this nature, though included some project-specific requirements relating to groundwater and surface water quality and flow. The agency recommendations (AR), and where they are addressed in this document, are listed in Appendix A, Table 15.1 along with the SEARs, and have been taken into account in preparing this assessment. Each SEAR and AR has been allocated a unique identification number (water assessment ID) for the purpose of reference within this document. Blue boxes identifying each relevant SEAR and/or AR precede the sections of the report where they have been addressed. Some SEARs and/or ARs contain multiple aspects that are addressed in a number of different sections of the report. In these cases, the full text of the SEAR and/or AR has been included in the blue box in each of the report section, even when only part of it is addressed in that section.

In addition, the *Information Guidelines for Independent Expert Scientific Committee (IESC) advice on coal seam gas and large coal mining development proposals checklist of specific information needs* (IESC 2015) has been included in Appendix B and cross-referenced with relevant sections of this document where the information has been provided.

1.5 Purpose of the water assessment

The key objectives of the water assessment are to:

- outline the proposed site water management arrangements for the project;
- assess the existing hydrological and hydrogeological and related environments and baseline conditions within the project and surrounding area;
- assess the regulatory environment within which the project will operate;
- quantify the requirements of the project for water access licences to satisfy project demands, and specify arrangements for acquiring them;

- identify and quantify the potential effects of the project on the current surface water and groundwater resources, and on water users both environmental and extractive (including cumulative effects);

- specify mitigation and management measures, and monitoring requirements for surface water and groundwater;

- satisfy the SEARs relevant to groundwater and surface water effects; and

- inform the wider community about the project and its potential effects on the local and regional water environments.

This assessment covers all issues relating to site water management, groundwater and surface water and their related environmental and other uses. For surface water, this includes issues relating to river waters, geomorphology, and flooding. Ecological effects are referred to in this report but are given more detailed treatment in the *Hume Coal Project Biodiversity Assessment Report* (EMM 2017c).

A number of consultants were commissioned for various water-related technical studies to inform the project. The water assessment was prepared using a number of technical assessments that have been appended to this document, namely:

- Water Balance, WSP PB 2016a (Appendix D);

- Surface Water Quality Assessment, WSP PB 2016b (Appendix E);

- Surface Water Flow and Geomorphology Assessment, WSP PB 2016c (Appendix F);

- Flooding Assessment, WSP PB 2016d (Appendix G);

- Groundwater Assessment, Volume 1: Data Analysis, Coffey 2016a (Appendix H);

- Groundwater Assessment, Volume 2: Numerical modelling and Impact, Coffey 2016b (Appendix I); and

- Hydrogeochemical Assessment, Geosyntec 2016 (Appendix K).

The technical studies have been carried out in accordance with the SEARs and ARs and with reference to leading practice guidelines, legislation and policies.

1.6 Project area and study area

The project area boundary is illustrated in Figure 1.4.

Each technical assessment (as discussed in Section 1.5) focused on a particular study area that was relevant to the subject matter. For example, the groundwater assessment's study area is larger than that examined in the water balance. The study area for each technical assessment is shown in Table 1.3.

Table 1.3 Defined study areas for each technical assessment

Technical assessment	Study area
Water balance	The surface infrastructure area (Figure 1.6) and the underground mine (Figure 1.5)
Surface water quality	The streams with potential to be affected by the project within the groundwater model domain (Figure 8.4)
Surface water flow and geomorphology	Streams adjacent to and downstream of the surface infrastructure areas within the Medway Rivulet and Oldbury Creek catchments; and streams affected by loss of baseflow due to aquifer depressurisation
Flooding	The surface infrastructure area (Figure 1.6) and the surrounding Medway Rivulet and Oldbury Creek catchments
Groundwater numerical model	The groundwater model domain (Figure 8.4)
Hydrogeochemical	The underground mine and portions of the groundwater systems down hydraulic gradient from the underground workings

1.7 Scope of the water assessment

The scope of the water assessment was to:

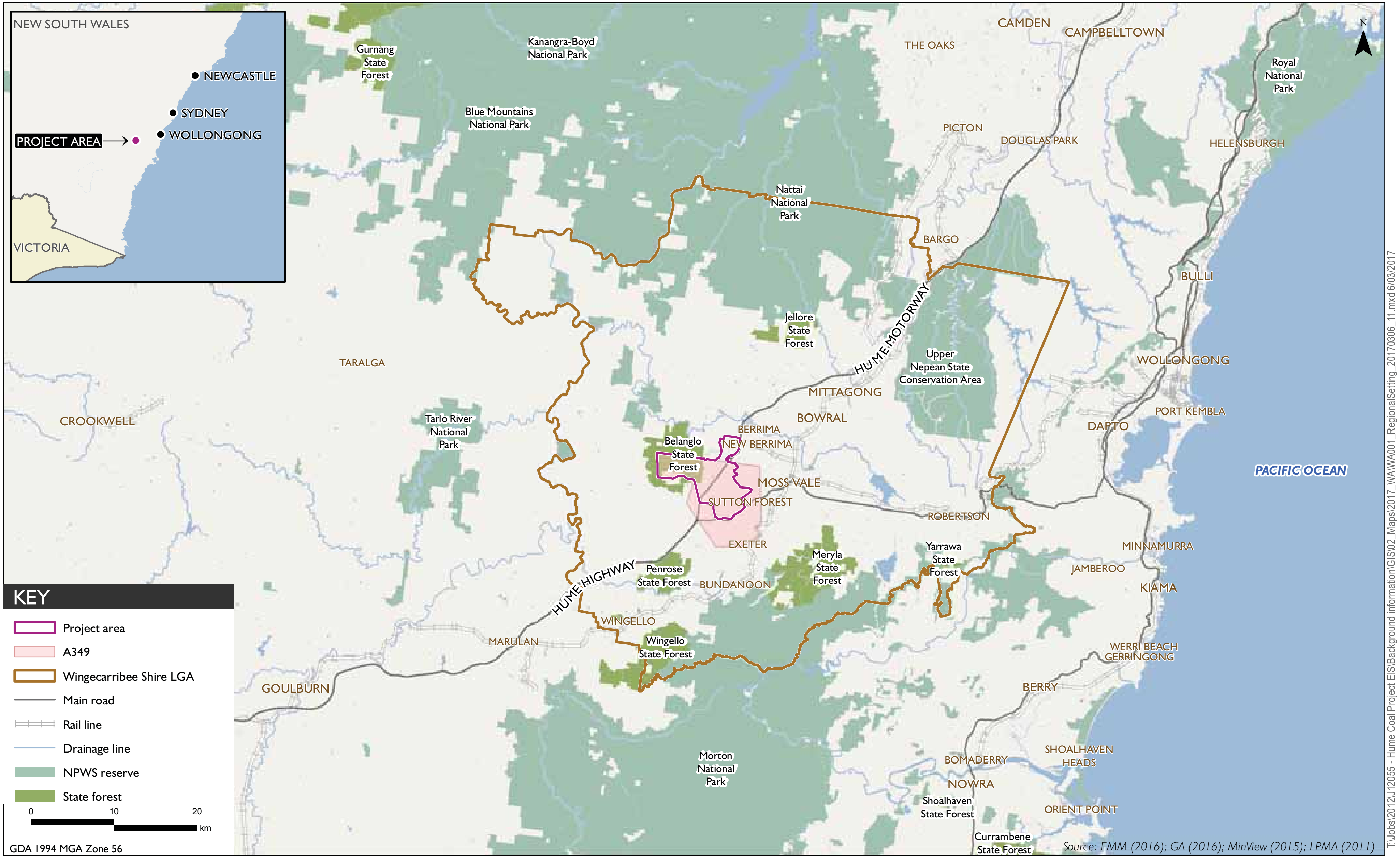
- assess the existing hydrological and hydrogeological environments and baseline conditions within the project and surrounding area;
- identify and quantify the potential effects of the project on the current surface water and groundwater resources, and on water users both environmental and extractive (including cumulative effects);
- specify mitigation and management measures, and monitoring requirements for surface water and groundwater; and
- discuss water licensing requirements in accordance with the relevant legislation.

1.8 Adoption of leading practices

Hume Coal has adopted a number of leading practices to produce a mine design that avoids and minimises impacts to water assets. The key leading practices adopted to minimise impacts to water related assets are:

- innovative and tailored first working mine design (ie imperceptible levels of subsidence or damage to the overlying Hawkesbury Sandstone);
- underground emplacement of coal rejects (ie removes the need for permanent surface stockpiles); and
- sealing of mined panels (ie allows groundwater to recover more rapidly).

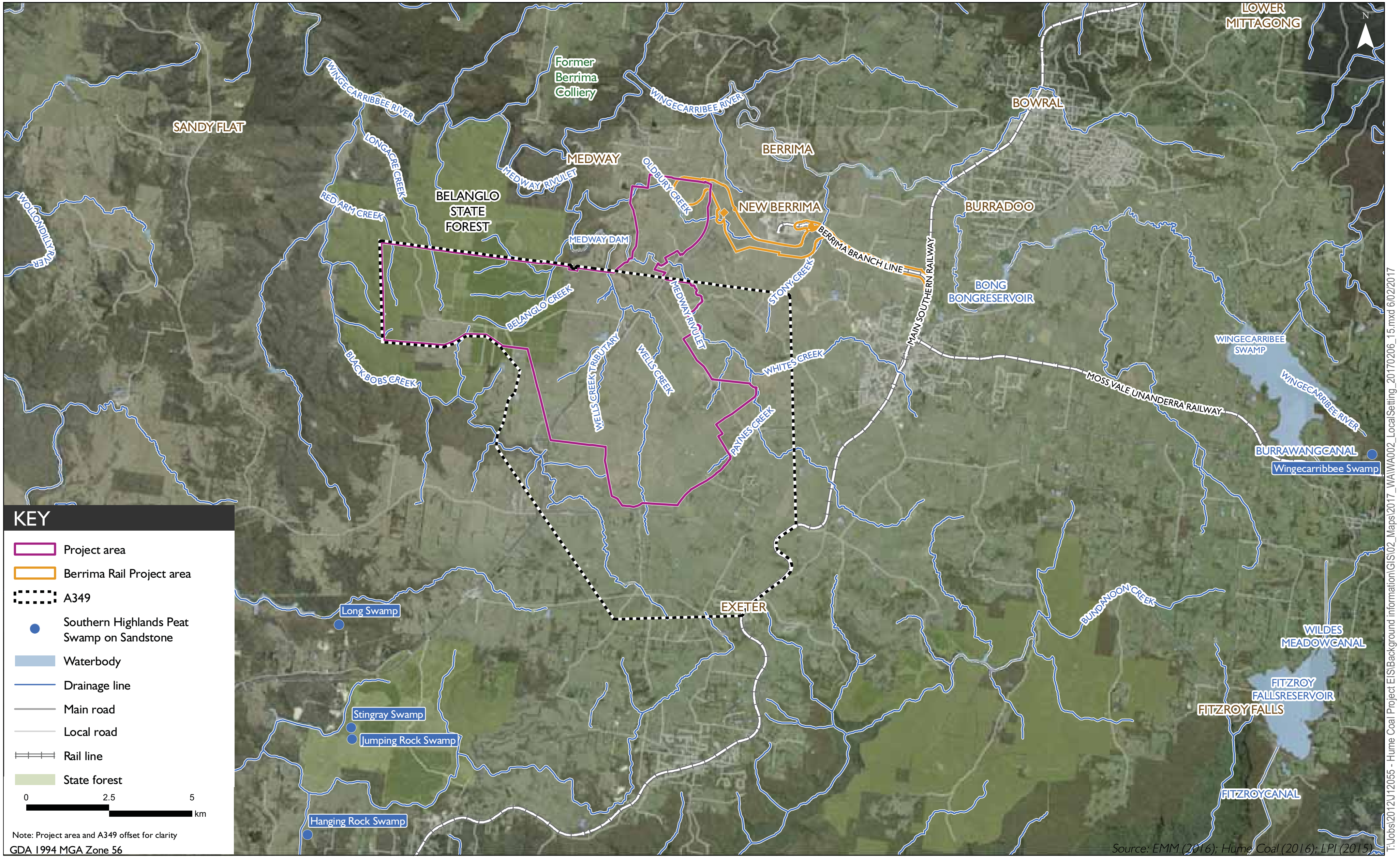
Extensive technical investigations have taken place over several years to develop and refine the project, and arrive at the proposed design.



Regional context

Hume Coal Project
Water Assessment

Figure 1.3

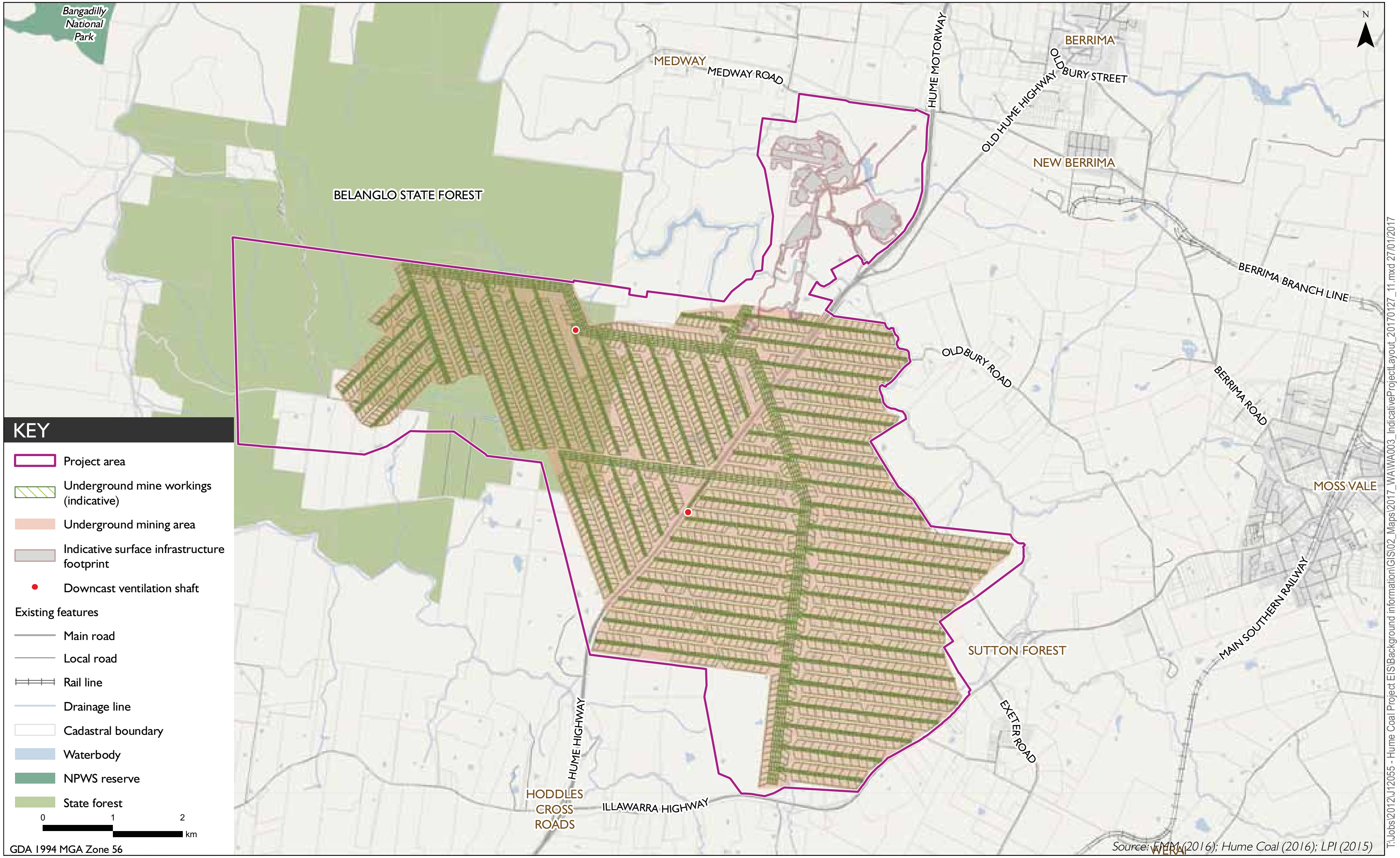


Local setting

Hume Coal Project

Water Assessment

Figure 1.4



Mine and surface infrastructure layout

Hume Coal Project

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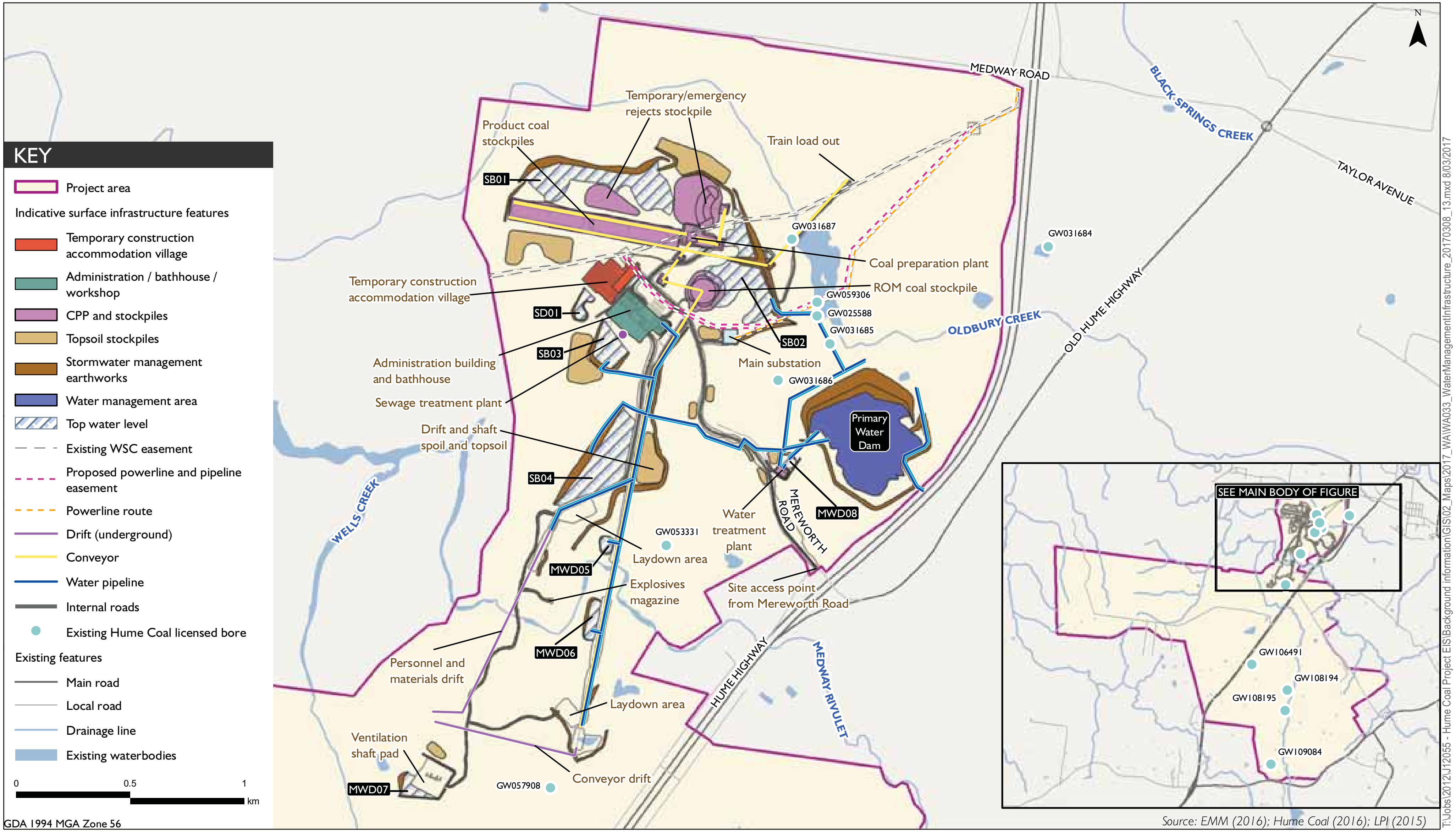
Figure 1.5



Water management structures

Hume Coal Project
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Figure 1.6

EMM HUMECOAL

2 Project setting

This chapter describes the project setting, topography, rainfall, and water resources, and gives details of the mining method and site water management.

AR 79: A full description of the development including those aspects which have the potential to impact on the quality and quantity of surface and groundwaters at and adjacent to the site, including:
- the mining proposal and mine layout
- the location, mapping and geomorphology of all creeks and water resources overlying and adjacent to the proposed mining area
- the hydrogeological fluxes between surface and groundwaters, including the filling of pine feather voids
- the location, management and storage of all hazardous materials- the disposal of wastes from the treatment of mine waters in the mine water treatment plant
- the management of dirty water from the washing and preparation of coal for transport
- the location, sizing and description of all water quality management measures
- the location and description of all water monitoring points (surface and ground waters)
- on-site domestic (sewage) wastewater management

2.1 General site description

The project area is about 100 km south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to Figure 1.3 and Figure 1.4). The nearest area of surface disturbance will be in the surface infrastructure area, which will be 7.2 km north-west of Moss Vale town centre. It is in the Southern Highlands region of NSW and the Sydney Basin Biogeographic Region.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns. In addition, industrial activities such as the Berrima Cement Works and Inghams Feed Mill, some extractive industry and major transport infrastructure such as the Hume Highway are present.

Surface infrastructure is proposed to be developed on largely cleared land owned by Hume Coal or affiliated entities, or for which there are appropriate access agreements in place with the landowner. Over half of the remainder of the project area (principally land above the underground mining area) comprises cleared land that is, and will continue to be, used for livestock grazing and small-scale farm businesses. Belanglo State Forest covers the north-western portion of the project area and contains pine forest plantations, areas of native vegetation and several creeks that flow through deep sandstone gorges. Native vegetation within the project area is largely restricted to parts of Belanglo State Forest and riparian corridors along some watercourses.

The project area is traversed by several drainage lines including Oldbury Creek, Medway Rivulet, Wells Creek, Wells Creek tributary, Belanglo Creek and Longacre Creek, all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream of the project area (Figure 1.4). The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean River catchments. Medway Dam is also next to the northern portion of the project area (Figure 1.4).

Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. However, there are steeper slopes and deep gorges in the west in Belanglo State Forest.

Existing built features across the project area include scattered rural residences and farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens, as well as infrastructure and utilities, including roads, electricity lines, communications cables and water and gas pipelines. Key roads that traverse or border the project area are the Hume Highway, Golden Vale Road, and the Illawarra Highway.

Industrial and manufacturing facilities near the project area include the Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima. Berrima Colliery's mining lease (CCL 748) also adjoins the project area's northern boundary. Production ended at Berrima Colliery in 2013 after almost 100 years of operation. The mine is being closed.

2.1.1 Historical mining activity

There is a long history of mining in the Southern Coalfield within the Wingecarribee Shire including mining for coal, iron ore, bauxite, gold, diamonds, shale, sand, clay, and kerosene shale. There is also a history of hard rock quarrying in the area including basalt quarries at Exeter and at Mount Gingenbullen as well as the heritage-listed dimension stone quarry at Mount Gibraltar. Mining still takes place at various locations within Wingecarribee Shire, including the Dendrobium longwall coal mine in the shire's north-east. Deposits of potentially commercial bauxite are known to occur in the south of the shire.

Chapter 5 of the *Hume Coal Project EIS* discusses historical mining activity in the Southern Coalfield in more detail. In summary, historical mines within and near the project area include:

- Berrima Colliery – to the north of Wingecarribee River. Berrima Colliery's mining lease (CCL 748) adjoins the project area's northern boundary; it is being closed having ceased operations in 2013. The workings are the most extensive of any mine in the area and comprise first workings and pillar extraction in the Wongawilli Seam. Mining operations began in 1926, with mechanisation starting in 1968.

- The Loch Catherine Mine (abandoned) – underneath the former Berrima Colliery stockpile pad bounded by Medway Rivulet and the Wingecarribee River. The mine worked the Wongawilli Seam. Operations ceased at Loch Catherine Mine in the 1960s. The adits are still open, and iron staining is evident in the water pooled at the mine entries.

- Southern Colliery (abandoned) – on Foxgrove Road, about 5 km south-west of the project area. Mining appears to have occurred in the Tongarra Seam. This was a small-scale mine that ceased operations many years ago.

- Numerous adits exist at coal seam outcrops along escarpments and are examples of pre-mechanisation (manual) abandoned workings. Typical examples of these adits are Black Bobs, Belanglo (abandoned in the 1950s), Belanglo Extended, and Flying Fox collieries to the west and north of the project area, Erith Colliery near Bundanoon, and two adits of unknown length along Longacre Creek, in the far north-east of the project area. Most are not sealed and drain into local watercourses.

2.1.2 Topography

The project area is situated on the elevated but relatively flat Nattai Plateau. Elevations typically range from around 550 to 735 metres above Australian Height Datum (AHD) (Figure 2.1). Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. Steeper slopes and deep gorges are located to the immediate west, north-west, and south of the project area and are products of incision from watercourse flow.

The Southern Highlands has some peaks of igneous origin. These include Mount Gingenbullen (800 mAHD) to the north-east of the project and Mount Gibraltar (860 mAHD) further north-east near Bowral (Figure 2.1). Broad basalt peaks are also observed to the south.

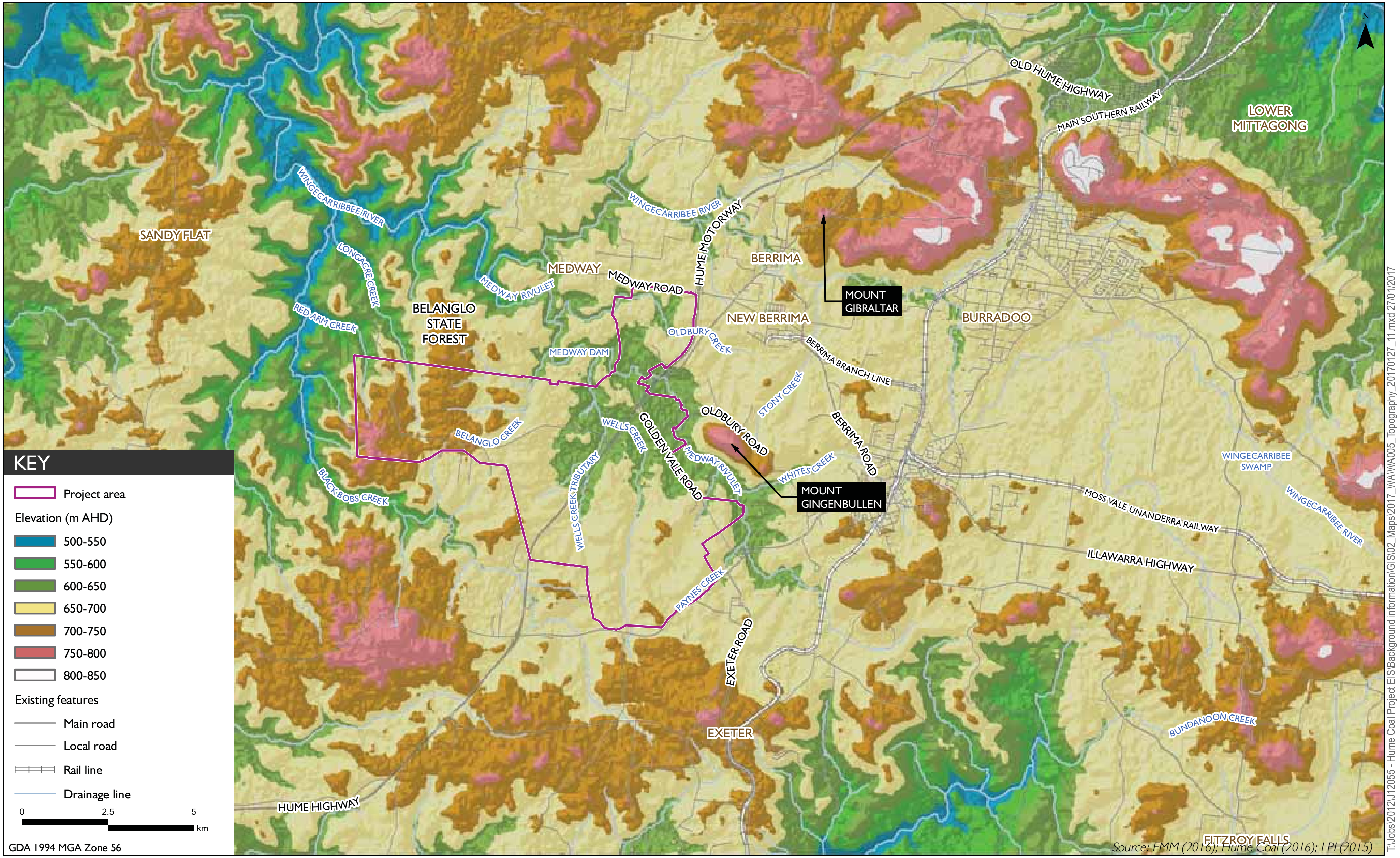
2.1.3 Meteorology

The project area's climate is cool temperate, characterised by warm summers and cool winters. September is typically the driest month. Table 2.1 summarises average climate data for the project area, mainly using data from the Bureau of Meteorology (BoM) station at Moss Vale, Hoskins St (station 068045), which began recording in 1871, and mean pan evaporation measurements have been referenced from the BoM Goulburn TAFE station (site number 070263), which began recording in 1971. The data in Table 2.1 shows that temperatures range from an average maximum of 25.8°C in January to an average minimum of 1.3°C in July.

Table 2.1 Local climate data

Parameter		Measurement	Month
Mean temperature at Moss Vale BoM station 068045			
Maximum	Annual	21.2°C	-
	Highest monthly	25.8°C	January
	Lowest monthly	11.8°C	July
Minimum	Annual	6.9°C	-
	Highest monthly	12.6°C	February
	Lowest monthly	1.3°C	July
Mean rainfall at Moss Vale BoM station 068045			
Annual		963 mm	-
Highest monthly		102 mm	June
Lowest monthly		60 mm	September
Mean pan evaporation at Goulburn TAFE BoM station 070263			
Annual		1,264 mm	-
Highest monthly		195 mm	January
Lowest monthly		33 mm	June

Figure 2.2 compares mean monthly evaporation and rainfall from the Goulburn and Moss Vale stations, respectively. Rainfall is relatively consistent throughout the year, although rainfall slightly decreases in the months of August and September. A soil moisture deficit is likely from September to March when evaporation typically exceeds rainfall. The long-term regional average annual rainfall for the project area is about 957 mm and is slightly lower than that observed at the Moss Vale station; this approximation is based on area-weighting of 20 nearby BoM climate stations (Coffey 2016b).



Topography

Hume Coal Project
Water Assessment

Figure 2.1

Evaporative losses from Medway Dam are about 100 ML per year. This is a conservatively low estimate of the losses based on the lake evaporation data used in the assessment and the water surface area of the Medway Dam waterbody. Further details are included in Appendix F (WSP PB 2016c).

In each technical study included in Appendices D - K, the source of the climatic data used has been selected based on its appropriateness in data completeness or spatial coverage. For example, the water balance assessment (WSP PB 2016a) used the SILO Data Drill data, which are interpolated estimates of climatic data at point locations derived from BoM stations (DSITIA 2015). This dataset is considered more appropriate for water balance modelling than individual BoM station data as it provides a long-term climate sequence. The flood assessment (WSP PB 2016d) required climate data specific to the flood assessment study area (the surface infrastructure area and the surrounding Medway Rivulet and Oldbury Creek catchments), and thus, the closest BoM stations and a Hume Coal weather station were used as data sources. Conversely, the numerical groundwater model used area-weighted data from 20 BoM climate stations (as mentioned above) covering a much broader area to better represent the climate of the numerical groundwater model's larger study area (Coffey 2016b). As a result, climatic statistics, including averages, referenced in each technical report vary slightly.

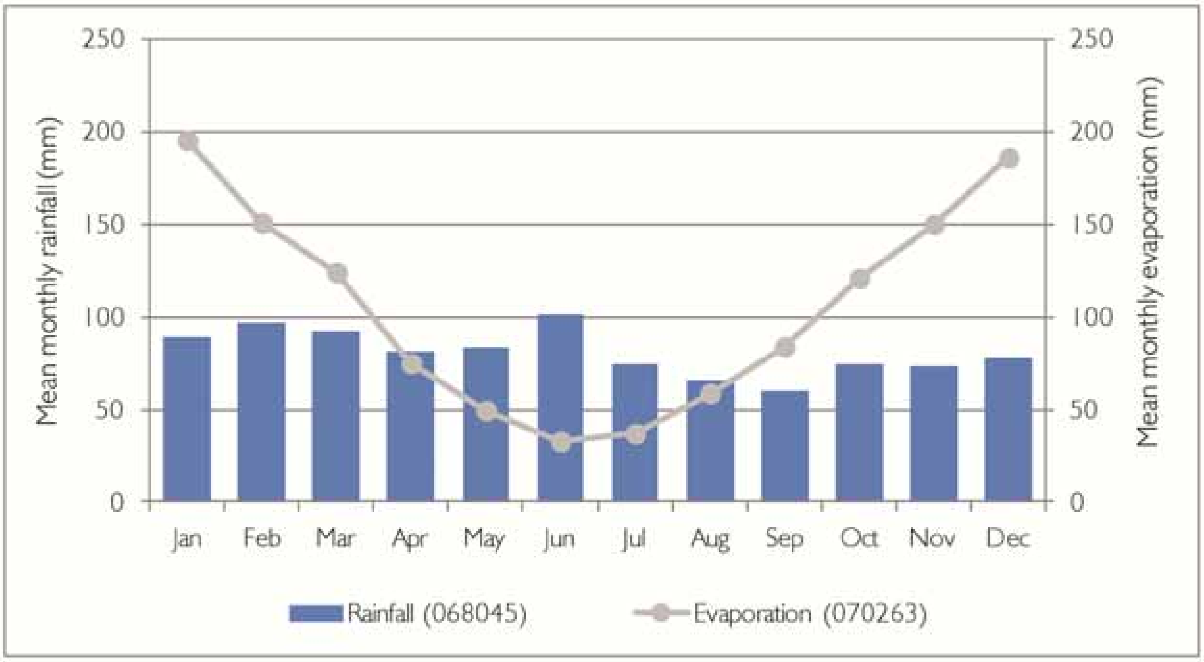


Figure 2.2 Mean monthly rainfall and evaporation

i Cumulative deviation rainfall

The long-term annual cumulative deviation from the mean (CDFM) of rainfall at Moss Vale (from 1900 to 2014) is plotted in Figure 2.3.

The CDFM plot is made by subtracting the mean annual rainfall (calculated from the whole dataset) from the actual annual rainfall observed in each particular year. Periods of below average rainfall plot as a downward trend while periods of above average rainfall plot as an upward trend. These deficits and excess in rainfall can also correspond to falling and rising groundwater levels respectively.

The CDFM plot for Moss Vale shows that for the 43 years from 1948–1991 rainfall was mainly above average, with the exception of two short-term below average periods. Rainfall from 1991 to 2011 was below the long-term average. Rainfall has been above average since 2011.

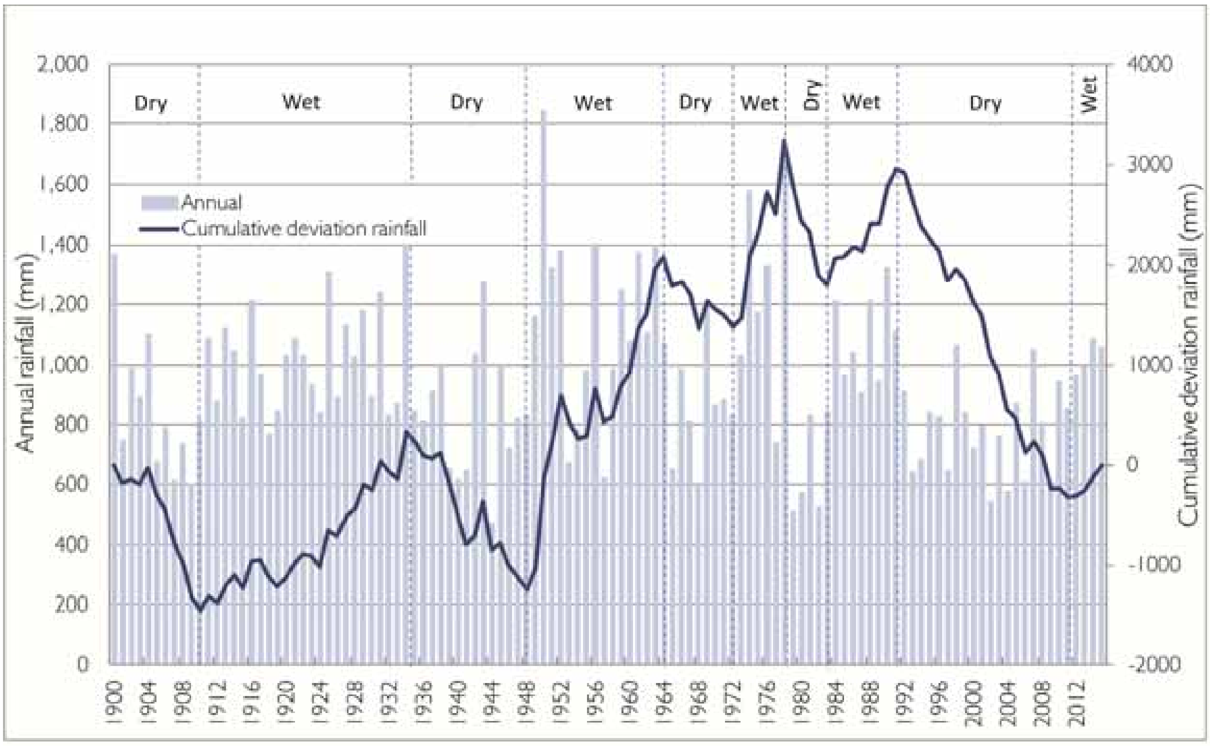


Figure 2.3 Annual cumulative deviation from the mean of rainfall (1900 – 2014)

2.1.4 Water resources

The project area and most of A349 are within the Wingecarribee River catchment, a sub-catchment of the Hawkesbury-Nepean River catchment. A small portion of the south-eastern corner of A349 is within the Bundanoon Creek catchment, a sub-catchment of the Shoalhaven River catchment (WSP PB 2016c). The surface water resources of both these sub-catchments are managed under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011*. The Wingecarribee River catchment is part of the Upper Nepean and Upstream Warragamba Water source in this water sharing plan.

The groundwater resources of the project are entirely within the Sydney geological basin, and are managed under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*. This water sharing plan divides the Sydney geological basin, and the project area is situated within the Nepean Management Zone 1 of the Sydney Basin Nepean Groundwater Source.

A detailed description of the water resources is provided in Chapters 5 and 6. A summary of the surface water and groundwater resources is provided below.

i Surface water resources

The Wingecarribee River catchment is a southern (upstream) sub-catchment of the larger Hawkesbury-Nepean River catchment, and is some 225 km^2 in area. It forms part of the 9,051 km^2 Warragamba Dam catchment, which supplies water to Sydney. The Hawkesbury-Nepean River catchment has an area of about 21,400 km^2.

The Warragamba Drinking Water catchment is managed by WaterNSW. Around one quarter of Warragamba Dam's catchment comprises 'special areas' where public access and land use are carefully regulated to protect water quality. The project area is not within a special area, nor is the nearby Medway Dam (refer to Figure 2.4).

The surface facilities will be within the Medway Rivulet and Oldbury Creek catchment areas, which form part of the Medway Rivulet Management Zone, flowing into the Wingecarribee River (Figure 2.4) within the Upstream Warragamba and Upper Nepean Unregulated River Water Source. The project area is traversed by several drainage lines (including creeks) generally flowing north to north-westerly, all of which discharge to the Wingecarribee River, at least 5 km downstream (north-west) of the project area boundary. Surface water features in and surrounding the project area are shown in Figure 1.4, and include the following local sub-catchments of the Wingecarribee River catchment:

- Medway Rivulet catchment, incorporating Medway Rivulet sub-catchment and Oldbury Creek sub-catchment (shown in Figure 2.4), where most of the project area and the surface infrastructure is located; and

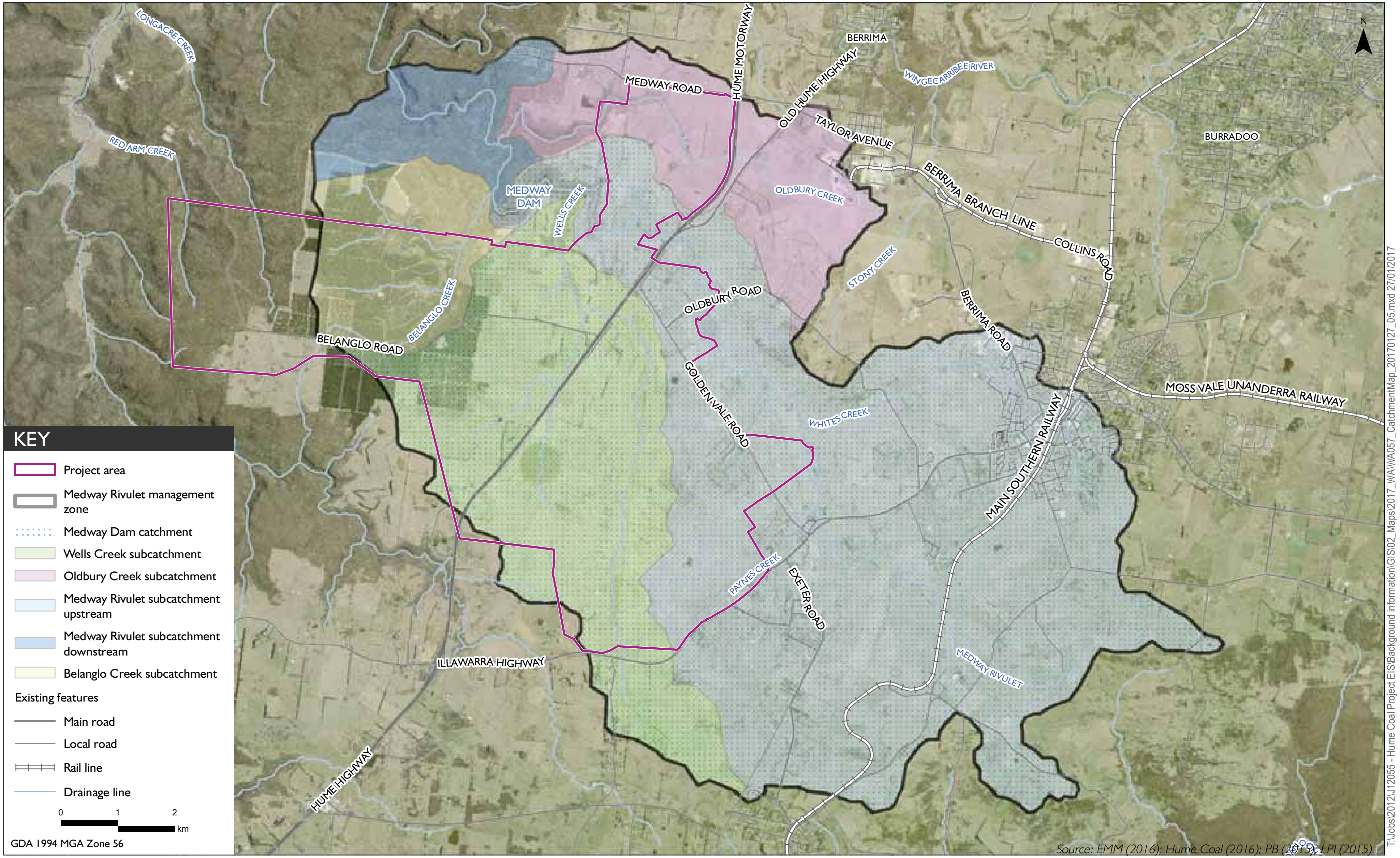
- Black Bobs Creek catchment, incorporating Red Arm Creek and Longacre Creek catchments.

The Wingecarribee River flows east to west, north of the project area. The median flow in Medway Rivulet and Oldbury Creek are 5 ML/day and 0.014 ML/day respectively, compared with a median flow in the Wingecarribee River, into which they eventually flow, of 30.1 ML/day (WSP PB 2016c).

Medway Rivulet is the main drainage line in the project area. Its primary tributaries include Oldbury Creek, Paynes Creek, Wells Creek, Wells Creek tributary and Whites Creek. The headwaters of Medway Rivulet start near Moss Vale. Surface water flow is influenced by several in-stream storages that impede continuous flow within the upper catchment. Near the project surface infrastructure area, Medway Rivulet is confined by steep gullies (WSP PB 2016c). Downstream of the project area, Medway Rivulet has been dammed to create Medway Dam, a 1,350 ML reservoir that is part of Wingecarribee Shire Council's water supply system. Treated sewage from the Moss Vale sewage treatment plant discharges into Whites Creek, which is a tributary of Medway Rivulet upstream of Medway Dam.

Medway Dam, shown in Figure 2.4, is a prescribed dam under Schedule 1 of the *Dams Safety Act 1978*. This dam is outside the project area and no mining will occur beneath it or its Notification Zone. Medway Dam is relatively small, with a capacity of about 1,350 ML. It supplies an 8 ML/day capacity water treatment plant that can provide water to Berrima and back-up supply to parts of Bowral and Mittagong and the Wingecarribee LGA system, but has not been operational since June 2013. The main water supply for these communities and the locality more broadly is from Wingecarribee Reservoir, around 14 km east of the proposed underground mining area, which has a 40 ML/day capacity water treatment plant. Additional back-up or supplementary supply is from Bundanoon Creek Dam.

Oldbury Creek begins near New Berrima and joins Medway Rivulet 1.5 km downstream from Medway Dam. Similarly to Medway Rivulet, the creek is characterised by several in-stream storages that impede continuous flow within the upper catchment. A large agricultural in-stream storage dam is near the northern part the surface infrastructure area. The treated sewage from the Berrima sewage treatment plant discharges directly into Oldbury Creek.



Subcatchments of the Medway Rivulet Management Zone

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Figure 2.4

ii Groundwater resources

The groundwater units within the project area are defined as:

- localised low permeability groundwater systems associated with the Robertson Basalt and Wianamatta Group shales;
- regional porous fractured rock groundwater system located in the Hawkesbury Sandstone; and
- localised water bearing zones associated with the Illawarra Coal Measures and the Shoalhaven Group.

In addition, localised groundwater systems can be associated with unconsolidated Quaternary alluvium in major streams and river valleys within the region (ie the upper reaches of the Wingecarribee River), although not within the project area.

The Hawkesbury Sandstone is the main groundwater bearing unit used in the project area, although a small number of bores are situated in the overlying shale, adjacent basalts and the underlying coal seam.

Groundwater within the Hawkesbury Sandstone is generally fresh with varying bore yields. The overlying Wianamatta Group Shale has low permeability and regionally retards (an aquitard) downward groundwater flow (Ross 2014). Groundwater within the shale is generally brackish to saline with very low bore yields. Reported yields from registered bores within 9km of the centre of the project area have a median value of 2.0 L/s; most of these bores extract groundwater from the Hawkesbury Sandstone (DPI Water 2015b).

2.2 Mining methods overview

A non-caving, first workings mining layout and method are planned. Mining will occur sequentially in panels (not longwall panels) that are separated from each other by solid barriers of unmined coal. The proposed method is low impact and will have negligible surface and subsurface subsidence, and minimal overburden fracturing. Mining will begin in the north of the extraction area and move west then to the south. Indicative underground mine progression is shown in Figure 2.5.

Individual mining panels will be separated by wide, solid (unmined) barrier pillars to prevent direct hydraulic connection between panels. The approximately 50 m wide barrier pillars will also aid geotechnical stability.

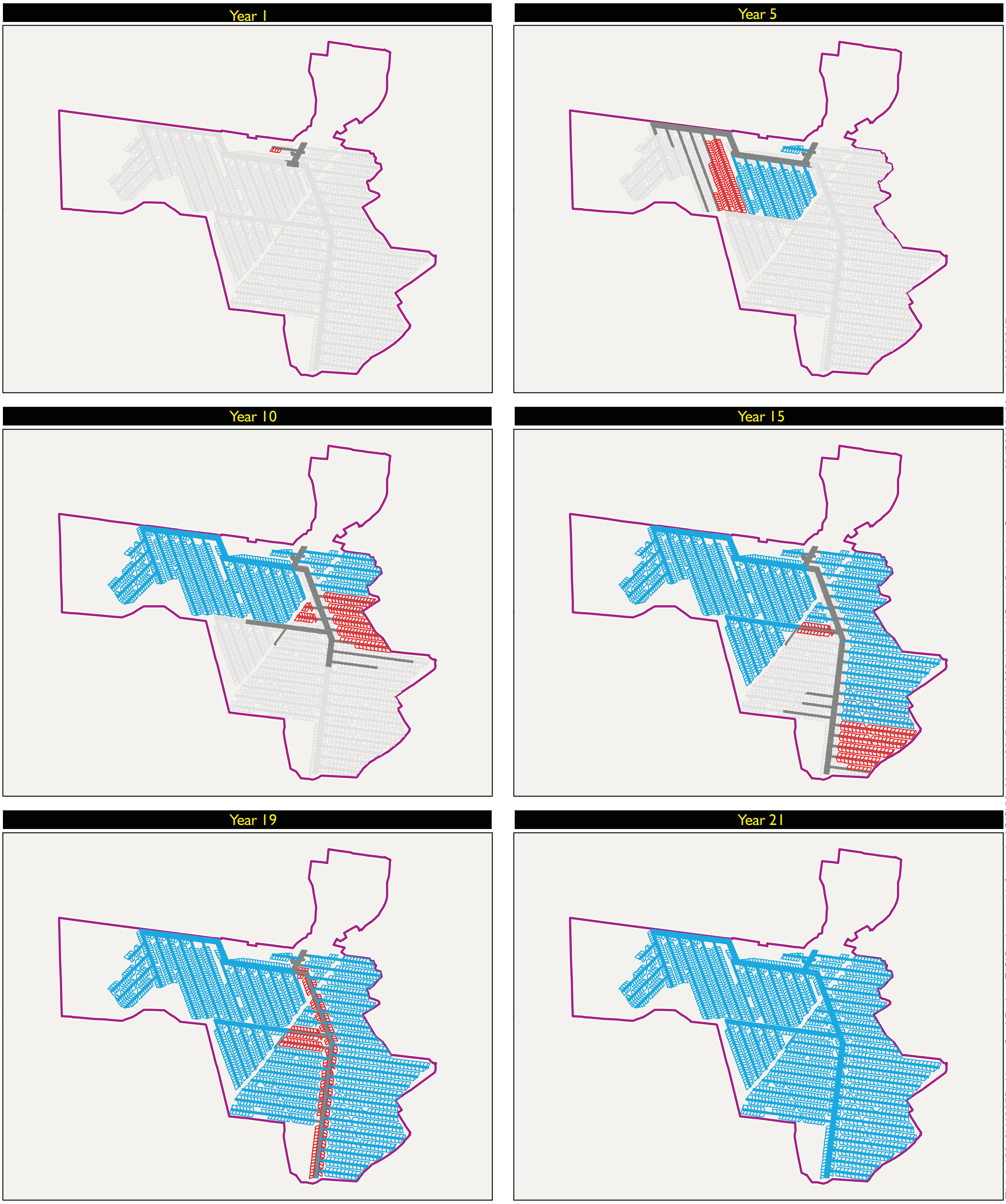
Once mined, the panels will contain open voids that will be used for the emplacement of coal reject materials. Mine voids will be backfilled with co-disposal reject (comprised of crushed rock rejects and water from the coal processing plant mixed with up to 1% limestone), to buffer any potential oxidation reaction of sulphur in the coal. It is estimated that reject and other rock wastes will fill some 36% of the total mined volume (Coffey 2016a).

After mining and backfilling operations are complete, individual panels will be sealed at the entrance with permanent seals (bulkheads) designed to sustain anticipated groundwater pressures, at an appropriate factor of safety (nominally a factor of four). The bulkhead seals will vary in thickness depending on the anticipated groundwater pressure. Water may be added to the sealed void before total filling or abstracted thereafter through valves constructed in the bulkheads.

Active injection of water behind the bulkheads will occur from year three (ie once the first bulkhead is sealed) through to year 19 of mining, resulting in a decreased volume of groundwater inflow to the workings and faster recovery post -mining. Once mining ceases (end of year 19) groundwater inflow to the void is expected to continue for three years (ie until all panels are full) (Coffey 2016b).

Once panels are sealed and flooded, the void will become part of the greater groundwater source. Relocating mine sump water into the underground sealed voids averts the need for management and or release of that water at the surface. Facilitating groundwater storage behind the bulkheads naturally and via injection will also greatly decrease groundwater depressurisation, and speed up the groundwater recovery time.

Minimal overburden deformation is expected to occur. Most will be small amounts of elastic deformation of the rock mass, while non-elastic deformation will be restricted to the immediate roof over the openings. The height of deformation was estimated to be 2 m into the roof above the panel (Coffey 2016b) with sensitivity analysis demonstrating that groundwater inflows would not be sensitive to doubling this height of deformation. Within the deformation (dilated) zone, existing cleats or defects may become enlarged and minor cracking may occur, which could increase hydraulic conductivity. The deformation zone is likely to become desaturated during mining activities. Above this zone, deformation will be negligible and groundwater saturation of the strata would be maintained (Coffey 2016b).



Source: Hume Coal (2016); EMM (2016)

0 1 2 km

GDA 1994 MGA Zone 56

KEY

- Project area
- Underground roadway
- Active underground workings
- Sealed underground workings
- Future underground workings

Indicative underground mine progression

Hume Coal Project

Water Assessment

Figure 2.5

2.3 Site water management overview

AR 1: Surface and groundwater usage and management

AR 17: Proposed management and disposal of produced or incidental water.

AR 26: Provide a description of any site water use (amount of water to be taken from each water source) and management including all sediment dams, clear water diversion structures with detail on the location, design specifications and storage capacities for all the existing and proposed water management structures.

AR 42: Description of all works and surface infrastructure that will intercept, store, convey, or otherwise interact with surface water resources.

AR 45: Works likely to intercept, connect with or infiltrate the groundwater sources.

AR 46: Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes.

AR 57: Proposed methods of the disposal of waste water and approval from the relevant authority.

AR 79: A full description of the development including those aspects which have the potential to impact on the quality and quantity of surface and groundwaters at and adjacent to the site, including:
- the mining proposal and mine layout
- the location, mapping and geomorphology of all creeks and water resources overlying and adjacent to the proposed mining area
- the hydrogeological fluxes between surface and groundwaters, including the filling of pine feather voids
- the location, management and storage of all hazardous materials- the disposal of wastes from the treatment of mine waters in the mine water treatment plant
- the management of dirty water from the washing and preparation of coal for transport
- the location, sizing and description of all water quality management measures
- the location and description of all water monitoring points (surface and ground waters)
- on-site domestic (sewage) wastewater management

AR 80: A detailed assessment of the development on water resources which considers the design, construction, operational and decommissioning phases and have regard for operation during periods of wet weather and include:
-details of measured and predicted coal mine, preparation area and stockpile area performance with respect to water quality management
-details of measures proposed to be adopted to offset impacts associated with construction activities eg earthworks, vegetation clearing and track construction
-impacts on overlying and adjacent creeks and water resources within risk management zone associated with subsidence
-impact of the proposed on-site domestic (sewage) wasterwater management and associated effluent disposal area
-pre-development and post development run off volumes and pollutant loads from the site
-details of the measures to manage site water associated with processing coal and coal reject, general stormwater runoff and any human activities likely to affect water quality at the site, and how neutral or beneficial effect on water quality (NorBE) principles will be assessed and applied
-assessment of the impacts of the development on receiving water quality and volume, both surface and groundwater including from the filling of pine feather voids and associated impact on interaction and baseflows of surface waters
-details of the structural stability, integrity, ongoing maintenance and monitoring of all site water management measures including dams over the life of the project
-details of proposed monitoring of groundwater levels, surface water flows, groundwater and surface water quality, along with information as to how the proposed monitoring will be used to monitor, and, if necessary, mitigate impacts on surface water and groundwater resources
-the principles outlined in the 'Managing Urban Stormwater - Soils and Construction - Mines and Quarries' Manual prepared by the Department of Environment and Climate Change (2008)

2.3.1 Water demand and supply

During construction, the project's water needs will be sourced via licensed groundwater bores, located on land owned by Hume Coal. Potable water will also be sourced from water supply bores and/or trucked to site and stored in tanks, both at construction sites and the accommodation village.

During operation the project will require water for a range of uses including:

- coal preparation plant (CPP) process water;
- co-disposed reject make-up water;
- product coal handling water;
- ROM stockpile water;
- underground operations water;
- administration and workshop area water; and
- accommodation village consumption and cleaning.

The water volumes for the various demands over the mine's 19-year life are presented in Figure 2.6. These volumes were inputs to the water balance model, which is discussed further in Section 8.2.

Potable water will continue to be sourced from bores and/or trucked to site and stored in tanks during mine operation. Water for use in amenities (non-potable) will be sourced from bores. This volume is negligible and, so is not included in the water balance model or shown in Figure 2.6.

Figure 2.6 Project water demands

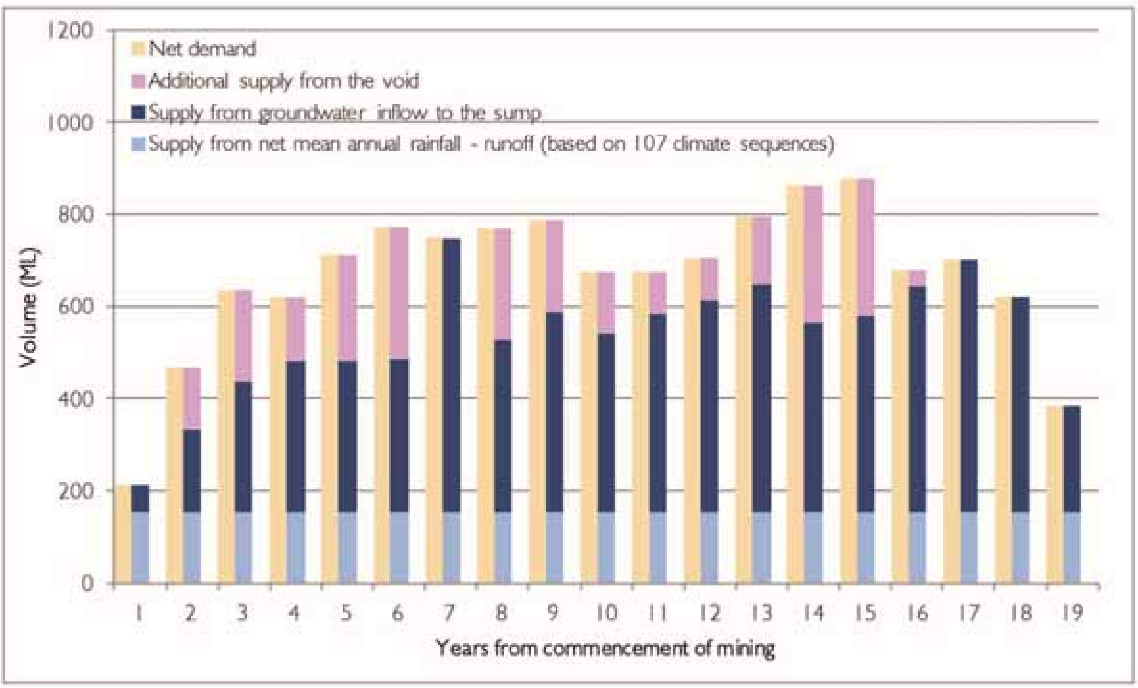
As discussed in Section 8.2, the water balance model (WSP PB 2016a) was run for 107 sets of climatic sequences for the duration of 19 years of mining. The water balance model estimates surpluses and deficits in meeting total annual project demands from available water supplies and it shows that project demands will be fully met by using:

- rainfall-runoff from the mine water dams;
- groundwater collected in the underground mine sump (where groundwater inflow to underground workings will be captured); and
- additional groundwater abstracted from behind the sealed mine void bulkheads as required.

Figure 2.7 show the relationship between project water demand and water supply sources used to meet these demands. The primary water supply sources will be captured rainfall-runoff, and groundwater inflow to the sump. In some years additional demands will be met by abstracting water from sealed mine voids.

Excess supply of water will be managed by injection to the void behind the bulkheads. If the void space is full and cannot take excess water, and the primary water dam (PWD) volume is also above the adopted capacity then the excess water will be treated in a water treatment plant (WTP) for release into Oldbury Creek, if required. The WTP is included in the project infrastructure as a provisional item only. In all climate sequences modelled, the water balance model indicates that the PWD has adequate capacity to store excess supply and that treatment and release will not be required.

Rainfall-runoff from two areas on the surface infrastructure not in direct contact with coal will be discharged directly into Oldbury Creek following confirmation that first-flush and water quality parameters have been met (refer to Section 2.3.2iii).



(based on mean annual climate sequence from 107 climate sequences)

Figure 2.7 Project water demands and supply volumes

2.3.2 Mine infrastructure and water management

AR 33: Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water, (pumps, dams, diversions, etc)

AR 34: Details on all bores and excavations for the purpose of investigation, extraction, dewatering, testing and monitoring. All predicted groundwater take must be accounted for through adequate licensing

AR 35: Details on existing dams/storages (including the date of construction, location, purpose, size and capacity) and any proposal to change the purpose of existing dams/storages.

AR 36: Details on the location, purpose, size and capacity of any new proposed dams/storages

The mine infrastructure will consist of the following:

- mine access, ventilation systems, and shaft(s);
- the administration and workshop area, including: administration, bathhouse, wash-down, workshop, fuel depot and lubricant storage facilities, warehouses, laydown areas, an explosives magazine, and other facilities;
- surface and groundwater management and treatment facilities including: dams, drains, sumps, pipelines, pumps and associated infrastructure;
- coal preparation plant and stockpiles including: coal product stockpile areas, conveyors, transfer points, a tertiary sizing station, enclosed screening station, coal washing facilities and a reject co-disposal reject plant;
- overland conveyors;
- train load-out facilities;
- ancillary facilities including: fences, access roads, car parking areas, a helipad, and communications and electricity reticulation infrastructure; and
- environmental management and monitoring equipment.

The surface facilities will be within the Medway Rivulet and Oldbury Creek catchment areas, which form part of the Medway Rivulet Management Zone within the Upstream Warragamba and Upper Nepean Regulated River Water Source. Rainfall within the infrastructure area will enter the mine water management system via a series of stormwater basins (SBs) or mine water dams (MWDs). Surface water and rainfall outside of the mine infrastructure area will be diverted back into the natural catchment areas.

The surface infrastructure area and underground mine workings are within Zone 1 of the Sydney Basin, Nepean Groundwater Source. Water intercepted in active mining areas will be pumped into the mine sump and enter the mine water management system. Water that flows or is pumped into the sealed mine void will remain an accessible part of the water source available for access from the surface by other users. Some of the void water may be harvested to supplement water supplies during times of deficit.

The water management infrastructure is shown in Figure 1.6.

i Water management system

The water management system for the project is detailed in the Hume Coal Project Water Balance Assessment Report (WSP PB 2016a). The water management system is based on the infrastructure layout plan and flowchart by prepared Arkhill Engineers (included in Appendix D (WSP PB 2016a)). The water management system will be implemented during operation to prevent contamination of local waterways, and will aim to use mine water as a priority to meet all demands (with the exception of potable water) over imported water. If the water demand cannot be fully met from the harvested rainfall-runoff and the groundwater collected from the mine sump, the water supply will be supplemented by harvested water from the sealed voids. Surface water runoff from areas of the site in direct contact with coal will be fully contained within the mine water management system to prevent discharge to local waterways. The water management objectives are to reuse water on site and minimise the release to more sensitive environmental areas.

The site water management involves:

- Runoff from undisturbed areas being diverted around or away from the infrastructure into natural watercourses via clean water diversion drains.

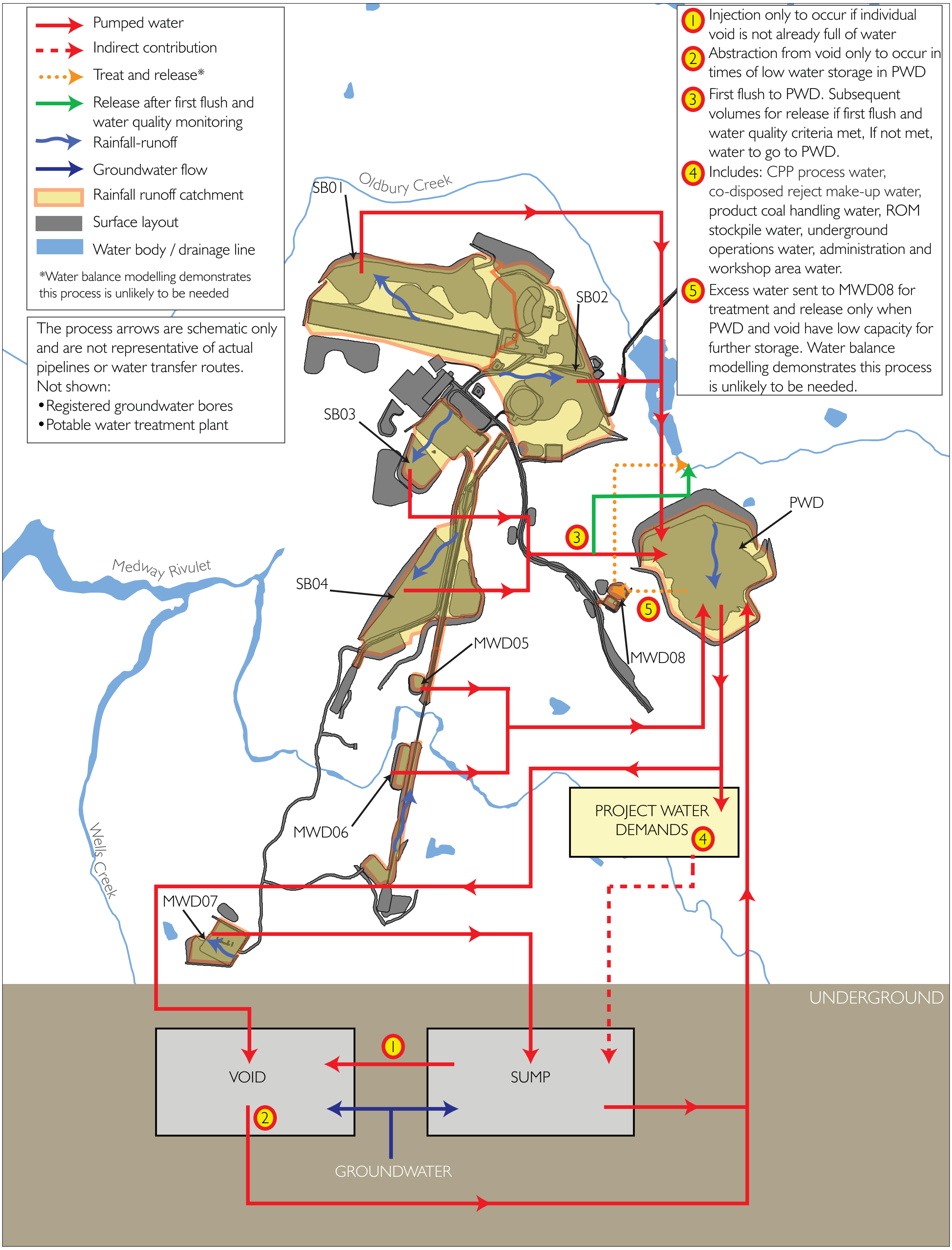
- Runoff from disturbed areas within the mine infrastructure footprint being directed to the SBs, MWDs and the PWD for storage and reuse.

- Runoff from areas where there is a low risk of coal contact (ie runoff from areas that do not contain coal stockpiles or the processing plant but that could contain small amounts of coal due to mine vehicle traffic) may be discharged to local creeks after collection of the first flush has been diverted into storage and reuse dams, and monitoring shows that post-first flush runoff is of an acceptable quality to discharge.

- Runoff from areas where there is a low risk of coal contact and that does not meet the adopted first flush criteria being transferred to the PWD for storage.

- Sewage from the administration and workshop area being treated and reused on site during operation. Grey water will be subject to primary treatment and reused. Black water will be subject to tertiary treatment and reused in the CPP.

Site water management is summarised schematically in Figure 2.8 and discussed in detail in the following sections.



Water management schematic

Hume Coal Project

Water Assessment

Figure 2.8

ii Dam and basin functions and water storage controls

There are no existing dams outside of the surface disturbance area that will be used as part of the project. There are about four minor agricultural dams within the surface disturbance area that will need to be removed and filled or otherwise incorporated in the earthworks design. A road that traverses an instream storage within Oldbury Creek will be widened to accommodate surface infrastructure; however, the instream storage's purpose will not be modified. Proposed water storage infrastructure for the project is discussed below.

The PWD will contain the runoff from coal contact areas, such as the CPP, ROM and product stockpiles. This dam will be maintained at adequate volume to provide enough storage for runoff collected at the MWDs during and after rainfall events. The dam will also supply water for all project water demands other than potable water, which will be sourced externally from licensed groundwater bores.

SB01 will collect runoff from the product stockpile and the temporary reject areas. Water collected in this basin will be transferred to the PWD for storage and reuse.

SB02 will collect runoff from the ROM stockpile and return water from the coal handling plant. Water collected in this basin will be transferred to the PWD for storage and reuse.

SB03 will collect runoff from the administration and workshop area. Water collected in this basin will not come into direct contact with coal or reject stockpiles. Water will be transferred to the PWD if the corresponding rainfall does not meet the first flush criteria. When the rainfall meets the first flush rainfall and water quality criteria, then water will be released to Oldbury Creek. This will minimise any reduction in flows that occurs due to runoff harvesting for the project water management.

SB04 will collect runoff from the mine road and conveyor corridor area north of Medway Rivulet. Water will be transferred to the PWD if the corresponding rainfall does not meet the first flush criteria. When the rainfall meets the first flush rainfall and water quality criteria, then water will be released to Oldbury Creek. This will minimise any reduction in flows that may occur due to runoff harvesting for the project water management.

MWD05 will collect runoff from the overland conveyor number 1 corridor, which will then be transferred to the PWD for storage and reuse. Technically, water from this dam could be handled in the same manner as water from SB03 and SB04; however, the catchment area is small and it is simpler to transfer it directly to the PWD.

MWD06 will collect runoff from the area in between the conveyor portal and the overland conveyor number 1 corridor, which will then be transferred to the PWD for storage and reuse. Technically water from this dam could be handled in the same manner as water from SB03 and SB04; however, the catchment area is small and it will be simpler to transfer it directly to the PWD.

MWD07 will collect runoff from the ventilation shaft pad area, which is then transferred to the underground mine sump via a borehole or pipe in the ventilation shaft for reuse or injection into the void. This avoids the need for an overland pipeline from this location.

MWD08 is designed to operate with a water treatment plant (WTP) near the PWD before water is released to Oldbury Creek. This dam, along with the WTP, is included as provisional infrastructure in the unlikely event that excess water stored in the PWD may need to be treated and released to Oldbury Creek. The water balance modelling indicates that this is not required for all climate sequences tested. This dam is not included in the water balance model as it is part of the provisional WTP and independent of the mine water balance, which covers transfer of water between the SBs, other MWDs, the underground mine, and the PWD. The capacity of this dam and the WTP would be determined during the detailed design stage of the project, if required.

The underground mine sump (sump) is the primary collection point for excess water in the underground mine. The sump will receive most inflows of groundwater originating from Zone 1 of the Sydney Basin Nepean Water Source. The sump will also receive water transferred from MWD07 and excess water from underground mining equipment operations, such as sprays.

Once a panel has been mined and the bulkhead is installed, the sealed void will receive excess water from the sump and the PWD. Water stored within a void behind a bulkhead will then begin receiving groundwater, allowing the system to recover more rapidly than it otherwise would. It will also provide a source of water that can be accessed to supply to the PWD if needed during particularly dry years.

Sediment dams will be constructed during the construction phase of the project. They will release water to the local catchment once the sediments are settled. When mining starts, these dams will not be part of the water management system and so have not been included in the water balance modelling.

Above-ground tanks will be used to store smaller volumes of water around the surface infrastructure area.

iii First flush criteria for SB03 and SB04

As discussed in Section 3.5.19, the following first flush criteria were developed for the project based on the applicable EPA guideline (NSW EPA 2013):

- The first flush is assumed to have occurred once the rainfall exceeds 20 mm in any 24-hour period. On such days, runoff could be released from SB03 and SB04 to Oldbury Creek, if water quality criteria are also met.

- Testing for total dissolved solids (TDS) and pH will be used to determine whether water quality is acceptable to be released. Results will be compared to trigger thresholds developed from baseline monitoring data.

- The first flush collected in SB03 and SB04 will be pumped to the PWD and contained within the mine water management system to prevent pollution of local streams. Only once the first flush collected in SB03 and SB04 has been pumped to the PWD will water from these two basins be released to Oldbury Creek provided water quality criteria are met.

- From the day of occurrence of the first flush, subsequent daily rainfall amounts less than 20 mm for the next four days are assumed to produce clean runoff and releases will be allowed to continue to Oldbury Creek.

- If daily rainfall remains less than 10 mm after the fifth day, no runoff will be released to Oldbury Creek until the next first flush event. If daily rainfall depth is above 10 mm, releases will continue until rainfall drops below 10 mm per day.

In the event that water quality in SB03 or SB04 does not meet the water quality criteria, water will not be released to Oldbury Creek and will be contained within the water management system. The water balance model (refer to Section 8.2) has demonstrated that the PWD has the capacity to store all runoff from SB03 and SB04 for all climate sequences, if required.

iv Dam and basin capacities

All SBs, MWDs and the PWD will have the capacity to accommodate at least the 200 year Annual Recurrence Interval (ARI) 72 hour storm runoff volume, with the exception of MWD07 which will have the capacity to store between the 100 and 200 year ARI 72-hour storm runoff volumes. Proposed capacities and catchment areas are listed in Table 2.2.

The capacities of these dams were based on physical constraints and the requirement that no dam overflows would occur when the dams are operated as part of the overall site water management system under historical climate conditions, including wet and dry sequences.

The capacity of the PWD has been sized to hold all water on site without the need to dispose of excess water in local waterways. The adopted dam capacity of 730 ML is significantly larger than the volume required to meet a 500 year ARI event and was assessed by the water balance modelling under historical climate conditions as able to prevent discharges for all 107 climate sequences (refer to Section 8.2).

The stage-storage-area relationships for the proposed basins and dams are based on the three-dimensional dam/basin designs (WSP PB 2016a).

The water balance modelling confirmed that the basins or dams will not spill with the adopted capacities for any of the wettest periods in the climate sequences.

Sediment dams for use during construction will be managed to achieve a neutral or beneficial effect (NorBE) on the receiving environment (WSP PB 2016b), and constructed according to the recommended criteria in the *Managing Urban Stormwater – Soils and Construction – Volume 2E Mines and Quarries* guidelines (DECC 2008) as a minimum. The sediment dams will include a ‘settling zone’ for temporary treatment storage and a ‘sediment zone’ to store sediment. The guidelines recommend that the ‘settling zone’ be sized to capture the 95th percentile 5-day duration storm event, and the ‘sediment zone’ be sized at 50% of the ‘settling zone’ volume. This sizing is based on a sensitive receiving environment and site disturbance duration of more than three years and would result in an average sediment dam overflow frequency of one to two overflows per year.

Table 2.2 Proposed basin and dam capacity summary

ID	Description	Catchment area (ha)	Proposed capacity (ML)
SB01	Proposed stormwater basin capturing runoff from product stockpile area	26.36	106.4
SB02	Proposed stormwater basin capturing runoff from CPP and ROM areas	22.64	91.1
SB03	Proposed stormwater basin capturing runoff from administration and workshop area	5.91	19.4
SB04	Proposed stormwater basin capturing runoff from mine road and conveyor embankment	14.73	140.2
MWD05	Proposed mine water dam capturing runoff from north of Medway Rivulet – overland conveyor no. 1	0.64	5.9
MWD06	Proposed mine water dam capturing runoff from south of Medway Rivulet – conveyor portal	2.69	14.8

Table 2.2 Proposed basin and dam capacity summary

ID	Description	Catchment area (ha)	Proposed capacity (ML)
MWD07	Proposed mine water dam capturing runoff from ventilation shaft pad dam	2.60	5.7
MWD08	Proposed mine water dam capturing runoff from water treatment area, if required	0.27	4.1
PWD	Proposed primary water dam storing mine water pumped from stormwater basins, mine water dams and underground mine sump dewatering	18.28	730.0

v Water pipelines

Water will be moved around the project area via pipelines, and possibly by water trucks most likely during construction. Exact locations of pipelines and construction details will be determined during detailed project design.

vi Water treatment

The water management system will include the following treatment systems:

- potable water treatment plant – to treat water from onsite groundwater bores;
- sewage treatment plant at the surface facilities;
- an oil and water separator to remove hydrocarbons from water from workshop and wash down bay areas;
- primary greywater treatment to remove solids before the treated water is used to irrigate landscaped areas or those being rehabilitated; and
- provisional water treatment plant at MWD08 if required – for treating excess water that may be discharged to Oldbury Creek, unlikely to be required based on water balance model results.

2.3.3 Wastewater management and release

The water management system has been designed to efficiently manage water and minimise impacts. Water management is staged, with different options being used depending on the volume of water required to be managed.

In the first instance, most water will be used on site for coal processing and infrastructure requirements. Any excess of water will then be pumped underground and into the sealed mine panels that have not been completely filled. This is an important mitigation strategy that will decrease the volume of groundwater inflow to mined workings and help recover groundwater levels generally.

The operational water management and balance during mining involves minor recycling and reuse of water on site. The concentration/accumulation of contaminants within the project water supply in the PWD as a result of this will be negligible due to the very low volume re-entering the system and dilution from rainfall and groundwater inflow (both of which are fresh).

SB03 and SB04 will collect runoff not in direct contact with coal. During and immediately following high rainfall events, these basins will release water into Oldbury Creek, following the direction of the first flush into the PWD and provided that water quality criteria are met (discussed in 2.3.2iii). Runoff from catchments in direct contact with coal and/or coal reject will not be released to creeks but will be pumped to the PWD for eventual reuse or storage.

Based on an estimated 20 L/day of sewage effluent (blackwater) per person, the construction accommodation village and office facilities were estimated to generate about 3 ML a year of blackwater. The blackwater will be trucked off-site to a licensed treatment facility using a licensed contractor until such time as the operational sewage treatment plant is commissioned. If the plant is commissioned before the treated effluent can be used on-site as process water, the treated effluent will be used for dust suppression on roads and earthworks or continued to be trucked off-site to a licensed treatment facility. During operation, water from the sewage treatment plant will undergo tertiary treatment and will then be used in the CPP. Grey water during both construction and operation will undergo primary treatment and then be reused on site.

The coal preparation plant will use the same chemicals that are typically used in all other coal mines. Reject from the preparation plant will be placed underground in the void space. This method of reject storage is consistent with the method used by other coal mines that backfill voids with tailings. Additional details regarding groundwater quality associated with reject emplacement are provided in Section 11.2.2.

Section 6.5 of the *Hume Coal Project EIS* (EMM 2017a) discusses alternative options considered for water management. Alternative options for water management that were considered are:

- managed aquifer recharge (MAR) into specifically designed bores to recharge directly into the Hawkesbury Sandstone; and
- water treatment and use (for example, for irrigation).

Chapter 13 of this report discusses the respective merits of the alternative options.

3 Regulatory and policy context and assessment

This chapter summarises relevant Commonwealth and NSW water legislation and supporting policies and guidelines.

AR 19: Consideration of relevant policies and guidelines

AR 23: The EIS should take into account the objects and regulatory requirements of the Water Act 1912 (WA 1912) and Water Management Act 2000 (WMA 2000), and associated regulations and instruments, as applicable

AR 25: Demonstrate how the proposal is consistent with the relevant rules of the Water Sharing Plan including rules for access licences, distance restrictions for water supply works and rules for the management of local impacts in respect of surface water and groundwater sources, ecosystem protection (including groundwater dependent ecosystems), water quality and surface-groundwater connectivity.

AR 27: Provide an analysis of the proposed water supply arrangements against the rules for access licences and other applicable requirements of any relevant WSP, including:

- *Sufficient market depth to acquire the necessary entitlements for each water source*
- *Ability to carry out a "dealing" to transfer the water to relevant location under the rules of the WSP*
- *Daily and long-term access rules*
- *Account management and carryover provisions*

AR 29: The EIS should take into account the following policies (as applicable):
· NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012)
· NSW Aquifer Interference Policy (NOW, 2012)
· Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012)
· Australian Groundwater Modelling Guidelines (NWC, 2012)
· Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals (IESC, 2014)
· Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources (Australian Govt. 2014)
· NSW State Rivers and Estuary Policy (1993)
· NSW Wetlands Policy (2010)
· NSW State Groundwater Policy Framework Document (1997)
· NSW State Groundwater Quality Protection Policy (1998)
· NSW State Groundwater Dependent Ecosystems Policy (2002)
· NSW Water Extraction Monitoring Policy (2007)
· Groundwater Monitoring and Modelling Plans - Information for prospective mining and petroleum exploration activities (NOW, 2014)
· NSW Code of Practice for Coal Seam Gas Well Integrity (DTIRIS 2012)
· NSW Code of Practice for Coal Seam Gas Fracture Stimulation (DTIRIS 2012)

The primary water related statutes that apply to the project are the *NSW Water Management Act 2000* (WMA 2000), *Water Act 1912 (*WA 1912*), Protection of the Environment Operations Act 1997* (POEO Act), and the *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (*EPBC Act), and their attendant regulations (including water sharing plans under the WMA 2000).

The requirements of the applicable legislation and policies and a summary of assessments of the project against key policy requirements are given in the following sections. Most critical is the NSW Aquifer Interference Policy (NOW 2012a). As such, discussion of this is included below in the context of the WMA 2000. Note also that a checklist of compliance against the Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals (IESC 2014) is given in Appendix B.

3.1 Water Act 1912

The WA 1912 is gradually being repealed and replaced by the WMA 2000 as water sharing plans (WSPs) are developed for water sources across NSW, and as new regulations are made. However, some aspects of the WA 1912 are still operational across all of NSW, such as licences for monitoring bores. Monitoring bores will continue to be licensed under the WA 1912 until the aquifer interference regulation commences and provides a mechanism to approve of these activities.

3.2 Water Management Act 2000

The WMA 2000 is based on the principles of ecologically sustainable development and the need to share and manage water resources for future generations. The WMA 2000 recognises that water management decisions must consider: economic, environmental, social, cultural and heritage factors. In addition, the WMA 2000 recognises that sustainable and efficient use of water delivers economic and social benefits to the state of NSW.

The WMA 2000 provides for water sharing between different water users, including environmental, basic rights or existing water access licence (WAL) holders and provides security for licence holders.

The licensing provisions of the WMA 2000 apply to those areas where a WSP has commenced; it has progressively been enacted across NSW since July 2004. The licensing provisions of the WMA 2000 become effective for any water source once a WSP for that water source commences.

One of the key components of the WMA 2000 is the separation of the water licence from the land; this facilitates opportunities for licence holders to trade water. The WMA 2000 outlines the requirements for taking and trading water through water access licences (WALs), water supply works, and water use approvals.

The WMA 2000 is the primary legislation governing water management and licensing within the project area. The licensing requirements for mining are similar to other licensing requirements, but there are some additional policies and clauses related to mining that need consideration, in particular the NSW Aquifer Interference Policy (AIP) (NOW 2012a), and Section 60I of the WMA 2000.

3.2.1 Water sharing plans

AR 24: Describe the ground and surface water sharing plans, water sources, and management zones that apply to the project. Multiple water sharing plans may apply and these must all be described.

AR 40: Identification of all surface water sources as described by the relevant water sharing plan.

WSPs are statutory documents that apply to one or more water source areas. They contain the rules for sharing and managing the water resources within water source areas. The WSPs also set the water management vision and objectives, management rules for WALs, what water is available within the various water sources, and procedures for dealing in licences and water allocations, water supply works approvals and the extraction of water. WSPs are designed to establish sustainable use and management of water resources. Each WSP is in place for 10 years.

WSPs describe the basis for water sharing, and document the water available and how it is shared between environmental, extractive, and other uses. The WSPs then outline the water available for extractive uses within different categories, such as: local water utilities, domestic and stock, basic rights, and access licences.

Two WSPs are applicable for the project area and surrounds. These WSPs cover numerous water sources, which are then subdivided into management zones, as described below.

<u>Surface water</u>

Water Sharing Plan for the Greater Metropolitan Region, Unregulated River Water Sources 2011 (Metropolitan surface water WSP):

- Upper Nepean and Upstream Warragamba Water Source:
  - Medway Rivulet Management Zone.
  - Lower Wollondilly River Management Zone.
  - Upper Wingecarribee River Management Zone.
  - Lower Wingecarribee River Management Zone.
  - Nattai River Management Zone.
- Shoalhaven River Water Source:
  - Bundanoon Creek Management Zone.

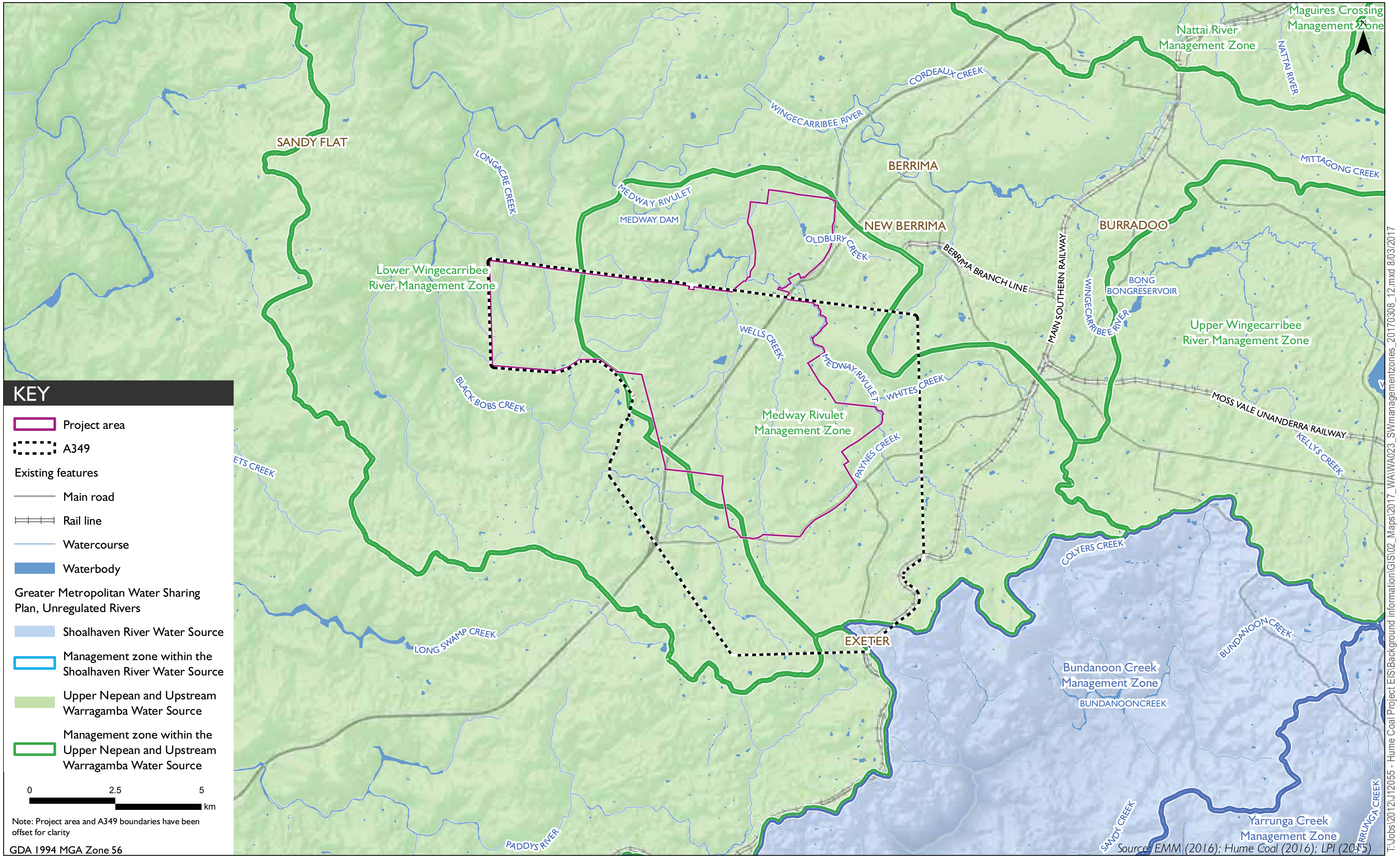
<u>Groundwater</u>

Water Sharing Plan for the Greater Metropolitan Region, Groundwater Sources 2011 (Metropolitan groundwater WSP):

- Sydney Basin Nepean Groundwater Source:
  - Nepean Management Zone 1.
  - Nepean Management Zone 2.
- Sydney Basin South Groundwater Source.

The WSP, water source, and management zone boundaries are shown in Figure 3.1 and Figure 3.2.

The project area is physically within and overlying the Upstream Nepean and Upstream Warragamba Water Source – Medway Rivulet and Lower Wingecarribee River Management Zones, and the Sydney Basin Nepean Zone 1 Groundwater Source. The project's effects regarding water sharing and licensing requirements are discussed in Chapter 12.



Surface water management zones

Hume Coal Project
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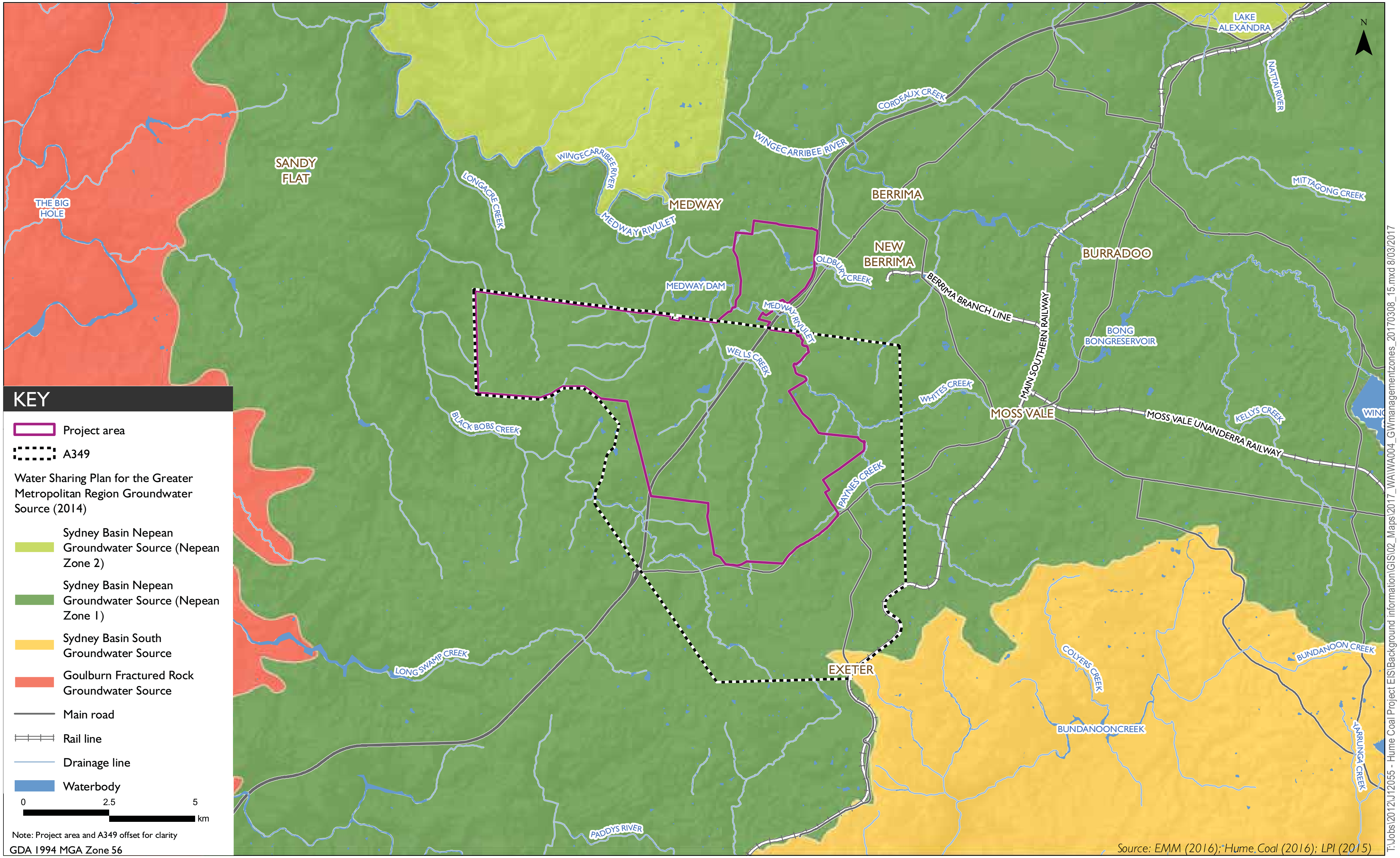
Figure 3.1



Groundwater management zones

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Figure 3.2

i Environmental water

Planned environmental water is water prescribed under the rules of a water sharing plan to protect the aquifer and GDEs (for groundwater) or the river and streams systems and associated ecosystems (surface water).

For groundwater, environmental water typically is defined as 100% of the storage volume within the aquifers as well as a proportion of the annual recharge volume. The environmental water volume set aside in the Metropolitan groundwater WSP for the Sydney Basin Nepean Groundwater Source is estimated to be 63,224,915 ML/yr; which is 100% of the storage (estimated at 63,100,000 ML) and approximately 56% (124,915 ML/yr) of the annual recharge (224,483 ML/yr). The volume that is able to be made available for extraction is called the long term average annual extraction limit (LTAAEL) and is equal to 99,568 ML/yr, or 0.16% of the total volume of water in that system (ie storage and annual recharge). The maximum annual volume of water that the project proposes to intercept from the Sydney Basin Nepean Source is 2,235 ML/yr, which is 2% of the LTAAEL and 0.004% of the total volume in the system. Figure 3.3 represents the environmental water, recharge, and LTAAEL components for the Sydney Basin Nepean Groundwater Source.

The environmental water provisions in the Metropolitan surface water WSP have complex environmental flow rules and daily release volume stipulations from various dams.

ii Water availability and licences

The groundwater presence, availability and licences for the Sydney Basin Nepean Groundwater Source and for the Sydney Basin South Groundwater Source are shown in Figure 3.3 and Figure 3.4, respectively. The information used to create these diagrams was sourced from the Metropolitan groundwater WSP, the background document to the WSP (NOW 2011c), and from a recent search of the NSW Water Register (DPI Water 2016a).

The surface water available for extractive uses within water sources and management zones of relevance to the project is shown in Table 3.1 and Figure 3.5 respectively. The dominant users of water in the Metropolitan surface water WSP are major water utilities and local water utilities, such as WaterNSW. For the Upper Nepean and Upstream Warragamba water source, the total volume of water utility licence is 653,539 ML/yr, which compares to a total of 15,540 ML/yr of the tradeable unregulated river licences available. Similarly, in the Shoalhaven River Water Source, the total volume of water utility licence is 27,275 ML/yr, which compares to a total of 6,143 ML/yr of the tradeable unregulated river licences available.

iii Other plan rules

The WSPs also establish the rules for granting licences, managing of water allocations and accounting for water, trading entitlements and water allocations, and in the case of groundwater, rules for managing the effects of water extraction between users, and between users and dependent environmental assets. In short:

- No new licences are currently being granted in the surface water sources or in the Sydney Basin Nepean Zone 1 Groundwater Source. Licences for groundwater can be granted by DPI Water and are granted by way of controlled allocation orders (under section 65 of the WMA 2000) in the adjacent groundwater sources of Sydney Basin South Groundwater Source, and Sydney Basin Nepean Zone 2 Groundwater Source (see Section 3.2.1.iv below).

- Trading entitlements and allocations between water sources and between management zones within water sources is prohibited in both groundwater and surface water WSP's.

- Significant carryover of unused allocation between water years is available for surface water licences. In the groundwater sources, carryover is limited to 10% of entitlement volume.

- Part 9 of the Metro Groundwater WSP outlines rules that apply to the location of water supply works (bores) and are predominantly distance conditions that apply to the location of bores in relation to property boundaries, other users, GDEs and streams.

The project will comply with the rules in both WSP's (details in Chapter 12). The project has secured the majority of the required licence volume from within the appropriate groundwater and surface water sources, and there is a clear pathway to secure remaining licence volume.

Dealings (trades) of groundwater licence volumes will be undertaken in accordance with the rules and principles in the WSP. In addition, the project would seek to participate in future controlled allocation orders as facilitated by DPI Water.

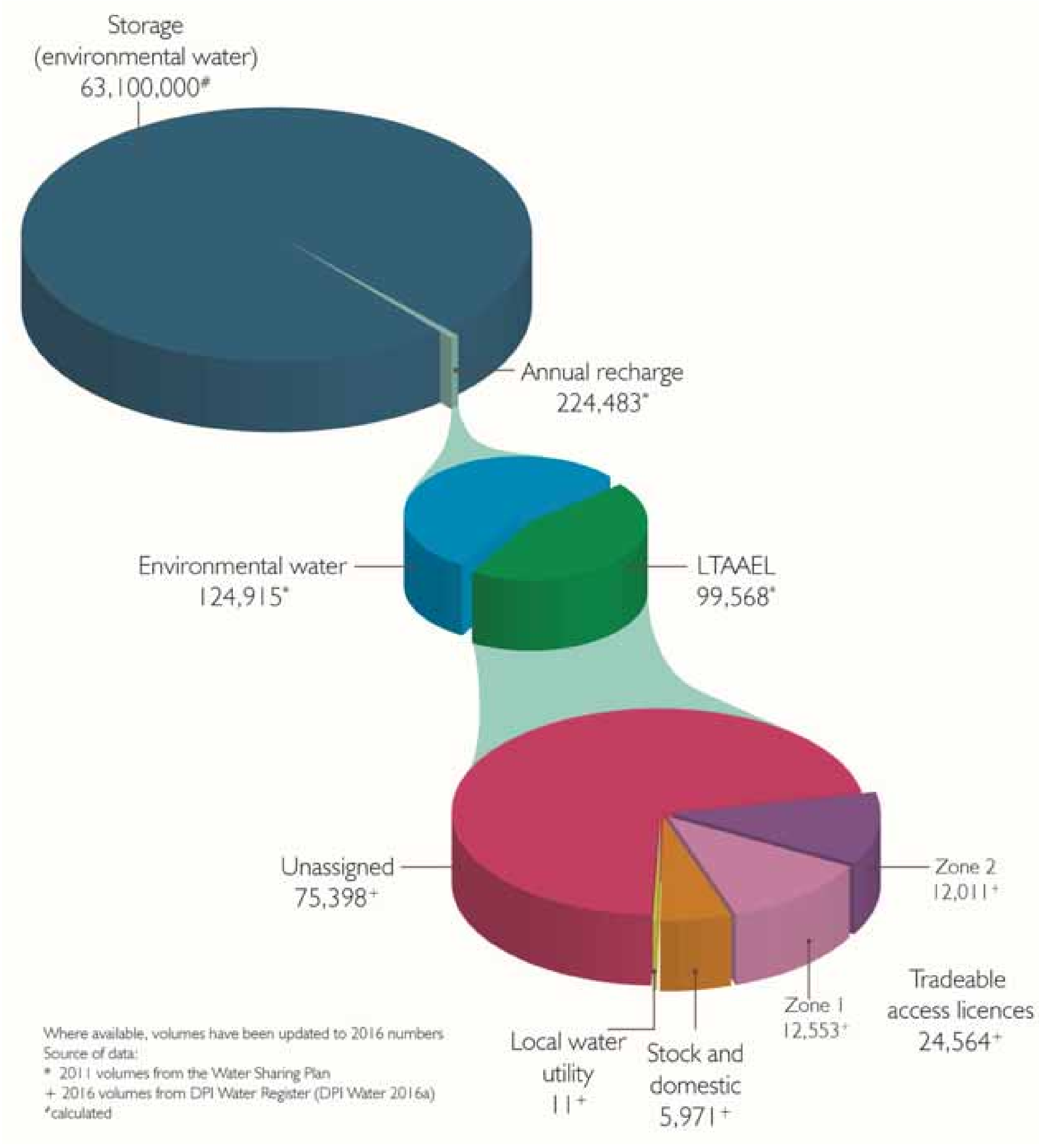

Figure 3.3 Sydney Basin Nepean Groundwater Source provisions (ML/yr)

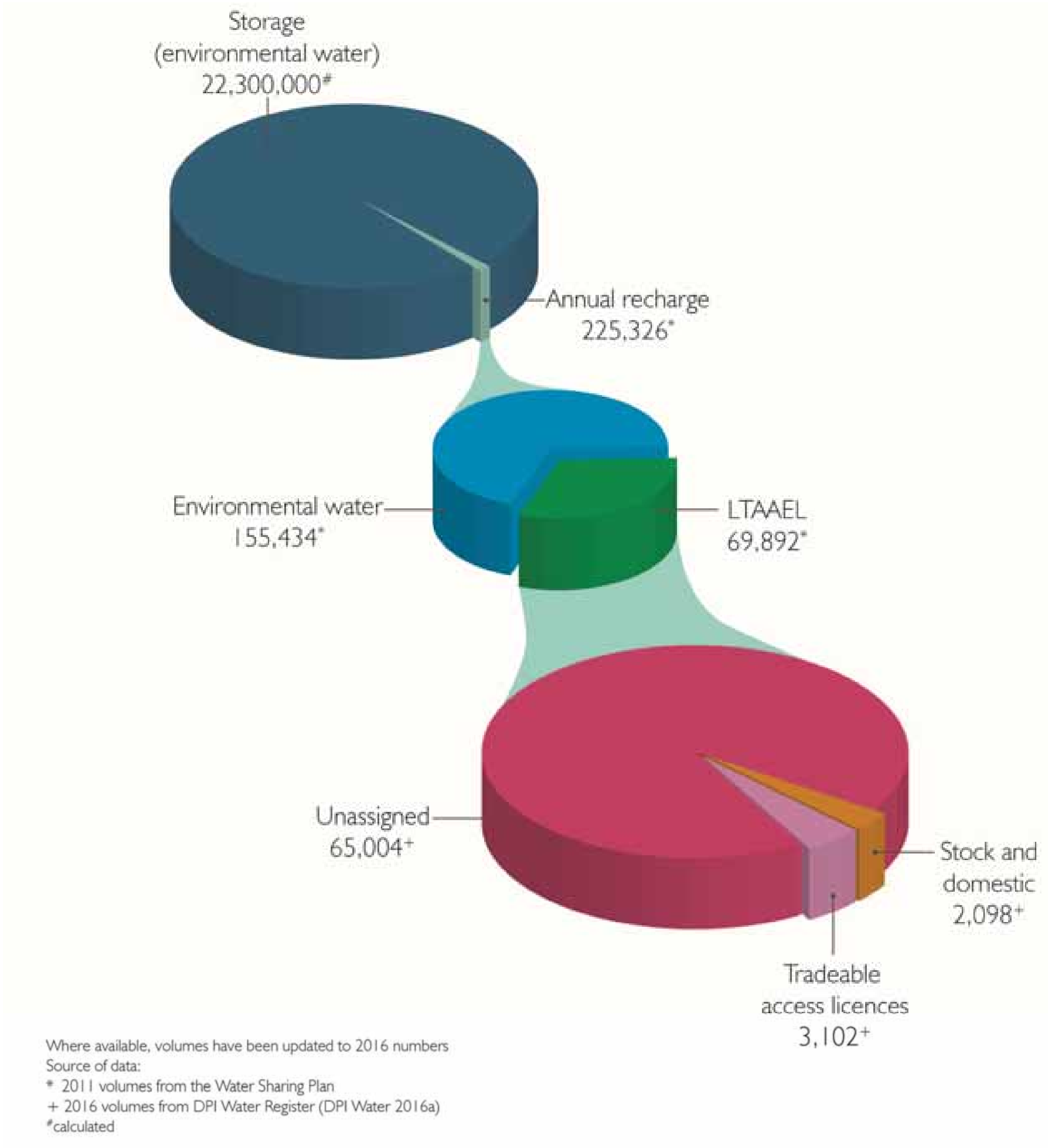

Figure 3.4 Sydney Basin South Groundwater Source provisions (ML/yr)

Table 3.1 Water rights in the WSP for the Greater Metropolitan Unregulated River Water Sources 2011 – Upper Nepean and Upstream Warragamba and Shoalhaven River

Surface water source	Unit	Upper Nepean and Upstream Warragamba	Shoalhaven River Source
Basic landholder rights			
Domestic and stock	ML/day	21	13.6
Native title	ML/yr	0	26.6 (ML/yr) in Kangaroo River
Harvestable rights		nd	nd
Water access licences			
Domestic and stock licences	ML/yr	440.7	243.4
Local water utility licences	ML/yr	8,539	27,031
Major utilities	ML/yr	645,000	329,000
Unregulated river access licences (tradeable)	Unit shares	15,540.20	10,976.80

Notes: nd - volume not defined based on an entire water source.

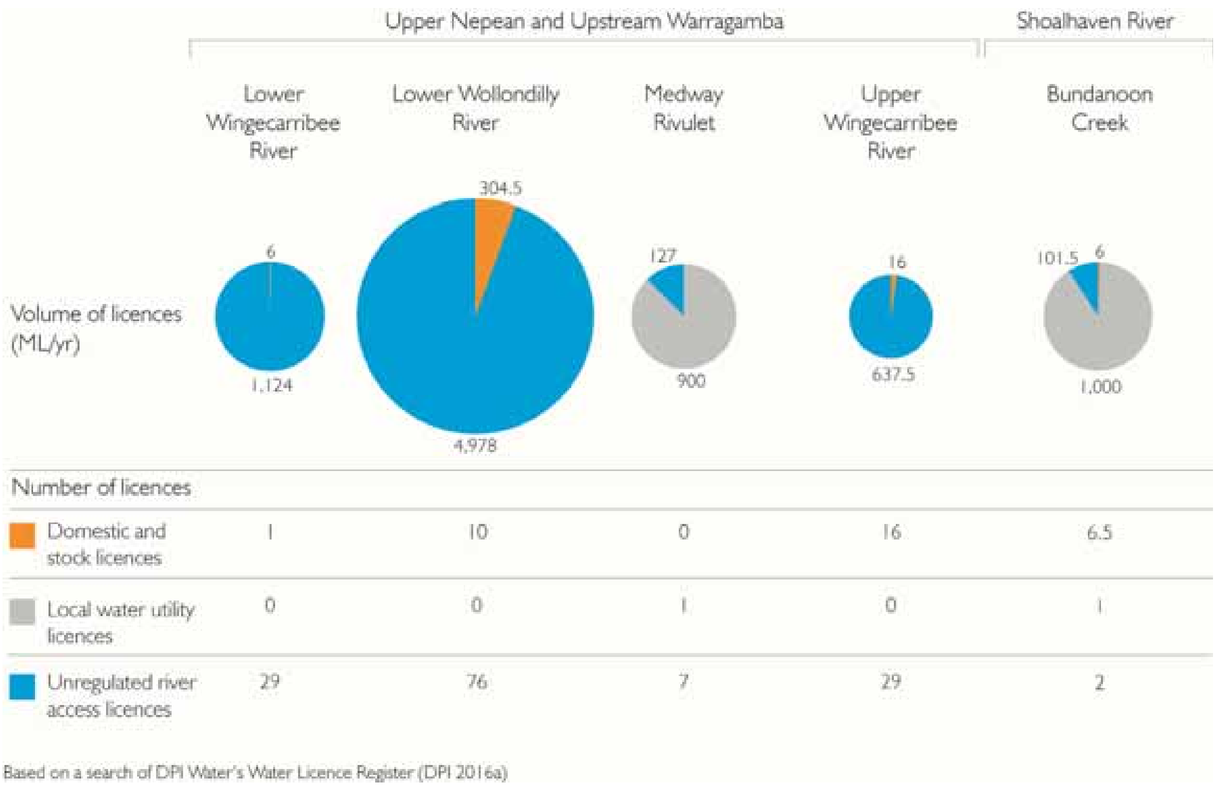

Figure 3.5 Number and volume of water access licences in relevant management zones

iv Controlled allocation

An access licence can be granted by the NSW Government where the right to apply for the licence has been acquired in accordance with a controlled allocation order made under Section 65 of the WMA 2000. Section 65 (1) provides that:

> The Minister may, by order published in the Gazette, declare that the right to apply for an access licence for a specified water management area or water source is to be acquired by auction, tender or other means specified in the order.

There have been two controlled allocation releases made within groundwater sources immediately next to the project area; details are provided in Table 3.2. A third was due to occur in late 2016, but at the time of writing this report no communication about the controlled allocation had been released.

Table 3.2 Controlled allocation release

Controlled allocation order	Water source	Units made available	Quantity of shares issued	Price paid per unit share ($)	Total price paid ($)
31 May 2013	Sydney Basin Nepean (Zone 2)	3,865	0	-	-
	Sydney Basin South	3,245	0	-	-
4 September 2014	Sydney Basin Nepean (Zone 2)	3,767	25	800	20,000
			6	900	5,400
			10	900	9,000
			10	910	9,100
	Sydney Basin South	3,061	15	820	12,300
			2,500	850	2,125,000
			300	850	255,000

3.2.2 NSW Aquifer Interference Policy

The dictionary to the WMA 2000 (under Section 91) defines an 'aquifer interference activity' as an activity involving any of the following:

- penetration of an aquifer;
- interference with water in an aquifer;
- obstruction of the flow of water in an aquifer;
- taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations; or
- disposal of water taken from an aquifer in the course of carrying our mining or any other activity prescribed in the regulations.

Section 91 (3) of the WMA 2000 relates to aquifer interference approvals. The requirement to obtain an aquifer interference approval under Section 91 is triggered only when a proclamation has been made under Section 88A that the particular type of approval is required. To date, no proclamation has been made specifying that an aquifer interference approval is required in any part of NSW.

In the meantime, the NSW Aquifer Interference Policy 2012 (the AIP) sets the policy with respect to aquifer interference. The policy explains the role and requirements of the Minister in determining applications for aquifer interference activities. There is a series of seven fact sheets relating to the AIP. Six of these factsheets are relevant to this assessment and have been considered with the policy itself. DPI Water's assessment framework for aquifer interference is included (and completed) in Appendix C. The AIP:

- clarifies the requirements for licensing water intercepted during aquifer interference activities (such as mining, quarrying, dewatering for construction); and
- defines and establishes 'minimal impacts' for water related assets (such as existing bores and groundwater dependent ecosystems.

The AIP specifically refers to 'take' that is 'required to allow for the effective and safe operation of an activity, for example dewatering to allow mining' (p.3), regardless of whether the take is required to be used. For mining projects in NSW, the take, use, and incidental interception of groundwater requires a licence. The AIP states that, unless specifically exempt, a WAL is required under the WMA 2000 where any act by a person carrying out an aquifer interference activity causes:

- the removal of water from a water source;
- the movement of water from one part of an aquifer to another part of an aquifer; and
- the movement of water from one water source to another water source, such as:
  - from an aquifer to an adjacent aquifer; or
  - from an aquifer to a river/lake; or
  - from a river/lake to an aquifer.

The AIP defines water sources as being either 'highly productive' or 'less productive' based on levels of salinity and average yields from bores; the mapped distribution of the highly productive and less productive groundwater sources in NSW are included in NOW (2012b). The AIP then further defines water sources by their lithological character, being one of: alluvium, coastal sand, porous rock, or fractured rock.

For each category of water source the AIP identifies thresholds for minimal impact considerations. These thresholds relate to impacts on the water table, water pressure and water quality, and are ranked as being either 'level 1 minimal impact' or 'level 2 exceeding minimal impact'. The definition of 'minimal impact' is given and the aspects applicable for the project have been reproduced in Table 3.3.

If an activity is assessed as being 'minimal impact' or the impacts are no more than the accuracy thresholds of the model, then it is defined as a 'minimal impact'. Where impacts are predicted to be 'greater than minimal impact', but additional studies show that impacts, although greater than 'minimal', do not prevent the long-term viability of the relevant water-dependent asset, then the impacts will be defined as 'acceptable'. Where impacts are predicted to be 'greater than minimal impact' and the long-term viability of the water-dependent asset is compromised, then the impact is subject to 'make good' provisions.

AIP Fact Sheet 4 (NOW 2013b) outlines how a minimal impact is to be considered. It describes how the minimal impact criteria are applied to both a water supply work and a groundwater dependent ecosystem (GDE) defined in a water sharing plan (Figure 3.6). This fact sheet also defines the term 'make good provisions' as the requirement to ensure that third parties have access to an equivalent supply of water through enhanced infrastructure or other means, for example deepening an existing bore, compensation for extra pumping costs or constructing a new pipeline or bore.

Table 3.3 Minimal impact criteria for 'highly productive' porous rock

Water table	Water pressure	Water quality
1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work. 2. If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work then make good provisions should apply.	1. A cumulative pressure head decline of not more than a 2 m decline, at any water supply work. 2. If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. 2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

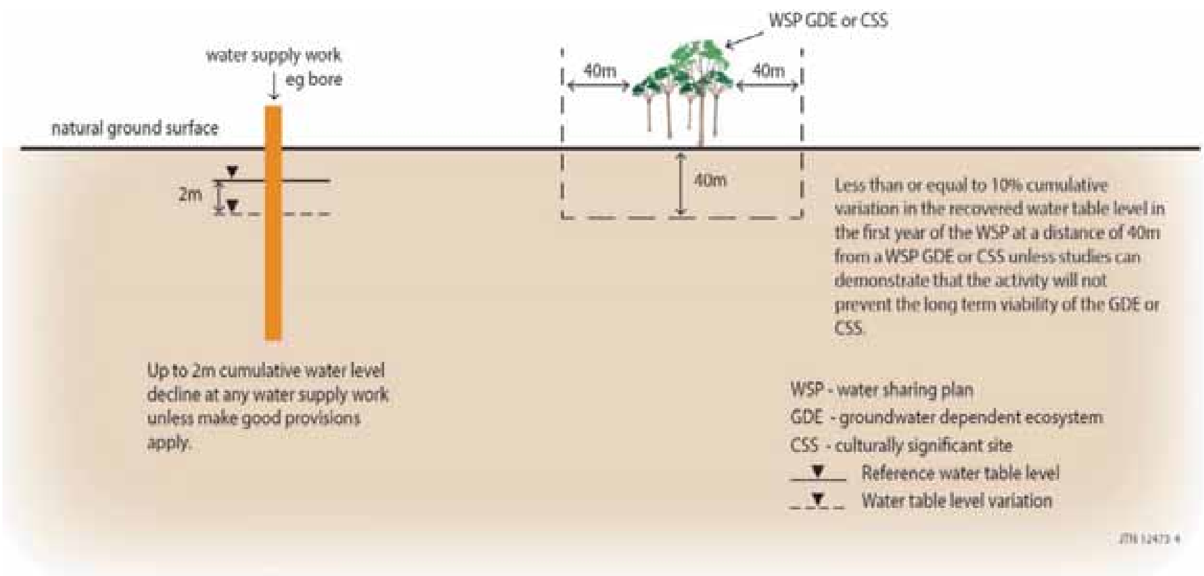

Figure 3.6 Porous or fractured rock groundwater source – minimal impact consideration

The AIP requires that two years of baseline groundwater data be collected and incorporated into an impact assessment before lodging a development application for an activity. The project has a monitoring network, developed in consultation with DPI Water (and former departments), that includes 54 conventional groundwater monitoring bores at 22 nested locations, 11 vibrating wire piezometer (VWP) sensors at three locations, three private landholder bores, 11 stream gauges, and 24 water quality monitoring sites. Groundwater monitoring began in 2011 and surface water monitoring began in 2012. Baseline data has been collected continuously for over five years across many monitoring locations within and surrounding the project area. The baseline monitoring program is discussed in Chapter 4.

An assessment of the project against the AIP can be found in Chapter 13 and Appendix O.

3.3 NSW Protection of the Environment Operations Act

The *Protection of the Environment Operations Act 1997* (PoEO Act) is the key piece of environment protection legislation administered by the NSW Environment Protection Authority (EPA). The Act enables the government to set protection of the environment policies that provide environmental standards, goals, protocols, and guidelines. The Act also establishes a licensing regime for pollution generating activities in NSW. Under section 48, an environment protection licence (EPL) is required for 'scheduled activities', which include coal mining. Accordingly, an EPL for the project will be sought by Hume Coal. The Act also includes a duty to notify relevant authorities of pollution incidents where material harm to the environment is caused or threatened.

3.4 Commonwealth Environment Protection and Biodiversity Conservation Act

The *Environment Protection and Biodiversity Conservation Act* (1999) (EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, which are defined as matters of national environmental significance. The EPBC Act was amended in June 2013 to make water resources a matter of national environmental significance, in relation to coal seam gas (CSG) and large coal mining developments (known as the 'water trigger').

The project was referred to the Commonwealth Department of the Environment for consideration under the 'water trigger' component of the EPBC Act. The water components of the referral document were prepared using an interim numerical groundwater model to estimate impacts. However, since that time, the mine plan and water management regime for the project have been modified, and the groundwater and surface water models have been updated to reflect the changes.

The project was declared to be a 'controlled action' by the Minister's delegate on 1 December 2015 in respect of its potential impact on water resources and listed threatened species. This means the project will require assessment and approval under the EPBC Act before it may proceed.

3.5 Relevant NSW policies and guidelines

Apart from the AIP, a number of other guidelines and policies are relevant to the water assessment. They are discussed in the following sections.

3.5.1 Guidelines for controlled activities on waterfront land

Under the WMA 2000, proponents are required to assess the impact of proposed controlled activities to find out whether no more than minimal harm will occur to waterfront land (DPI Water 2015a). Waterfront land includes the bed and bank of a river, lake or estuary, and all land within 40 m of the highest bank of the river, lake or estuary. If controlled activities are proposed within this corridor, then an approval must be obtained from DPI Water.

The project proposes to construct a conveyor and widen an existing roadway over Medway Rivulet. This activity is proposed on waterfront land and meets the criteria for requiring a controlled activity approval. However, as the project is a State Significant Development under section 89J (1) (g) of the EP&A Act 1979, (once development consent is granted) it will be exempt from requiring an approval to undertake work on waterfront land. Despite that, the assessment of these activities has been considered in accordance with the policies and guidelines in respect of waterfront land and riparian corridors.

Riparian corridors (RC) are the transition zone between land and a watercourse In July 2012, new rules commenced that provide more flexibility in how RCs can be used and assessed. For first, second, third and fourth order and greater watercourses, a vegetated riparian corridor (VRC) has been pre-determined and standardised within the greater RC. Proponents may undertake works within the outer 50% of a VRC, as long as the activity is offset by connecting an equivalent area to the RC within the development site.

The main focuses of these guidelines relate to impacts to water quality and sediment bank erosion and sediment load. These factors have all been assessed in the Surface Water Quality and Surface Water Flow and Geomorphology Assessments (Appendices E and F).

3.5.2 Risk assessment guidelines for groundwater dependent ecosystems

The risk assessment guidelines for groundwater dependent ecosystems (2012) (GDE Risk Assessment Guidelines) are the NSW requirements for assessment and management of groundwater dependent ecosystems (GDEs) under the WMA 2000. The dictionary to the Metro Groundwater WSP provides that:

> groundwater dependent ecosystems include ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.

The GDE Risk Assessment Guidelines provide that GDEs:

> explicitly include any ecosystem that uses groundwater at any time or for any duration in order to maintain its composition and condition.

An ecosystem's dependence on groundwater can be variable, ranging from partial and infrequent dependence, ie seasonal or episodic (facultative), to total continual dependence (entire/obligate) (Figure 3.7).

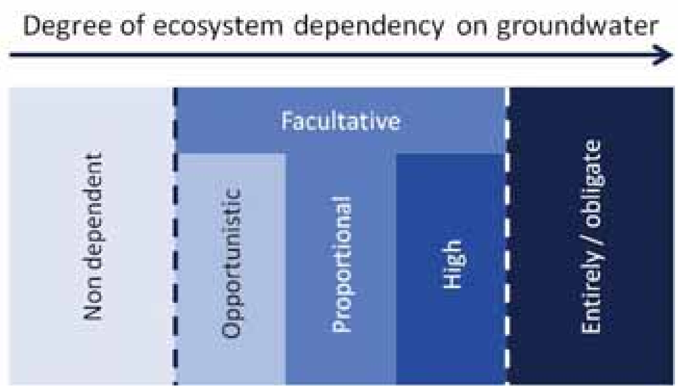

Figure 3.7 Groundwater dependent ecosystem level of dependence on groundwater

A GDE assessment was made for the project, which considered variations in available water and ecosystem types with assessment methods based on the GDE Risk Assessment guidelines. There are no High Priority GDEs listed within the project area. Long Swamp was the only High Priority GDE listed within the Metro Groundwater WSP within the groundwater model domain for the project, about 9 km south-west of the project area. Long Swamp has been studied, and monitored, in detail as part of the water assessment, and there are no impacts predicted to occur at Long Swamp as a result of the project. Long Swamp is discussed in more detail in Section 6.10.2.

3.5.3 State Rivers and Estuary Policy

The NSW State Rivers and Estuary Policy (1993) encourages sustainable management of the state's rivers, estuaries, and wetlands to halt or reduce:

- declining water quality;
- loss of riparian vegetation;
- damage to river banks and channels;
- declining natural productivity;
- loss of biological diversity; and
- declining natural flood mitigation.

The project has been assessed against this policy and component policies and each of the above listed objectives has been specifically considered. In summary, the surface water quality assessment (WSP PB 2016b) has concluded that:

- the project's water quality effects will be negligible;
- there will be no loss of riparian vegetation or damage to natural river banks and channels;
- surface water resources in the project area will not decline in their natural level of productivity;
- there will be no loss of biological diversity; and
- flooding effects will be negligible and a full flood study for the project has been conducted.

3.5.4 Wetlands Policy

The NSW Wetlands Policy (DECCW 2010) supersedes the 1996 NSW Wetlands Management Policy. The new policy adopts an improved approach to managing natural resources and aligns the management of wetlands to current legislation and challenges.

A wetland is defined as areas of land that are wet by surface and/or groundwater for a sufficient period that plants and animals adapt to and depend on that moisture for at least part of their life cycle. Wetlands can be permanent or ephemeral. The policy contains 12 guiding principles focused on conservation, water and land management, sustainability, prioritisation of significant wetlands, recognition of wetlands' cultural significance, climate change, protection, and reporting.

The project has referenced the 2010 NSW Wetlands Policy in its both ecology and water assessments. There is one identified priority wetland close to the project area, Long Swamp. Further discussion of wetlands is given in the *Hume Coal Project Biodiversity Assessment Report* (EMM 2017c).

3.5.5 State Groundwater Policy Framework Document

The NSW State Groundwater Policy Framework Document (DLWC 1997) aims to manage the groundwater resources of the state so they can sustain environmental, social, and economic outcomes for the people of NSW. The policy will be considered in resource management decisions made in NSW.

The document is a framework for the following three policies:

- NSW State Groundwater Quantity Management Policy (2001 (unpublished));
- NSW State Groundwater Quality Protection Policy (DLWC 1998); and
- NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002).

This policy establishes the overarching principle for the management of groundwater in NSW, which still remains valid 19 years after its inception. The principles of sustainability across the three environmental, social, and economic aspects are still referenced in modern water policies released by the NSW Government.

The project's mine design, operation, and rapid rehabilitation and applied mitigation strategies will considerably minimise groundwater inflow and overall groundwater impacts. The design of the mine closely follows the NSW State Groundwater Policy Framework Document objectives of achieving beneficial environmental, social, and economic outcomes for the state of NSW.

3.5.6 State Groundwater Quality Protection Policy

The NSW State Groundwater Quality Protection Policy (DLWC 1998) is a component policy of the NSW State Groundwater Policy Framework Document. The NSW State Groundwater Quality Protection Policy requires that the water quality within groundwater systems is managed in accordance with the management principles given in Table 3.4.

Table 3.4 State Groundwater Quality Protection Policy (1998) principles

Groundwater quality management principles	Hume Coal's consideration of the principle
The most sensitive identified beneficial use (or environmental value) is maintained.	The beneficial use of groundwater is considered to be irrigation, domestic and stock. Groundwater quality impacts of the project will be negligible and the beneficial use category will not change as a result of the project (Appendix K).
Town water supplies are afforded special protection against contamination.	There are no nearby town water supply bores.
Groundwater pollution should be prevented.	Groundwater chemistry post-mining and recovery has been modelled and groundwater pollution will not occur (Appendix K).
For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.	The project is a State Significant Development, and as such a thorough impact assessment has been made. Baseline environmental monitoring and assessment of the project's potential impacts has been occurring continuously for over five years.
Groundwater extractors should be responsible for environmental damage or degradation caused by applying groundwater that is incompatible with soil, vegetation or receiving waters.	Groundwater taken to the surface will be managed within the water management system at the surface.
Groundwater dependent ecosystems are afforded protection.	There is one High Priority Groundwater Dependent Ecosystem within the groundwater model domain for the project – no water quality impacts are predicted at this location. There are no High Priority Groundwater Dependent Ecosystems within the project area.
Groundwater quality and quantity management is integrated.	The assessment of baseline groundwater quantity and quality and potential impacts have been integrated and the impact assessment model includes both chemistry and quantity changes.
The cumulative impacts of developments on groundwater quality should be recognised.	Groundwater quality changes as a result of the project are anticipated to be negligible. As such, cumulative groundwater quality impacts are also not anticipated as a result of the project.
Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.	Post-mining, the mine surface infrastructure will be decommissioned and areas will be rehabilitated to a state where they can support land uses similar to the current land uses.

A water management plan will be prepared for the project; details of the plan are discussed in Section 13.2.2. The water management plan will incorporate ongoing monitoring and modelling required for the project as it progresses. The plan will be prepared in consultation with and, if required, approval by relevant NSW government agencies.

3.5.7 State Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (DLWC 2002) was used with the more recent GDE Risk Assessment Guidelines (NOW 2012d) to assess ecosystems in the project area that potentially rely on groundwater. There are five principles within the NSW State Groundwater Dependent Ecosystems Policy; these are summarised in Table 3.5 with commentary on how the principle has been applied to the project.

Table 3.5 State GDE Policy principles

Principle	Hume Coal assessment
Principle one The scientific, ecological, aesthetic and economic values of GDEs, and how threats to them may be avoided, should be identified and actions taken to ensure protection of the most vulnerable and valuable ecosystems.	The one high priority GDE (as per the Metro Groundwater Sharing Plan) is Long Swamp, and this system has been specifically assessed. No impacts are predicted to this priority GDE.
Principle Two Groundwater extractions should be managed within the sustainable yield of the groundwater system, to maintain and/or restore ecological processes and biodiversity of their dependent ecosystems.	The project's licensable water take is within the sustainable limits of the respective water sources, and licences will be obtained where and when required.
Principle Three Priority should be given to ensure sufficient groundwater of suitable quality is available when it is needed for: • protecting known or likely GDEs; and • GDEs that are under immediate or high degree of threat from groundwater related activities.	No impacts to water quality are predicted for Long Swamp, or the groundwater table in the area around the GDEs as a result of the project.
Principle Four The Precautionary Principle should be applied to protect GDEs where scientific knowledge is lacking. Adaptive management systems and research to improve understanding is essential to their management.	The GDE, ecology and water studies for the project are rigorous and are ongoing. Adaptive management is proposed for terrestrial ecosystems as required.
Principle Five Planning, approval, and management of developments and land use activities should aim to minimise adverse impacts on GDEs by: • maintaining natural patterns of groundwater flow and not disrupting groundwater levels that are critical for GDEs; • not polluting or causing adverse changes in groundwater quality; and • rehabilitating degraded groundwater systems where practical.	The project contains mitigation strategies to maximise the rate of recovery post mining (ie minimising open active draining panels) which will accelerate the recovery of groundwater pressures and flow paths to pre-mining levels and directions. Geochemistry and hydrogeochemistry studies demonstrate that beneficial use of the water quality will be maintained post-mining (Appendix K).

3.5.8 Water Extraction Monitoring Policy

The NSW Water Extraction Monitoring Policy (DWE 2007) applies to the extraction of water to guarantee equitable sharing of the state's water resources. The policy applies to the extraction of all water in NSW, including regulated rivers, unregulated rivers, groundwater systems and return flows under Section 76 of the WMA 2000.

The principles state that monitoring of water extraction should be accurate and appropriate for the scale and extraction methods proposed. The policy indicates that flow meters are preferable (due to their high level of accuracy) but alternative options (provided they are calibrated to water extraction volumes) are also acceptable and include: electricity consumption, pump operating hours, pump revolutions, pumping diaries, and volume and number of water trucks.

Water extraction for the project will be monitored and recorded in accordance with the NSW Water Extraction Monitoring Policy using flow meters. The water extraction components for the project are:

- groundwater inflow to the mine sump – this water will be pumped either behind bulkheads or to the surface. Flow meters will be installed and maintained on these pumps;
- groundwater extracted from bores for water supply – bores that supply water for the project will have meters installed to monitor groundwater extraction;
- rain water harvesting – the internal catchment area of the site has been calculated with reference to the NSW harvestable rights guidelines and is within the minimal allowable take;
- water pumped from the primary water dam (PWD) to the various water users on site (the CPP, the administration and workshop area, underground machinery, fire-fighting supplies) will be monitored using flow meters; and
- surface water captured in mine water dams – with the exception of the PWD, all mine water dams will be pumped back to the PWD, and this water will be monitored using flow meters.

3.5.9 Groundwater monitoring and modelling

A groundwater monitoring and modelling plan (GMMP) is required as a standard condition of licence for exploration (drilling) under the Mining Act 1992 and Petroleum (Onshore) Act 1991. The project's GMMP (EMM 2017b) has been prepared in accordance with the *Groundwater Monitoring and Modelling Plans – Information for prospective mining and petroleum exploration activities* (NOW 2014).

The GMMP conceptualises the groundwater regime in the project area and describes how the design of the groundwater monitoring network responds to this. Details of the monitoring regime, including duration, frequency and location of monitoring, are included to demonstrate that the network will meet the requirements of the AIP. The numerical groundwater flow modelling has been designed to meet the requirements of the AIP.

The GMMP will be refined over time as a staged and project specific plan, and will evolve from the original plan (prepared by Parsons Brinckerhoff in April 2013), coinciding with establishing the project's monitoring network. The current version (August 2016 (EMM 2017b)) has been prepared following the analysis of monitoring data and the initial development of the project-specific numerical model. Feedback from DPI Water has also been incorporated into the latest version. The GMMP will continue to be updated as the project progresses, including during rehabilitation.

3.5.10 Code of Practice for Coal Seam Gas Well Integrity

This code of practice (DTIRIS 2012a) does not apply to the project as there are no extractive gas reserves in the Wongawilli coal seam within the project area.

3.5.11 Code of Practice for Coal Seam Gas Fracture Stimulation

This code of practice (DTIRIS 2012b) does not apply to the project as there are no extractive gas reserves in the Wongawilli coal seam within the project area.

3.5.12 State Environmental Planning Policy (SEPP) (Sydney Drinking Water Catchment)

AR 78: Specifically address clauses 9(1) and (2) and 10(1) of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011. In particular, the EIS must describe and justify how the development would have a neutral or beneficial effect on water quality.

The State Environmental Planning Policy (SEPP) (Sydney Drinking Water Catchment) 2011 is applicable as the project is within the Sydney drinking water catchment area. The policy aims to maintain healthy water catchments that will deliver high quality drinking water while permitting development. It provides that a consent authority must not grant consent to development under Part 4 of the Environmental Planning and Assessment Act 1979 on land in the Sydney drinking water catchment unless it is satisfied that it would have a neutral or beneficial effect (NorBE) on water quality.

3.5.13 Independent Inquiry into the Hawkesbury Nepean River System

In 1998, the Healthy Rivers Commission made an independent inquiry into the health of and activities with potential to cause degradation of the Hawkesbury Nepean River system (HRC 1998). The inquiry proposed that targets be set for environmental flows, river health, and nutrient and algael concentrations in river water. Priority locations for further management were also identified.

The inquiry paved the way for future policies and management of the Hawkesbury Nepean River System, leading to the establishment of the Sydney Catchment Authority (SCA) in 1999. The SCA's role was to manage and protect the drinking water catchments and catchment infrastructure, and to supply bulk water to Sydney Water and a number of local councils. On 1 January 2015 the SCA was abolished and its functions were transferred to WaterNSW.

The findings of the independent inquiry, particularly the principles of NorBE (neutral or beneficial effects on water quality), were taken into account in the project's planning stage. This is discussed in the following section and also in Section 9.

3.5.14 Neutral or Beneficial Effect on Water Quality Assessment Guideline

The Neutral or Beneficial Effect on Water Quality Assessment Guideline (SCA 2015) outlines the assessment and approval process made by the SCA in applying the principles of NorBE. A neutral or beneficial effect on water quality means any introduced water will be comparable to or will have better quality than the receiving water body, thereby having no identifiable negative impact on the receiving water quality.

Achieving NorBE has been a fundamental goal for the project, and it has received detailed consideration in the mine design and water infrastructure and management. A primary objective has been to minimise water releases from the project area. There are only two locations where the occasional release of storm water to Oldbury Creek may occur during very high rainfall events. These are discussed in detail in Section 2.3. The principles of NorBE have been firmly applied and sampling and inspection of both the collected water and the receiving water body will occur before water is released.

During very high rainfall water may be released from the PWD to manage on-site water in emergencies. This water would be treated in a purpose-built water treatment plant before release, with treatment being to a standard that complies with NorBE for Oldbury Creek (Section 2.3). Water balance modelling demonstrates, however, that the PWD has enough capacity to contain all surplus water and treatment and release of water from the PWD is not required. Refer to Section 8 for further details.

3.5.15 Floodplain Development Manual and Flood Prone Land Policy

The Floodplain Development Manual and Flood Prone Land Policy (DIPNR 2005) were developed to provide guidance to local councils during the development and implementation of detailed local floodplain risk management plans. The manual clearly sets out the floodplain risk management process to be used by local councils.

The flood assessment for the project has considered flooding changes with regard to the above-mentioned manual (WSP PB 2016d). Further discussion on the flood assessment is included in Section 8.2.1.

3.5.16 Wingecarribee Local Environmental Plan

The Wingecarribee Local Environmental Plan was prepared in accordance with the Environmental Planning and Assessment Act 1997 and Environmental Planning and Assessment Regulation 2000. The plan aims, among other things, to: minimise flood risk to life and property associated with the use of the land; allow development that is compatible with the land's flood risk, taking into account projected climate change; and avoid significant adverse impacts on flood behaviour and the environment.

The project's flooding assessment for the project considers these objectives of the Wingecarribee Local Environmental Plan. With appropriate mitigation measures in place, the flood assessment indicates that the project will have: negligible impacts on flood levels in the Medway Rivulet catchment; flood level impacts within acceptable limits for public roads and private land in the Oldbury Creek catchment during mine operation; and negligible changes on flood levels in the Oldbury Creek catchment during mine rehabilitation.

3.5.17 Water Management (General) Regulation

AR 37: Applicability of any exemptions under the Water Management (General) Regulation 2011 to the project.

Clause 18 (1) of the Water Management (General) Regulation 2011 with item 12 in Schedule 5 of that Regulation, provides an exemption from the requirement to hold a water access licence in circumstances where surface water is taken by a landholder by means of an excluded work referred to in any of items 1–9 of Schedule 1 of the Regulation. It is not expected that Hume Coal will rely on any of these exemptions.

Section 89J(1)(g) of the *Environmental Planning and Assessment Act 1979* exempts a State Significant Development authorised by a development consent from requiring a water use approval under section 89, a water management work approval under section 90, or an activity approval (other than an aquifer interference approval) under section 91 of the WMA 2000. These exemptions apply to the project.

3.5.18 Draft regulation establishing water return flow rules

Section 75 of the WMA 2000 provides for a regulation to be made to establish water return flow rules. Section 76 provides for such a regulation to allow water used under a licence to be 'regained'. In 2014, DPI Water stated its intention to make a regulation on return flows across NSW. The current DPI Water website (DPI Water 2015a) states:

> 'Return flow rules are likely to be made for aquifer access licences before the end of 2014. Once these rules are put in place, licence holders will be able to receive a credit to their water allocation account for water returned to the same groundwater source from which it was taken, providing specific conditions are met. Licence holders will only need to hold enough licence shares to account for the net amount of water extracted, ie the amount of water initially extracted minus the amount of water returned. Water usage fees will only be applied to the net amount of water extracted.'

The draft form of the proposed return flow regulation was discussed at a public information session in September 2014 (J Gill 2014, pers comm, September). At the public information session 'frequently asked questions' sheets explaining how the regulation would work were distributed, and various plans were outlined, including an intention the flow regulation would have state-wide application. Once enacted, this regulation would provide Hume Coal with a means to redistribute licence shares to other users within the Nepean Zone 1 groundwater source. Technically, these rules will not change the operation or impact of the mine; however, administratively, they would allow more licence holders to take groundwater from Zone 1, as the groundwater removed during the project will be put back into the water source after it is taken.

Until a water return flow regulation is made under Section 75 of the WMA 2000, the obvious benefits of such a scheme will not be available to the community.

3.5.19 Stormwater first flush pollution

The NSW EPA provides guidelines about the definition and design of stormwater pollution control systems (NSW EPA 2013). Pollutants deposited onto an exposed area can be picked up and carried in rainfall-runoff. Usually stormwater that runs off an area in the early periods of rainfall is more polluted than the stormwater that runs off later, after the rainfall essentially cleans or washes the catchment. First flush is defined as the stormwater that contains this initial high pollutant load.

First flush collection can form an important part of a stormwater pollution control system by minimising the availability of pollutants in stormwater runoff, particularly in small catchments, especially if a large proportion of the catchment is impervious (paved surfaces and roads). Collection of the first flush can also act as an emergency backup if there is a pollutant spill, reducing the risk of pollution entering the receiving environment.

First flush should be collected and separated from stormwater runoff, as discussed in NSW EPA (2013). This water should be re-used or disposed of quickly and properly. The amount of rainfall suggested to be contained depends on the potential pollutants present and the catchment surfaces. For all types of pollutants and pervious surfaces (including natural ground surfaces) it is recommended the first 20 mm of rainfall be contained as the first flush.

First flush criteria for non-direct coal contact catchments in the project have been designed in accordance with these guidelines. Refer to Section 2.3.2 for more details.

3.6 Relevant Commonwealth guidelines

3.6.1 Australian Groundwater Modelling Guidelines

The Australian Groundwater Modelling Guidelines, National Water Commission (NWC) (Barnett et al. 2012) provide a consistent and sound approach for the development of groundwater flow models in Australia. The guidelines 'propose a point of reference and not a rigid standard' and provide direction on scope and approaches while acknowledging that techniques are continually evolving and innovation is to be encouraged. The guidelines provide a confidence-based classification system that defines three different classes of model:

- class 1 – low confidence in model predictions, suitable for use in low value resource or low risk developments;

- class 2 – high confidence in model predictions, suitable for use in high value resources or projects with medium to high risk developments; and

- class 3 – high confidence in model predictions, suitable for use in high value resources and projects such as regional sustainable yield assessments.

The guidelines provide information on the data requirements for each model class, such as spatial distribution of bores and temporal groundwater level data. Groundwater resource assessments at major development sites generally require the use of a class 2 model. The onerous data requirements to achieve a class 3 model (ie reliable metered extraction and the duration of the prediction to be not more than three times the calibration data period) mean that for most major projects in NSW a full class 3 model is practically unattainable.

The numerical groundwater model for the project is a class 2 model with many elements classified as meeting class 3 requirements. The numerical model has been prepared in accordance with the Australian modelling guidelines and peer reviewed using the structure of the 'review checklist' as per Chapter 9 (Table 9-2) of the modelling guidelines. Two independent pre-eminent hydrogeologists, Dr Frans Kalf and Dr Noel Merrick, were engaged to peer review the numerical model. Dr Merrick stated in his peer review of the model:

> 'The reviewer finds that the modelling study is fully compliant with guidelines, and often goes beyond state of the art techniques' (Merrick 2016).

The model was judged by both peer reviewers to be fit for purpose in accordance with the guidelines and their professional judgement. The peer review reports, Merrick (2016) and Kalf (2016), are included in Appendix J.

3.6.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council (ANZECC & ARMCANZ) 2000 describe the water quality objectives for marine and freshwater environments, aquatic ecosystems, primary industries, and recreational water.

The guidelines should be considered when setting water quality objectives for natural and semi-natural water resources in Australia and New Zealand sustaining current or likely future environmental values (uses). They also set out a framework for the application of water quality trigger levels.

The guidelines are a generic reference and should be used accordingly, ie only as a default reference. It is recommended to collect and use site-specific baseline data to establish baseline conditions and develop trigger levels. Project impacts should be assessed using site-specific baseline data and not the generic guidelines. The project has enough data to establish appropriate baseline water quality conditions and trigger levels for ongoing water monitoring and management planning. Further details on baseline monitoring are included in Chapter 4.

3.6.3 Significant Impact Guidelines 1.3: Coal Seam Gas and Large Coal Mining Developments – Impacts on Water Resources

The Commonwealth Government released impact guidelines to assist any proponent who proposes to take an action that involves a coal seam gas development or a large coal mining development to decide whether the action will have or is likely to have a significant impact on a water resource (DoE 2013). According to the guidelines, a referral to the Commonwealth Department of the Environment (DoE) for a decision by the Minister on approval is required.

In the case of the project, these guidelines were examined before referral documentation was lodged with the DoE (EMM 2015b).

3.6.4 Information Guidelines for Independent Expert Scientific Committee Advice on Coal Seam Gas and Large Coal Mining Development Proposals

The Independent Expert Scientific Committee (IESC) is a statutory body established under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The IESC provides advice to the Commonwealth Government on water-related matters for projects referred to the Commonwealth under the EPBC Act 'water trigger', and also on projects referred to the IESC by state authorities.

The IESC provides advice upon request from either the Commonwealth or state governments. The advice is scientific and not regulatory or political. The IESC published guidelines (IESC 2015) to outline its role in providing its scientific advice. The IESC guidelines provide a checklist of information requirements to adequately assess a project's impacts. The project considered these requirements; they have been fully considered in the impact assessment to ensure it addresses the guidelines.

3.6.5 National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia

The National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia (NWQMS 2013) provides a risk-based management framework to protect and enhance groundwater quality for the maintenance of specified environmental values. The framework involves the identification of specific beneficial uses and values for the major groundwater systems, and a number of protection strategies that can emerge to protect each aquifer, including monitoring for all aquifers.

The guidelines, including defined environmental values and water quality objectives, have been referenced in the project's groundwater quality impact assessment (Geosyntec 2016).

3.6.6 Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWG) (NHMRC 2016) apply to water intended for drinking and include health and aesthetic values for metals, pesticides and organic compounds. The guidelines aim to guarantee safety at the point of use based on current scientific evidence.

The project references these guidelines as the project is within the drinking water catchment areas for the Sydney metropolitan area.

3.6.7 Australian Rainfall and Runoff – a Guide to Estimation

The Australian Rainfall and Runoff – a Guide to Estimation (IEA 1987) is the national guideline to estimate design flood volumes and velocities in Australia. It provides robust estimates of flood risks to avoid development in high risk areas and sound design of infrastructure in flood-prone areas, and has been referenced as part of the project's flood impact assessment (WSP PB 2016d).

4 Baseline monitoring program

This chapter provides an overview of the baseline surface water and groundwater monitoring for the project. The monitoring results are presented in subsequent sections.

AR 49: Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations.

AR 69: The EIS must assess the impacts of the development on water quality, including:
a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.
b. Identification of proposed monitoring of water quality.

AR 70: The EIS must assess the impact of the development on hydrology, including:

- *a. Water balance including quantity, quality and source.*
- *b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.*
- *c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.*
- *d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (eg river benches).*
- *e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.*
- *f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.*
- *g. Identification of proposed monitoring of hydrological attributes.*

AR 79: A full description of the development including those aspects which have the potential to impact on the quality and quantity of surface and groundwaters at and adjacent to the site, including:
- the mining proposal and mine layout
- the location, mapping and geomorphology of all creeks and water resources overlying and adjacent to the proposed mining area
- the hydrogeological fluxes between surface and groundwaters, including the filling of pine feather voids
- the location, management and storage of all hazardous materials- the disposal of wastes from the treatment of mine waters in the mine water treatment plant
- the management of dirty water from the washing and preparation of coal for transport
- the location, sizing and description of all water quality management measures
- the location and description of all water monitoring points (surface and ground waters)
- on-site domestic (sewage) wastewater management

AR 80: A detailed assessment of the development on water resources which considers the design, construction, operational and decommissioning phases and have regard for operation during periods of wet weather and include:
-details of measured and predicted coal mine, preparation area and stockpile area performance with respect to water quality management
-details of measures proposed to be adopted to offset impacts associated with construction activities eg earthworks, vegetation clearing and track construction
-impacts on overlying and adjacent creeks and water resources within risk management zone associated with subsidence
-impact of the proposed on-site domestic (sewage) wastewater management and associated effluent disposal area
-pre-development and post development run off volumes and pollutant loads from the site
-details of the measures to manage site water associated with processing coal and coal reject, general stormwater runoff and any human activities likely to affect water quality at the site, and how neutral or beneficial effect on water quality (NorBE) principles will be assessed and applied
-assessment of the impacts of the development on receiving water quality and volume, both surface and groundwater including from the filling of pine feather voids and associated impact on interaction and baseflows of surface waters
-details of the structural stability, integrity, ongoing maintenance and monitoring of all site water management measures including dams over the life of the project
-details of proposed monitoring of groundwater levels, surface water flows, groundwater and surface water quality, along with information as to how the proposed monitoring will be used to monitor, and, if necessary, mitigate impacts on surface water and groundwater resources
-the principles outlined in the 'Managing Urban Stormwater - Soils and Construction - Mines and Quarries' Manual prepared by the Department of Environment and Climate Change (2008)

Surface water and groundwater monitoring are essential components in characterising the project area's baseline, pre-mining, hydrogeological and hydrologic environments. Baseline water level and water quality field data collected from the various groundwater systems and watercourses has been used to determine the overall water chemistry, flow paths, recharge and discharge characteristics, and groundwater–surface water connectivity. Field data has been an important input to validate the hydrogeological and hydraulic conceptual and numerical models.

A comprehensive water monitoring network has been designed and used to establish enough baseline data for the project, incorporating temporal and spatial variations. Monitoring began in 2011 as per the project's original groundwater monitoring and modelling plan *(GMMP)* (PB 2011). Subsequent iterations of the GMMP have been developed, the most recent one being by EMM (2016b), which have been prepared in accordance with the *Groundwater Monitoring and Modelling Plans – Information for prospective mining and petroleum exploration activities 2014* (NOW 2014).

4.1 Surface water monitoring

4.1.1 Surface water monitoring network

A dedicated surface water quality and flow monitoring network has investigated the hydrologic conditions in the project area, providing over four years of baseline data (2012 – 2016, inclusive). The project surface water monitoring network consists of 11 stream flow gauging locations and 24 water quality monitoring locations (Figure 4.1) (WSP PB 2016e). The network has added more monitoring locations over time to increase the spatial data coverage. The monitoring locations were developed in consultation with DPI Water (formerly NOW) to:

- create spatial representation across the project area, including upstream and downstream locations, and different land use scenarios;
- characterise major drainages (ie larger stream orders) and streams that will be undermined;
- examine the potential for surface water–groundwater interaction; and
- monitor key potentially sensitive receptors, including Medway Dam and Long Swamp (Figure 1.4).