PEABODY

WILPINJONG COAL
GROUNDWATER MANAGEMENT PLAN

(WI-ENV-MNP-0041)

AUGUST 2017

Document Owner		Document Approver
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General Description of Changes from Previous Version

Document No.	Version	Date	Prepared/Reviewed By	Distribution	Description of Change
GWMP-R01	G	February 2006	WCPL, Resource Strategies, Mr Ian Callow (AGE)	DNR, DP&I	Original plan - developed for initial development phase of the project
GWMP-R01	H	6 March 2006	WCPL, Resource Strategies, Mr Ian Callow (AGE)	DP&I	Amended to address DP&I comments. **This version was approved by DP&I.**
GWMP-R02	B	March 2009	WCPL, Resource Strategies	NSW Office of Water (NOW)	Periodic review
GWMP-R02	C	December 2010	WCPL, Mr Andrew Durick (AGE), Dr Steve Perrens (Evans and Peck)	OEH, NOW and DP&I	Revision following the August 2010 Modification and to address NOW comments
WI-ENV-MNP-0006	1	20 June 2014	WCPL, Palaris, Dr Noel Merrick (HydroSimulations), Resource Strategies	OEH, NOW	Revised following approval of Mod 5 (PA 05-0021). Also incorporates requirements of groundwater licences, ML 1573 and Exploration Licences (EL) 7091 and 6169.New format. Forms appendix (Appendix 6) to Water Management Plan (WMP). Submitted to OEH and NOW for consultation
WI-ENV-MNP-0006	1.1	30 June 2014	WCPL, Palaris	DP&E, OEH and NOW	Minor amendments to address comments by Resource Strategies prior to submission to DP&E.
WI-ENV-MNP-0006	2	November 2014	WCPL, Palaris	DP&E, OEH and NOW	Minor amendments to address comments by DP&E and NOW.
WI-ENV-MNP-0041	1	June 2016	WCPL	DP&E	Change of Document number match SAWOL MS number
WI-ENV-MNP-0041	2	October 2016	WCPL	DP&E	MOD 7
WI-ENV-MNP-0041	**3**	August 2017	WCPL, HydroSimulations	DP&E, DPI Water and EPA	Updated to reflect Development Consent (SSD-6764)

CONTENTS

TABLES

FIGURES

ATTACHMENTS

1 Introduction

The Wilpinjong Coal Mine (the Mine) is owned and operated by Wilpinjong Coal Pty Limited (WCPL), a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody).

The Mine is an existing open cut coal mining operation situated approximately 40 kilometres (km) north-east of Mudgee, near the Village of Wollar, within the Mid-Western Regional Local Government Area, in central New South Wales (NSW). The mine produces thermal coal products which are transported by rail to domestic customers for use in electricity generation and to port for export. Open cut mining operations are undertaken 24 hours per day, seven days per week.

The Wilpinjong Coal Mine originally operated under Project Approval (PA 05-0021) that was granted by the Minister for Planning under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 1 February 2006. Modification of the Project Approval subsequently occurred six times[1] with the most recent modification (Modification 7) approved in August 2016. The existing Site Water Management Plan (including an Erosion and Sediment Control Plan, Surface Water Management and Monitoring Plan and Surface and Ground Water Response Plan) was developed in accordance with NSW Project Approval 05-0021 and the last revision was approved on 20 March 2017.

On 24 April 2017, WCPL was granted Development Consent (SSD-6764) for the Wilpinjong Extension Project that provides for the continued operation of the Mine at rates of up to 16 million tonnes per annum (Mtpa) of run-of-mine (ROM) out to 2033, and access to approximately 800 hectares (ha) of open cut extensions. Development Consent (SSD-6764) has superseded the Project Approval (Project Approval 05-0021). This Groundwater Management Plan (GWMP) has been prepared to satisfy the relevant conditions in Development Consent (SSD-6764). Where relevant, this GWMP builds on the relevant components of the existing/approved Site Water Management Plan, including previous feedback from consultees and where relevant trigger levels that have already been previously agreed.

The Secretary of the NSW Department of Planning and Environment (DP&E) approved Dr Noel Merrick as a suitably qualified and experienced person for the preparation/review of the GWMP on 24 May 2017. This GWMP was prepared in consultation with Dr Noel Merrick.

[1] Mod 2 was withdrawn.

2 Statutory and Project Approval Requirements

2.1 Specific Development Consent Requirements

This GWMP has been prepared in accordance with Condition 30(d)(iv), Schedule 3 of Development Consent (SSD-6764). Table 1 presents these requirements and indicates where they are addressed within this GWMP.

Table 1
Specific GWMP Requirements

Development Consent (SSD-6764) Condition	GWMP Section
Water Management Plan	
30. Prior to carrying out any development under this consent, unless the Secretary agrees otherwise, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary...	
(d) … this plan must include a:	
(iv) Ground Water Management Plan that includes:	
• detailed baseline data of groundwater levels, yield and quality in the region that could be affected by the development, including privately-owned groundwater bores and groundwater dependent ecosystems;	Section 4
• groundwater assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts;	Section 7
• a program for accurately delineating the boundary of the Wilpinjong Creek alluvial aquifer in any areas intersected by mining;	Section 4.3
• a program to monitor and report on:	Section 6
o impacts of the development on:	
– groundwater supply of potentially affected landowners;	
– regional and local (including alluvial) aquifers;	
– groundwater dependent ecosystems and riparian vegetation;	
o connectivity and groundwater leakage to/from Cumbo Creek following relocation;	Section 6
o the seepage/ leachate from water storages and emplacements;	Section 6
o groundwater inflows into open cut/ voids and transfers to the water management system;	Section 6
o ground water levels and/or pressure and quality in the alluvial, coal seam, and inter-burden aquifers; and	Section 6
• a program to review and validate the groundwater model for the development, including independent expert review; and	Section 5
• a plan to respond to any exceedances of the trigger levels and/or performance criteria, and mitigate and/or offset any adverse groundwater impacts of the development, including measures to provide compensatory water supply to any affected groundwater users under condition 24 of this schedule;	Section 8

2.2 General Management Plan Requirements

Condition 3, Schedule 5 of Development Consent (SSD-6764) outlines general management plan requirements that are applicable to the preparation of the GWMP. Table 2 presents these requirements and indicates where they are addressed within this GWMP.

Table 2
General Management Plan Requirements

Development Consent (SSD-6764) Condition	GWMP Section
Management Plan Requirements	
3. The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include:	
(a) detailed baseline data;	Section 4
(b) a description of:	
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 2
• any relevant limits or performance measures/criteria;	Section 7
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 7
(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 8
(d) a program to monitor and report on the:	Sections 6, 8 and 9
• impacts and environmental performance of the development;	
• effectiveness of any management measures (see c above);	
(e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 7
(f) a program to investigate and implement ways to improve the environmental performance of the development over time;	Sections 6.4 and 9
(g) a protocol for managing and reporting any:	WMP
• incidents	
• complaints	
• non-compliances with statutory requirements; and	
• exceedances of the criteria and/or performance criteria; and	
(h) a protocol for periodic review of the plan.	WMP

2.3 Specific Guidance from Regulatory Agencies

The approved Site Water Management Plan (including the relevant sub-plans) was prepared in consultation with the EPA and DPI Water, as required by Condition 28, Schedule 3 of the previous Project Approval for the Wilpinjong Coal Mine (Project Approval 05-0021).

Consultation was also undertaken with a variety of regulators throughout the assessment and approval of the Wilpinjong Extension Project. A number of additional, specific requirements and commitments for this GWMP that arose from this consultation programme were subsequently reflected in Condition 30(d)(iv), Schedule 3 of Development Consent (SSD-6764). Table 3 presents these additional requirements/commitments and indicates where they are addressed in this GWMP.

Table 3
Specific Regulatory Agency Requirements

Regulator	Requirement	GWMP Section
DPI Water	Make good provisions for Wollar State School bore.	Sections 7.1.3 and 8.1.4
	Metering of water used for pastoral activities on Peabody-owned land.	Section 5.1
IESC	A plan for the conduct of additional core testwork as mining advances.	Section 6.2
	Solubility studies of arsenic, selenium and molybdenum in waste and reject material.	Section 6.2
	Install additional groundwater bores in backfill areas.	Section 6.3
	Include analyses for molybdenum in the groundwater sampling program.	Section 6.1
	Monthly and event based metals monitoring.	Section 6.1
	Resume monitoring at four piezometers in the vicinity of the existing Tailings Dams (PZ13, PZ20, PZ21 and PZ26). Describe the screened intervals of the relevant piezometers.	Section 6.1

3 Existing Groundwater Conditions

The key geological features in the vicinity of the Wilpinjong Coal Mine of relevance to hydrogeological processes are:

- elevated sandstone plateaus of the Narrabeen Group;
- a thin veneer of recent alluvium/colluvium along Wilpinjong Creek and alluvium along Cumbo Creek and Wollar Creek (with alluvial bodies being quite narrow);
- unconsolidated deposits in western portions of the Wilpinjong Coal Mine and extending into the Moolarben Coal Complex tenements with coarse-grained lithology up to almost 60 m deep;
- overburden, consisting of the Permian Illawarra Coal Measures (including the Moolarben Coal Member, which is a secondary economic coal resource);
- the Ulan Coal Seam (the primary economic coal resource);
- the Marrangaroo Conglomerate and underlying Nile Sub-Group; and
- the Shoalhaven Group and older units acting as the 'basement'.

There is no evidence of major faulting over the Wilpinjong Coal Mine, although faults have been observed and mapped by WCPL. There are minor intrusions, dykes and sills in parts of the Wilpinjong Coal Mine area.

Alluvial deposits are associated with Wilpinjong and Cumbo Creeks in the vicinity of the Wilpinjong Coal Mine, along Wollar Creek to the east of Pit 8 (Figure 1) and along Moolarben Creek (to the south-west of the Wilpinjong Coal Mine).

Colluvial deposits are also evident along the north of Wilpinjong Creek below the escarpments of the Goulburn River National Park, which adjoins Peabody-owned land north of Wilpinjong Creek.

A prior drainage system and/or some other process has resulted in coarse-grained deposits which are located in areas of Pits 5 and 6 and extend to the west in the approved Moolarben Coal Complex tenements.

There are two distinct groundwater systems in the Wilpinjong Coal Mine area:

- Alluvial groundwater system – associated primarily with Wilpinjong Creek and Wollar Creek.
- Porous rock groundwater system – primarily the Illawarra Coal Measures.

None of the identified groundwater systems are significant aquifers.

The most permeable units are the Ulan Coal Seam, alluvium and Marrangaroo Formation (Marrangaroo Conglomerate), while the sandstones of the Narrabeen Group are of lower permeability.

The Illawarra Coal Measures also include layers of low permeability mudstones and siltstones.

3.1 Alluvial Aquifers

Alluvial deposits are associated with Wilpinjong and Cumbo Creeks in the Wilpinjong Coal Mine area, and Wollar Creek to the east of Pit 8.

Detailed field investigations (Section 4.3) indicate the extent of alluvial deposits are generally much narrower than the previous regional geological mapping, with long thin deposits along Wilpinjong Creek, Cumbo Creek, and in the northern part of Slate Gully. This interpretation is supported by analysis of bore logs from the NSW Pinneena database. The interpreted extent of unconsolidated sediments in the vicinity of the Wilpinjong Coal Mine is shown on Figure 1.

DPI Water has identified a portion of the alluvial aquifer associated with Wilpinjong Creek and lower Wollar Creek as 'highly productive'. It is noted that in the vicinity of the Wilpinjong Coal Mine this 'highly productive' aquifer is largely confined to Peabody-owned land. In addition, HydroSimulations (2015) concluded that on the basis of the available data, including NSW Pinneena database records and water quality data, that it is unlikely that the current 'highly productive' classification for this area of the alluvial water source is valid. This conclusion was made in the context of recorded lithology and thickness of alluvium; the fact that no bores intersecting the declared 'highly productive' alluvium along Wollar Creek or Wilpinjong Creek have a recorded bore yield of greater than 5 litres per second in the Pinneena bore database; and also the distribution of groundwater salinity.

3.2 Unconsolidated Tertiary Deposits

Unconsolidated Tertiary deposits (i.e. a prior drainage system) have been interpreted as a Palaeochannel at the Moolarben Coal Complex, with the extent of these features being mapped by RPS Aquaterra (2011) and TEM surveys at Wilpinjong Coal Mine (Groundwater Imaging Pty Ltd, 2014). In addition, these features have been identified in Pit 5 of the Wilpinjong Coal Mine where channel like deposits can be observed in the pit wall.

Bore logs support the presence of such a feature, extending between the Moolarben Coal Complex and Wilpinjong Coal Mine, which has been filled with sandy unconsolidated material, with some bores showing greater than 20 m of sands and/or gravel.

These sediments are generally not coincident with modern drainage lines and when encountered in Pit 5 at the Wilpinjong Coal Mine have typically been dry.

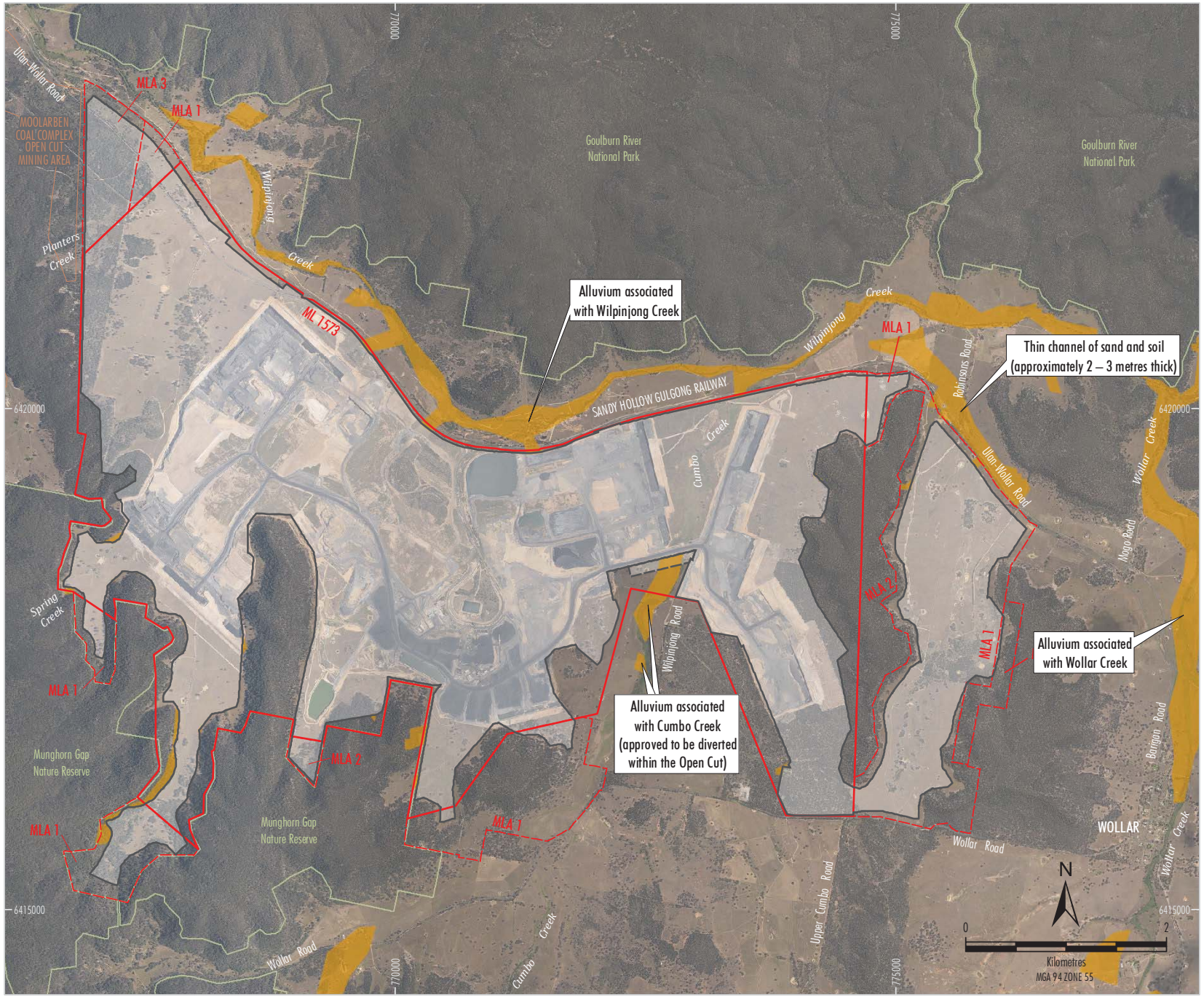
3.3 Groundwater Recharge

Recharge to the groundwater systems occurs from rainfall and runoff infiltration and lateral groundwater flow, especially from the elevated Narrabeen Group to the alluvium of Wilpinjong Creek. Seepage faces would be expected along the cliff faces bordering Wilpinjong Creek after rainfall events, and perched water tables might be sustained at high elevations due to the presence of occasional lower permeability beds between the sandstone layers.

Although groundwater levels are sustained by rainfall infiltration, they are controlled by topography, geology and surface water levels in local drainages.

Local groundwater tends to mound beneath hills but mounding is expected to be slight to the south of the Wilpinjong Coal Mine, because sub-cropping coal seams are dry there.

Wilpinjong Creek and Cumbo Creek are conceptualised by HydroSimulations as gaining systems under natural conditions. During short events of high surface flow, streams would lose water to the host aquifer, but during recession, the aquifer would discharge water slowly back into the stream from bank storage.



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Interpreted Extent of Unconsolidated Sediments

Figure 1

Groundwater, under natural conditions, is expected to discharge upwards from the Permian rocks to the alluvium associated with Wilpinjong Creek. Loss by evapotranspiration is likely along the creek corridors where the water table is near the ground surface (generally 2 to 3 m below ground level).

In the main open cut areas associated with the Wilpinjong Coal Mine the depth to groundwater can be as shallow as 5 m below ground but is more typically 10 to 50 m below ground.

The direction of groundwater flow in the vicinity of the Wilpinjong Coal Mine is generally northward and down dip of the coal seams. A groundwater divide is present around the Moolarben Coal Complex, with flow in that area occurring to the north and north-west as well as to the east. This divide is primarily caused by a reversal of groundwater flow in some areas due to mining at the Ulan Mine Complex.

4 Baseline Data

4.1 Historical Groundwater Investigations

In 2001 the Department of Infrastructure, Planning and Natural Resources (DIPNR) (now DPI Water) conducted field surveys and groundwater assessments in the greater Wollar Creek catchment. The field survey components were primarily conducted in 2001 and methodology included field measurements of groundwater levels and salinities in private bores, wells, dams and sections of creeks in the greater Wollar Creek catchment (DIPNR, 2003).

A hydrogeological study including a drilling and sampling program was undertaken for the Mine in 2004 (Geoterra, 2004). The groundwater testwork program included two 24 hour pumping tests and falling/rising head tests.

A pumping test to determine the potential drawdown effects of developing a production bore was conducted from July to October 2005 (Geoterra, 2005). The pumping test involved the installation of a test production bore (PB1) and associated monitoring piezometers. The test bore was pumped for a period of 42 days and the response/change in the aquifer was observed.

Since the Wilpinjong Coal Project EIS, Merrick (2005) assessed alluvial-rock leakance by using the HotSpots analytical model to interpret the data acquired in the 42 day pumping test by Geoterra (2005). Over that limited period of time, no observable response was found in the alluvial aquifer due to pumping from the Ulan Coal Seam.

4.2 Baseline Groundwater Monitoring

A groundwater monitoring network has been in place at the Mine since April 2006. The previous version of the Water Management Plan (approved on 20 March 2017) established the baseline data set for the Wilpinjong Coal Mine as comprising data from pre-mining (2004) to the end of 2009 (prior to approval being granted for an increased mining rate in early 2010). The baseline period for this GWMP has been kept consistent with this previously agreed baseline period.

The details of monitoring bores in the WCPL baseline monitoring network are summarised in Table 4 and shown on Figure 2. Field pH and EC readings have been taken at the same time as monthly water level readings at GWa1-GWa8 in alluvium and at GWc1 to GWc5 in coal.

The existing groundwater level and water quality data recorded during the previous studies/reports (Section 4.1) has been augmented over time. Baseline groundwater quality and level monitoring has been undertaken at the locations summarised in Table 4. Monitoring has also been undertaken at selected landholder bores, wells and waterholes.

Baseline groundwater level and quality data is provided in Attachment 1. Typical baseline electrical conductivity (EC) and pH values are provided in Table 5.

Table 4
Baseline Groundwater Monitoring Sites

Monitoring Site	Lithology	Start Date	End Date	Frequency	Location
GWa1, GWa2, GWa3, GWa4	Alluvium	20 April 2006	-	monthly	Wilpinjong Creek
GWa7	Alluvium	14 April 2008	-	monthly	Wilpinjong Creek
GWa5, GWa6	Alluvium	20 April 2006	-	monthly	Cumbo Creek
GWa8	Alluvium	20 April 2006	-	monthly	Wollar Creek
GWa10, GWa11, GWa12, GWa14, GWa15	Alluvium	May-June 2007	-	15 minutes	Wilpinjong Creek
GWc1, GWc2, GWc3	Ulan Coal	20 April 2006	-	monthly	Wilpinjong Creek
GWc4, GWc5	Ulan Coal	20 April 2006	-	monthly	Wollar Creek
GWc10, GWc11, GWc12, GWc14, GWc15	Ulan Coal	20 April 2006	-	15 minutes	Wilpinjong Creek
DB1, DB2[1]	Ulan Coal	23 May 2006	1 April 2007	monthly	Pit 1
DB6, DB7[1]	Ulan Coal	30 July 2006	1 April 2007	monthly	Pit 1
DB3, DB4, DB5[1]	Ulan Coal	30 July 2006	1 April 2007	monthly	Pit 2 - Pit 4

[1] A network of production bores was drilled for dewatering (DB1-DB7) and water supply (WSB1 to WSB15). Five of the DB-series bores were pumped in May-June 2006 and all were used for water level measurement from July 2006 to April 2007. Of the WSB-series bores, only five were ever pumped (WSB10-WSB15) and then only for a few months (March to June 2007).

Table 5
Typical Baseline EC and pH Values by Aquifer Type

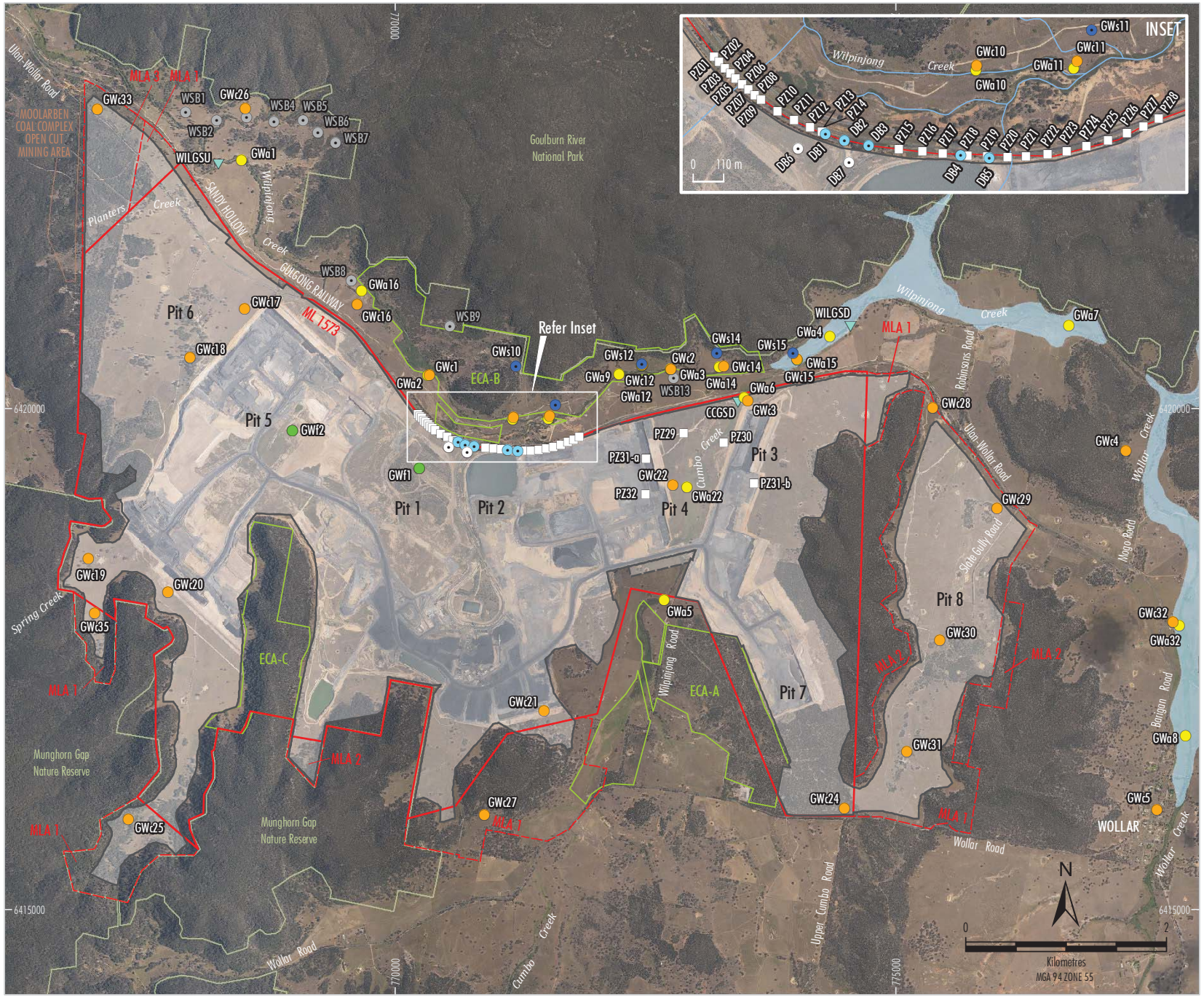
Aquifer Type	EC (µS/cm)		pH	
	Average	Maximum Recorded	Minimum Recorded	Maximum Recorded
Alluvium	~2,350[1]	4,100	6.9	8.4
Mesozoic Laccolith Intrusion	~2,225[1]	2,550	6.5	6.9
Illawarra Coal Measures	~3,200	6,176[1]	5.6[2]	8.3[2]
Nile Subgroup / Shoalhaven Group	~5,700[1]	6,470	7.1[3]	7.1[3]

[1] Average calculated using ratio of 0.68 EC/TDS.

[2] Range does not include two alkaline sites (EW5049 and EW5052), which were affected by cement seals at the base of the piezometers and two excessively acidic sites (EW2004 and EW2005).

[3] There is only one pH record for the Nile subgroup.

Additional expansions/augmentations to the monitoring network since the baseline data period (end of 2009) are summarised in Section 6.1.



LEGEND

- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Relocated Block Bank and Cumbo Creek Disturbance Area
- Enhancement and Conservation Area
- DPI Water - Mapped Highly Productive Alluvial Aquifer

Groundwater Monitoring Sites

- Alluvial Groundwater Monitoring
- Hard Rock Groundwater Monitoring
- Spoil Monitoring
- Water Supply Bore
- Dewatering Bore
- Dewatering Bore - Never used, now a Monitoring Bore
- Water Supply Bore - Never used
- Piezometer

Surface Water Monitoring Sites

- Surface Water Gauging Station

Source: WCPL (2017); DPI Water (2015); NSW Dept of Industry (2015)
Orthophoto: WCPL (Dec 2015)

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Groundwater Monitoring Network

Figure 2

WIL-12-11_GWMP 2017_201A

4.3 Wilpinjong Creek Alluvial Investigations

A number of investigations into the nature and extent of the alluvium associated with Wilpinjong Creek has been undertaken at the Wilpinjong Coal Mine. These investigations include:

- A transient electromagnetic (TEM) survey in 2011 by (Groundwater Imaging, 2011).
- An investigative drilling program in 2013 (Groundwater Exploration Services Pty Ltd, 2013).
- A supplementary TEM survey in 2014 (Groundwater Imaging, 2014).

These investigations suggest that the actual alluvial deposits are generally much narrower than the regional mapping, with long thin deposits along Wilpinjong Creek, Cumbo Creek, and in the northern part of Slate Gully.

4.4 Cumbo Creek Geotechnical Site Assessment

In April 2014, 80 boreholes were excavated along a section of Cumbo Creek as part of a geotechnical site assessment for the proposed Cumbo Creek relocation (Barnson, 2014). The boreholes were excavated to a depth of 3 m in nine transects across the creek. Bulk samples were taken from the boreholes at various depths for laboratory testing (i.e. Atterberg Limit [Plasticity Index] testing).

Topsoil of approximately 0.1-0.5 m depth was encountered at most boreholes. The topsoil was classified as sandy silts and silty sands of firm to stiff consistency.

Alluvial soils were encountered at all 80 boreholes. The depth of alluvial soils ranged from beneath the topsoil to maximum depths of 3m at all boreholes. The alluvial profiles comprised of silts, sands and clays with varying amounts of gravel. There are areas of possible weathered sandstone of low strength at some borehole locations and refusal was encountered at these locations.

Coal was encountered in four of the boreholes; BH4 at 2.6m, BH6 at 2.7m, BH79 at 1.6m and BH80 at 2.3m.The coal was noted to be of low strength. Refusal was not encountered within any of these layers.

Groundwater was encountered in five boreholes; BH23 at 2.6m, BH39 at 2.6m, BH40 at 2.6m, BH41 at 2.6m and BH50 at 2.6m.

4.5 Private Groundwater Bores

In consultation with landowners, a bore census (WCPL, 2005a) was conducted by WCPL in February 2005 to collect additional data on local registered and known bores/wells, known springs and spring-fed dams. The information collected was used to supplement the data from the above studies, all of which was collated for the groundwater assessment included in the Wilpinjong Coal Project EIS (WCPL, 2005b).

Since that time, Peabody has acquired most of the land in the vicinity of the Wilpinjong Coal Mine. Accordingly, WCPL undertook a contemporary investigation of private groundwater bore locations and use in 2015 to support the Wilpinjong Extension Project Groundwater Assessment (HydroSimulations, 2015). This investigation found that bores on private or public land in the vicinity of the Wilpinjong Coal Mine are limited to:

- one bore at Wollar Public School that is used for watering recreational areas and gardens; and
- one privately-owned bore (GW063717) to the south west of the Wilpinjong Coal Mine for stock and domestic use. This land has subsequently been purchased by MCO.

The Wollar Public School bore is screened in the Shoalhaven Group, which is relatively low-yielding. The bore is 60 m deep, with approximately 40 to 50 m of available drawdown. The maximum predicted drawdown is 6 m, meaning that the bore is unlikely to go dry as a result of the Wilpinjong Coal Mine (HydroSimulations, 2015).

5 Groundwater Predictions

Contemporary groundwater modelling of the effects of the Wilpinjong Coal Mine was undertaken for the Wilpinjong Extension Project Groundwater Assessment (HydroSimulations, 2015). The key outcomes of this groundwater modelling are provided in the following sub-sections.

5.1 Mine Inflows and Groundwater Licensing

The average predicted pit inflows (combined) over the life of the Wilpinjong Coal Mine are predicted to generally range from approximately 0.7 ML/day to 4.5 ML/day and average approximately 1.9 ML/day (712 ML/year), with the majority derived from the porous rock groundwater system.

The predicted annual groundwater volumes required to be licensed over the life of the Wilpinjong Coal Mine and post-mining are summarised in Table 6.

Table 6
Estimated Groundwater Licensing Requirements

Groundwater Source	Existing Peabody /WCPL Licences (units)	Total Licensing Requirement (units)		
		During Mining	Post-Mining (2033-2045)	Post-Mining (2045-2100)
Wollar Creek Alluvium[1]	474	171	143	147
Goulburn River Alluvium[2]	511	<10*	<10*	<10*
Porous Hard Rock[3]	2,021	1,099	Nil	Nil

Source: After HydroSimulations (2015).

1 Wollar Creek Water Source under the *Water Sharing Plan Sharing Plan for the Hunter Unregulated and Alluvial Sources, 2009*.

2 Goulburn River Water Source under the *Water Sharing Plan Sharing Plan for the Hunter Unregulated and Alluvial Sources, 2009*.

3 Sydney Basin – North Coast Water Source under the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*.

* Groundwater modelling results indicate that the take from the Goulburn River alluvium will be small, with a maximum take of some 10 ML/a. Given the groundwater model overestimates drawdown in the Ulan Seam north of the mine, it is considered that the take in practice would be much less than the modelled maximum take of 10 ML/a, probably less than 1-2 ML/a, which for licensing purposes is considered to be negligible (HydroSimulations, 2016). Notwithstanding, DPI Water has requested that the full 10 ML/a amount is licensed.

WCPL will meter water used under WCPL water access licences for pastoral practices so that the combined water take from mining and pastoral activities remains below the licensed volume.

5.2 Porous Rock Groundwater System

As mining operations progress, each open cut acts as a localised groundwater sink. This will cause a change in groundwater flow direction and, in some places, a localised reversal of flow direction.

There will also be a change in hydraulic properties where the waste rock is subsequently used to backfill the mine voids. As waste rock will have a higher permeability than natural rock material (associated with the porous rock groundwater system), there will be associated reductions in localised hydraulic gradients.

Numerical modelling predicts a substantial reduction in potentiometric head in the deeper porous rock groundwater system (Illawarra Coal Measures) in the near vicinity of the Wilpinjong Coal Mine as a result of cumulative mining activities.

Recovery of the groundwater water table and pressures within the porous rock groundwater system is predicted to occur over many decades following the cessation of mining.

The Pit 2 and Pit 6 final void lakes will remain as permanent and localised groundwater sinks. At equilibrium, natural groundwater flow direction is expected to be restored to a dominant northerly direction through the mine footprint toward Wilpinjong Creek, with the exception of around the Pit 2 and Pit 6 final voids.

There will be no discernible deterioration in groundwater quality in the porous rock groundwater system as a result of mining, including in the long term.

5.3 Alluvial Groundwater System

The numerical modelling conducted for the Wilpinjong Coal Mine predicts minimal drawdown (approximately 1 m) in the aquifers of the shallow alluvial groundwater system along Wilpinjong Creek. Drawdowns are predicted to be even less pronounced in the more distant alluvial aquifers associated with Wollar Creek.

There will be no discernible deterioration in groundwater quality in the alluvial groundwater system as a result of mining, including in the long term.

5.4 Groundwater Users

No groundwater drawdown exceeding the NSW Aquifer Interference Policy (NSW Government, 2012) minimal harm criterion of 2 m at a sub-surface water supply construction such as a bore or well is predicted to occur on any privately owned land.

Drawdown exceeding the NSW Aquifer Interference Policy (NSW Government, 2012) minimal harm criterion of 2 m is however predicted at one bore in the porous rock aquifer located on Crown land at the Wollar Public School.

The Wollar Public School bore is screened in the Shoalhaven Group, which is relatively low-yielding. The bore is 60 m deep, with approximately 40 to 50 m of available drawdown. The maximum predicted drawdown is 6 m, meaning that the bore is unlikely to go dry as a result of the Wilpinjong Coal Mine.

Consistent with the requirements of the NSW Aquifer Interference Policy (NSW Government, 2012), WCPL will continue to implement appropriate contingency measures for Wilpinjong Coal Mine related drawdown greater than 2 m at any relevant private bore or the Wollar Public School bore. Appropriate contingency measures for an impact on a groundwater supply user may include:

- deepening the affected groundwater supply;
- construction of a new groundwater supply; or
- provision of a new alternative water supply.

WCPL met with the Wollar Public School in April 2016 to discuss the groundwater drawdown predictions at the school bore and the future availability of make good provisions, should these be required.

6 Groundwater Monitoring Program

6.1 Groundwater Levels and Quality

The historical and baseline groundwater monitoring networks (Sections 4.1 and 4.2) have been progressively updated to include additional monitoring bores as mining progresses (Figure 2).

Key updates to the groundwater monitoring program include:

- 28 monitoring bores (PZ01 to PZ28) were installed adjacent to Pit 1 and Pit 2 to monitor tailings dam seepage from tailings dams TD1, TD2 and TD3.
- Four monitoring bores (PZ29 to PZ32) were installed adjacent to Pits 3 and 4 in 2012.
- WCPL converted 20 exploration boreholes into monitoring bores 2013 – 2014 (GWc16 to GWc35).
- WCPL also developed some alluvial holes specifically for groundwater monitoring in 2013 – 2014 (GWa16[2], GWa22 and GWa33).
- Two bores were installed into backfilled material in Pits 1 and 5 in 2014 (GWf1 and GWf2).

The first 14 tailings dam piezometers (PZ01 to PZ14) were monitored for water level, pH and electrical conductivity (EC) from April 2008 to December 2011. The second group (PZ15 to PZ28) were monitored for water level, pH and EC from November 2009 to December 2011. Additional bores (PZ29 to PZ32) were installed in 2012 adjacent to Cumbo Creek. Tailings dams TD1 to TD5 have been decommissioned and are being progressively capped and rehabilitated. As a result, WCPL discontinued monitoring at these locations. Following installation of belt press filters, TD6 is only used as an emergency storage. However, as recommended by the IESC, WCPL will resume monitoring at four piezometers in the vicinity of the tailings dams (PZ13, PZ20, PZ21 and PZ26).

The exploration bores being converted to groundwater monitoring bores, or developed specifically for groundwater monitoring in 2013 – 2014 have been installed with real time dataloggers and subject to hydraulic testing and water quality and level monitoring (Groundwater Exploration Services Pty Ltd, 2013).

A summary of the complete Wilpinjong Coal Mine groundwater monitoring network is provided in Table 7, including the frequency at which groundwater levels are monitored.

A summary of historical water quality monitoring and planned ongoing water quality monitoring is provided in Table 8. The planned ongoing water quality monitoring has considered the following recommendations from IESC:

- Include analyses for molybdenum in the groundwater sampling program.
- Monthly and event based metals monitoring.

The incorporation of monthly metals monitoring will assist with identifying seepage from nearby backfilled open cut pits and decommissioned tailings dams.

[2] GWa16 is being re-drilled in 2017 due to operational reasons.

Table 7
Groundwater Monitoring Network

Monitoring Site	Geology	Start Date	End Date	Frequency (levels)	Location
GWa1, GWa2, GWa3, GWa4	Alluvium	20 April 2006	-	12 hours	Wilpinjong Creek
GWa7	Alluvium	14 April 2008	-	monthly	Wilpinjong Creek
GWa5, GWa6	Alluvium	20 April 2006	-	monthly	Cumbo Creek
GWa8	Alluvium	20 April 2006	-	monthly	Wollar Creek
GWa10, GWa11, GWa12, GWa14, GWa15	Alluvium	May-June 2007	-	15 minute	Wilpinjong Creek
GWc1, GWc2, GWc3	Ulan Coal	20 April 2006	-	monthly	Wilpinjong Creek
GWc4, GWc5	Ulan Coal	20 April 2006	-	monthly	Wollar Creek
GWc10, GWc11, GWc12, GWc14, GWc15	Ulan Coal	20 April 2006	-	15 minute	Wilpinjong Creek
DB1, DB2	Ulan Coal	23 May 2006	1 April 2007	monthly	Pit 1
DB6, DB7	Ulan Coal	30 July 2006	1 April 2007	monthly	Pit 1
DB3, DB4, DB5	Ulan Coal	30 July 2006	1 April 2007	monthly	Pit 2 - Pit 4
PZ01 – PZ14	Coal Measures	28 April 2008	30 Dec 2011	monthly	Pit 1
PZ15 – PZ28	Coal Measures	12 Nov 2009	30 Dec 2011	monthly	Pit 1 - Pit 2
PZ29 – PZ32	Coal Measures	19 Nov 2012	-	-	adjacent Pits 3 and 4
GWa16	Alluvium	Nov-Dec 2013	-	12-hourly	Wilpinjong Creek
GWc16	Ulan Coal	Nov-Dec 2013	-	daily	Wilpinjong Creek
GWc17, GWc18	Ulan Coal	Nov-Dec 2013	-	daily	Pit 6
GWc22	Ulan Coal	Nov-Dec 2013	-	daily	Pit 4
GWa22	Alluvium	Nov-Dec 2013	-	12-hourly	Cumbo Creek/Pit 4
GWc23	Marrangaroo Formation	Nov-Dec 2013	-	12-hourly	Pit 7
GWc24	Ulan Coal	Nov-Dec 2013	-	daily	Pit 7
GWc25	Ulan Coal	Nov-Dec 2013	-	daily	Pit 5
GWc26	Permian overburden	Nov-Dec 2013	-	daily	Wilpinjong Creek North of Pit 6
GWc27	Permian overburden	Nov-Dec 2013	-	daily	South of Pit 2
GWc28, GWc29	Ulan Coal	Nov-Dec 2013	-	daily	Pit 8 - north
GWc30, GWc31	Ulan Coal	Nov-Dec 2013	-	daily	Pit 8 - south
GWa32, GWa34	Alluvium	Nov-Dec 2013	-	12-hourly	Wollar Creek
GWc32	Moolarben Coal	Nov-Dec 2013	-	daily	Wollar Creek
GWc34	Shoalhaven Group	Nov-Dec 2013	-	daily	Wollar Creek - south
GWf1	Spoil (final landform)	2014	-	daily (logger)	Pit 1
GWf2		2014	-	monthly	Pit 5

Table 8
Groundwater Quality Monitoring

Monitoring Locations		Historical Monitoring		Planned Monitoring	
		Frequency	Parameters	Frequency	Parameters
Water Supply Bores	GWs10, GwS11, GWs12, GWs14, GWs15	Monthly (During Extraction)	Water level, field pH and EC. Volume of water extracted.	Monthly (During Extraction)	Water level, field pH and EC. Volume of water extracted.
Alluvial Bores	GWa1, GWa2, GWa3, GWa4, GWa5, GWa6, GWa7, GWa8, GWa10, GWa11, GWa12, GWa14, GWa15, GWa16, GWa22, GWa32, GWa33	Monthly	Water level, temperature field pH and EC.	Monthly	Water level, temperature field pH and EC.
		Quarterly	TDS, Na, K, Mg, Ca, Cl, HCO_3, $CaCO_3$, SO_4 and Metals (Copper, Zinc, Iron, Aluminium, Nickel, Manganese, Barium, Strontium, Lead, Arsenic and Selenium).		TDS, Na, K, Mg, Ca, Cl, HCO_3, $CaCO_3$, SO_4 and Metals (Copper, Zinc, Iron, Aluminium, Nickel, Manganese, Barium, Strontium, Lead, Arsenic, Selenium and Molybdenum.
Coal Measures Bores	GWc1, GWc2, GWc3, GWc4, GWc5, GWc10, GWc11, GWc12, GWc14, GWc15, GWc16, GWc17, GWc18, GWc19, GWc20, GWc22, GWc23, GWc24, GWc25, GWc26, GWc27, GWc28, GWc29, GWc30, GWc31, GWc33, GWc32,GWc345, GWc35	Monthly	Water level, temperature, field pH and EC.	Monthly	Water level, temperature field pH and EC.
		Quarterly	TDS, Na, K, Mg, Ca, Cl, HCO_3, $CaCO_3$, SO_4 and Metals (Copper, Zinc, Iron, Aluminium, Nickel, Manganese, Barium, Strontium, Lead, Arsenic and Selenium).		TDS, Na, K, Mg, Ca, Cl, HCO_3, $CaCO_3$, SO_4 and Metals (Copper, Zinc, Iron, Aluminium, Nickel, Manganese, Barium, Strontium, Lead, Arsenic, Selenium and Molybdenum.
Tailings Dam Bores	PZ13, PZ20, PZ21 and PZ26	Nov 2009 to Dec 2011. Discontinued after 2011.	Water level, pH and EC.	Monthly	Water level, temperature field pH and EC. TDS, Na, K, Mg, Ca, Cl, HCO_3, $CaCO_3$, SO_4 and Metals (Copper, Zinc, Iron, Aluminium, Nickel, Manganese, Barium, Strontium, Lead, Arsenic, Selenium and Molybdenum.
Landholder bores, wells and waterholes		As required	To be determined	As required	To be determined

6.2 Groundwater Testwork

Consistent with the IESC's recommendation, WCPL would opportunistically undertake core sampling and testing during exploration drilling within or near the Wilpinjong Coal Mine. Where practicable, aquifer properties such as effective porosity, horizontal permeability and vertical permeability would be determined. Core samples would be obtained and tested from a minimum of two boreholes annually until the end of 2020. The outcomes of testwork would be incorporated into progressive groundwater model reviews that would be undertaken every three years (Section 6.4).

WCPL would create and maintain a database of testing data, which would be used to constrain and validate model parameters and guide any future groundwater assessments.

Consistent with the IESC's recommendation, core testing would also include solubility studies of waste and reject material for key metals identified in past geochemistry assessments at the Wilpinjong Coal Mine (i.e. arsenic, selenium and molybdenum).

6.3 Final Landform Monitoring

WCPL has installed two bores in backfilled open cuts in 2014 (GWf1 in Pit 1 and GWf2 in Pit 5).

These bores will continued to be monitored in order to provide data for future groundwater modelling (e.g. recharge rates through spoil, spoil permeabilities, and to validate modelling assumptions and predictions.

WCPL will also install and monitor an additional bore in the Pit 8 final landform (assuming GWc31 is removed by mining as planned).

6.4 Groundwater Modelling Review

The numerical model developed and used for the Wilpinjong Extension Project Groundwater Assessment (HydroSimulations, 2015) would be used as a management tool for the periodic review and calibration of predicted groundwater impacts through the life of the Wilpinjong Coal Mine. Consistent with Dr Frans Kalf's recommendation in his Peer Review of the Wilpinjong Extension Project Groundwater Assessment, this review would be undertaken at least every five years after commencement of the Wilpinjong Extension Project, over the life of the Wilpinjong Coal Mine. WCPL will undertake numerical groundwater model reviews every three years and will include any available data obtained from testwork undertaken in accordance with Section 6.2.

The results of the groundwater monitoring program would inform progressive refinement of the numerical model as each of the open cut mining areas is developed. Revised outputs from the numerical model would be reported in the Annual Review, as relevant over the life of the Wilpinjong Coal Mine and used to inform regular site water balance reviews (refer to Site Water Balance for additional information).

6.5 Groundwater Dependent Ecosystems

There are no 'high priority groundwater dependent ecosystems identified in the relevant water sharing plans in the vicinity of the Wilpinjong Coal Mine.

There is potential for groundwater dependent ecosystems to occur on the plateaus in the vicinity of the Wilpinjong Coal Mine. However, any groundwater dependent ecosystems on these plateaus would be accessing perched groundwater systems associated with the Narrabeen Group and would not be affected by mining in the deeper strata (HydroSimulations, 2015).

Wilpinjong Creek is considered to be a groundwater dependent ecosystem (i.e. the stream and associated riparian vegetation). Groundwater interaction between Wilpinjong Creek and the underlying alluvium varies with time. Wilpinjong Creek is generally a gaining stream, however, there have been occasions when in some sections there has been a brief reversal of gradient between the stream water level and the water table level (WRM Water and Environment, 2015).

The alluvial groundwater monitoring described in Section 6.1 would assist with monitoring for potential mine-related effects on the stream. Annual stream health monitoring (described in the SWMP) would monitor for effects on the riparian vegetation in Wilpinjong Creek.

7 Trigger levels

7.1 Groundwater Levels

7.1.1 Mining Effect

Numerical modelling predicts a substantial reduction in potentiometric head in the deeper porous rock groundwater system (Illawarra Coal Measures) in the near vicinity of the Wilpinjong Coal Mine as a result of cumulative mining activities (Section 5.2). Accordingly, trigger levels for water levels in the coal measures are not considered to be warranted.

The numerical modelling conducted for the Wilpinjong Coal Mine predicts minimal drawdown (approximately 1 m) in the aquifers of the shallow alluvial groundwater system along Wilpinjong Creek. Drawdowns are predicted to be even less pronounced in the more distant alluvial aquifers associated with Wollar Creek.

Trigger levels are required for alluvial monitoring bores to monitor for potentially adverse groundwater impacts and effects beyond those predicted in the groundwater modelling. Accordingly, trigger levels are proposed to be established for alluvial monitoring bores at 1 m below the previous minimum recorded water level in the bore.

The alluvial deposits along Wilpinjong Creek are very thin in places (Section 4.3). Therefore, some of the alluvial bores are not deep enough to be used for trigger levels. The relevant details and proposed trigger levels for the alluvial monitoring bores are presented in Table 9. Three successive monthly exceedances (or two successive quarterly exceedances) of the lower thresholds will trigger an investigation.

Table 9
Alluvial Monitoring Bore Details and Water Level Triggers

Monitoring Site	Depth (mbgl)	Screened Interval (mbgl)	Deepest Observed SWL in Baseline Period		Trigger Level	
			mbgl	mAHD	mbgl	mAHD
GWa1	5.0	1.5 – 5.0	DRY	DRY	N/A	N/A
GWa2	9.0	3.0 – 8.5	2.8	373.4	3.8	372.4
GWa3	4.5	2.0 – 4.5	3.9	360.5	DRY*	DRY*
GWa4	4.5	2.6 – 4.1	3.3	353.8	DRY*	DRY*
GWa5	4.3	2.4 – 3.9	1.6	372.8	2.6	371.4
GWa7	4.6	2.7 – 4.2	DRY	DRY	N/A	N/A
GWa8	3.6	2.1 – 3.6	2.8	353.3	DRY*	DRY*
GWa10	5.3	3.4 – 4.9	3.5	367.1	4.5	366.1
GWa11	3.9	2.0 – 3.5	3.5	365.2	DRY*	DRY*
GWa12	4.7	2.8 – 4.3	3.3	362.3	4.3	361.3
GWa14	4.1	2.2 – 3.7	3.3	358.0	DRY*	DRY*
GWa15	3.5	1.6 – 3.1	2.9	355.0	DRY*	DRY*

* Historical observations at these groundwater bores have indicated SWLs that represent less than 1 m of head in the bore. Therefore, these bores could go dry without indicating a mining effect that exceeds the predicted 1 m drawdown. For these bores, a statistical analysis will be performed on the number of dry days to determine whether there are significantly more than could be expected under natural conditions.

7.1.2 Water Supply Borefield Effect

WCPL commissioned AGE to investigate and determine reporting and cease-to-pump triggers for licensed production bores WSB10, WSB11, WSB12, WSB14 and WSB15 (Section 4.2.2.2) (AGE, 2005).

Triggers have been determined based on the expected maximum drawdown, as a result of the development of the open cut and water supply borefield.

Importantly, WCPL has not pumped water from the production bores since June 2007 (WCPL has used the water stored in mine water storages and open cut pits for operational water requirements). Notwithstanding, cease to pump levels for the water supply bores are presented in Table 10.

Table 10
Water Supply Borefield – Cease to Pump Trigger Levels

Production Bore	Groundwater Bore	Cease-to-Pump Trigger Level (m AHD)	Expected Maximum Drawdown Level (m AHD)
WSB10	GWs10	346	341
WSB11	GWs11	348.5	344
WSB12	GWs12	332.5	327
WSB14	GWs14	319.5	311
WSB15	GWs15	314.5	305

In addition, WCPL has installed a monitoring bore in the alluvium at a site located between the bores authorised by WCPL's water supply licences and Wilpinjong Creek (GWa16)[3]. The water level in GWa16 will be recorded at daily intervals during pumping from the water supply borefield.

7.1.3 Private Landholders and Wollar Public School

Bores on private or public land in the vicinity of the Wilpinjong Coal Mine are limited to (Section 4.5):

- one bore at Wollar Public School that is used for watering recreational areas and gardens; and
- one formerly privately-owned bore (GW063717) to the south west of the Wilpinjong Coal Mine for stock and domestic use. This land has subsequently been purchased by MCO.

Drawdown exceeding the NSW Aquifer Interference Policy (NSW Government, 2012) minimal harm criterion of 2 m is predicted at one bore in the porous rock aquifer located on Crown land at the Wollar Public School (HydroSimulations, 2015).

The Wollar Public School bore is screened in the Shoalhaven Group, which is relatively low-yielding. The bore is 60 m deep, with approximately 40 to 50 m of available drawdown and will be monitored by WCPL on a quarterly basis. The maximum predicted drawdown is 6 m, meaning that the bore is unlikely to go dry as a result of the Wilpinjong Coal Mine (HydroSimulations, 2015).

[3] GWa16 is being re-drilled in 2017 due to operational reasons.

Should WCPL receive notice from the Wollar Public School that they have observed a decrease in water level and/or reduction in yield from the bore, WCPL would initiate an investigation to determine whether the Wilpinjong Coal Mine has resulted in greater than 2 m drawdown at the bore. If the investigation indicates that a greater than 2 m drawdown effect has occurred as a result of the Wilpinjong Coal Mine, WCPL would implement the contingency measures described in Section 8.1.4.

7.2 Groundwater Quality

The baseline monitoring results indicate that despite fluctuations in some water quality parameters, groundwater quality has remained relatively consistent at each coal monitoring location throughout the period of monitoring. However, some alluvial monitoring bores have recorded very high salinities and very large fluctuations in salinity.

The groundwater monitoring program has indicated that baseline concentrations of EC in the aquifers are always outside of the ANZECC and ARMCANZ (2000) default trigger values, while pH deviations from the default range are uncommon. Water quality records have been examined for baseline data collected from 2004 to 2009 (i.e. the established baseline data period) and grouped according to lithology.

The means, standard deviations, 80th percentiles and maxima are presented in Table 11 for EC and Table 12 for pH.

Table 11
Baseline Water Quality EC Statistics per Lithology

Aquifer Type	EC (µS/cm)			
	Mean	Standard Deviation	80th percentile	Maximum
Alluvium	4,610	3,830	8,800	15,340
Coal	2,740	1,250	3,600	7,500
Coal Measures	3,340	1,560	5,240	2,380

Table 12
Baseline Water Quality pH Statistics per Lithology

Aquifer Type	pH			
	Mean	Standard Deviation	80th percentile	Maximum
Alluvium	7.0	0.4	7.3	8.4
Coal	7.1	0.5	7.3	11.9
Coal Measures	6.5	1.5	7.1	11.3

For trigger purposes, the water quality statistics for April 2006 to December 2009 have been analysed for EC and pH at the alluvium and coal monitoring sites. The means, standard deviations, 80th percentiles and maxima are presented in Table 13 for EC.

Although ANZECC and ARMCANZ (2000) recommend using the 80th percentile values as being suitable for trigger values, a trigger would be initiated 20 percent of the time due to natural causes.

For the trigger to be a meaningful indicator of a possible mining effect, an investigation should not be triggered unless the 80th percentile value is exceeded on either of:

- Three consecutive monthly monitoring events; or
- Two consecutive quarterly monitoring events.

Table 13
Baseline Water Quality EC Statistics per Bore

Monitoring Site	Aquifer Type	EC (µS/cm)			
		Mean	Standard Deviation	80th percentile Criteria	Maximum
GWa1	Alluvium	8,409	3,721	12,272	12,730
GWa2	Alluvium	1,816	602	2,280	3,300
GWa3	Alluvium	1,577	398	1,970	2,050
GWa4	Alluvium	2,409	340	2,596	3,100
GWa5	Alluvium	10,634	3,204	13,926	15,340
GWa6	Alluvium	5,592	1,604	6,720	10,140
GWa7	Alluvium	9,130	2,575	10,126	10,490
GWa8	Alluvium	2,342	580	2,898	3,700
GWc1	Coal	2,341	476	2,844	3,260
GWc2	Coal	1,134	159	1,290	1,400
GWc3	Coal	3,144	248	3,304	3,800
GWc4	Coal	2,314	213	2,412	2,800
GWc5	Coal	4,665	574	4,798	6,030

The minima, 20th percentiles, 80th percentiles and maxima are presented in Table 14 for pH.

In accordance with the previous version of the Water Management Plan (approved in October 2016), the ANZECC and ARMCANZ (2000) default trigger values (6.5 - 8.0) will be used at all sites rather than using slightly different values at individual bores, as the default range captures all 20th and 80th percentile values.

Table 14
Baseline Water Quality pH Statistics per Bore

Monitoring Site	Aquifer Type	pH			
		Minimum	20th percentile	80th percentile	Maximum
GWa1	Alluvium	6.8	6.9	7.2	7.6
GWa2	Alluvium	6.0	6.6	7.0	7.8
GWa3	Alluvium	6.3	6.6	7.3	7.8
GWa4	Alluvium	6.1	6.8	7.1	7.4
GWa5	Alluvium	6.4	6.7	7.1	7.9
GWa6	Alluvium	7.1	7.3	7.6	7.8
GWa7	Alluvium	6.6	6.7	7.0	7.7
GWa8	Alluvium	6.6	7.0	7.4	7.7
GWc1	Coal	6.2	6.8	7.2	7.7
GWc2	Coal	6.8	7.1	7.7	8.0
GWc3	Coal	6.4	6.6	7.3	7.8
GWc4	Coal	6.5	6.7	7.1	8.0
GWc5	Coal	6.5	6.8	7.0	7.9

8 Groundwater Response Plan

This section outlines WCPL's Trigger Action Response Plans (TARPs) in the event that trigger conditions established in Section 7 are exceeded.

Where applicable, these response protocols remain consistent with the approved protocols previously agreed with DP&E and the relevant consultees in the previous version of the Water Management Plan (approved in October 2016).

8.1 Groundwater Levels

8.1.1 Mining Effect

Trigger levels for alluvial monitoring bores have been set based on the predicted impacts of the Wilpinjong Coal Mine (incorporating the Wilpinjong Extension Project) (Section 7.1.1). Three successive monthly exceedances (or two successive quarterly exceedances) of the lower thresholds will trigger an investigation. In the event that one of the trigger levels is exceeded, the response protocol in Table 15 would be implemented.

Table 15
Groundwater Levels – Mining Effect TARPs

TARP	
Trigger	• Three consecutive water monitoring results cause trigger to be exceeded (Section 6.1).
Action	1. Notify the WCPL ECM. 2. Check and validate the data which indicates an exceedance of the trigger conditions. 3. Notify DP&E, EPA, DPI Water and other relevant agencies as soon as practicable that an exceedance of the trigger level has occurred and investigation will be undertaken. 4. Check and validate the data which indicates an exceedance of the trigger conditions. 5. Identify plausible and possible causative mechanisms and assess/quantify these against all relevant data and information to identify most likely causes. 6. Conduct a preliminary investigation with a review of the monitoring results in conjunction with site activities being undertaken at the time, baseline groundwater monitoring results, groundwater results at nearby locations, the prevailing and preceding meteorological and streamflow conditions and changes to the landuse/activities being undertaken in the contributing hydrogeological regime, including mining activities. 7. Review groundwater modelling (Section 6.4). 8. Provide a preliminary investigation report to DP&E, EPA DPI Water and relevant agencies within 7 days of identifying the non-compliance.

Table 15 (continued)
Groundwater Levels – Mining Effect TARP

TARP	
Response	• Where monitoring results indicate values exceeding the relevant threshold of acceptable variance or impact assessment criteria, conduct a further detailed risk based investigation. • Develop/design contingency and remedial measures based on the results of the above investigations. Contingency and remedial measures considered practical for implementation may include: o Undertake landholder and government consultation; o Offset groundwater leakage from the Wilpinjong Creek alluvial aquifer; o Review and refine the GWMP including undertaking additional specific monitoring of private landholder bores; o Review Site Water Balance and predictive groundwater model; o Review mine plan impacts on alluvial groundwater source.
Plan	• Communicate results of investigation and subsequent contingency and remedial measures to government agencies as required and summarise in the Annual Review. • If required, review and update the WMP and resubmit to DP&E. • Where an investigation determines that an exceedance of the water management performance measures in Table 6 of Development Consent SSD-6764, WCPL would (in accordance with Schedule 5, Condition 2 of Development Consent SSD-6747): o take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur; o consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and o implement reasonable remediation measures as directed by the Secretary.

8.1.2 Groundwater Predictions

Groundwater monitoring results will be used for the verification and refinement of the groundwater model (Section 6.4). A TARP has been developed in the event that monitored groundwater effects are materially different from the groundwater model predictions (Table 16).

Volumes of water pumped directly from the open cut pits will be monitored and the data recorded by means of flow meters fitted to pipelines or recording of pumping times and rates. Water reporting to the open cut pits may include both groundwater seepage inflows and incident rainfall and runoff.

Estimates of seepage inflows to the open cut will be determined using the most contemporary available groundwater model. The rainfall runoff component estimates will also be determined where appropriate for comparison using the rainfall records and the existing site water balance model.

8.1.3 Water Supply Borefield

Cease to flow triggers for pumping from the water supply borefield have been established in Section 7.1.2. If the monitoring results indicate the cease-to-pump trigger level is exceeded, the TARP in Table 17 will be initiated.

8.1.4 Private Landholders and Wollar Public School

Consistent with the requirements of the NSW Aquifer Interference Policy (NSW Government, 2012), WCPL would continue to implement appropriate contingency measures for Wilpinjong Coal Mine related drawdown greater than 2 m at any relevant private bores or the Wollar Public bore (Section 7.1.3).

Appropriate contingency measures for an impact on a groundwater supply user may include:

- deepening the affected groundwater supply;
- construction of a new groundwater supply; or
- provision of a new alternative water supply.

8.2 Groundwater Quality

Water quality triggers for groundwater have been developed in accordance with the ANZECC Guidelines for Fresh and Marine Water Quality (2000). The development and detail of these triggers is discussed in Section 7.2. For the trigger to be a meaningful indicator of a possible mining effect, an investigation should not be triggered unless the 80th percentile value is exceeded on either of:

- three consecutive monthly monitoring events; or
- two consecutive quarterly monitoring events.

In the event that one of the trigger levels is exceeded, the response protocol in Table 18 will be implemented.

8.3 Groundwater Dependent Ecosystems

A stream health monitoring program has been developed to detect any potential changes in aquatic biology in Wilpinjong and Cumbo Creeks. Annual channel stability surveys are also undertaken to monitor the quantity and quality of riparian vegetation along Wilpinjong and Cumbo Creeks and to determine the need for any maintenance and/or contingency measures. This program and the development of stream health triggers are discussed in the SWMP.

In the event that deterioration is identified in Wilpinjong Creek, which is identified as a groundwater dependent ecosystem (Section 6.5), during stream health monitoring or annual channel stability surveys, the processes outlined in the SWMP will be implemented.

Table 16
Groundwater Levels – Groundwater Predictions TARP

TARP	
Trigger	• Monitored maximum groundwater drawdowns deviate by more than 50% from predictions made in the EA. • Increased groundwater make in the open cut workings compared to predictions made in the EA or any other subsequent assessment. • Consecutive pressure monitoring data from the regional monitoring network, over a period of six months, shows an unexpected effect from the previous data or groundwater model predictions; or • Annual review of the depressurisation of the coal measures shows an unexpected effect from the previous data or groundwater model predictions.
Action	1. Notify the WCPL ECM. 2. Check and validate the data which indicates an exceedance of the trigger conditions. 3. Notify DP&E, EPA and other relevant agencies as soon as practicable that an exceedance of the trigger level has occurred and investigation will be undertaken. 4. Conduct a preliminary investigation with a review of the monitoring results in conjunction with site activities being undertaken at the time, baseline groundwater monitoring results, groundwater results at nearby locations, the prevailing and preceding meteorological and streamflow conditions and changes to the landuse/activities being undertaken in the contributing hydrogeological regime, including mining activities. 5. Engage a qualified groundwater consultant to review monitoring data against the groundwater model and confirm if the model assumptions are correct/ reflect what is occurring in the mine. 6. Provide a preliminary investigation report to DP&E, EPA and relevant agencies within 7 days of identifying the exceedance.

Response	• Develop/design contingency and remedial measures based on the results of the above investigations. Contingency and remedial measures considered practical for implementation may include:
	  ○ review and refine this GWMP;
	  ○ identify if the installation of additional piezometers is required;
	  ○ review and refine the Site Water Balance and predictive groundwater model;
	  ○ review mine plan impacts on alluvial groundwater source;
	  ○ consult with relevant government agencies on investigation and outcomes;
	  ○ repair, replace, or construct new water management infrastructure.

Plan	• Communicate results of investigation and subsequent contingency and remedial measures to government agencies as required and summarise in the Annual Review.
	• If required, review and update the WMP and resubmit to DP&E.
	• Where an investigation determines that an exceedance of the water management performance measures in Table 6 of Development Consent SSD-6764, WCPL would (in accordance with Schedule 5, Condition 2 of Development Consent SSD-6747):
	  ○ take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur;
	  ○ consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and
	  ○ implement reasonable remediation measures as directed by the Secretary.

Table 17
Groundwater Levels – Water Supply Borefield TARP

TARP	
Trigger	• Monitoring results exceed the relevant reporting trigger or cease-to-pump trigger in Section 7.1.2.
Action	1. Notify the WCPL ECM. 2. Turn off the relevant production bore until the investigation under this protocol is completed. Pumping from the relevant production bore will not recommence until such time as it can be determined that the predicted maximum drawdown is unlikely to be exceeded within the next six months or the groundwater level recovers to a level above the relevant cease-to-pump trigger. 3. Check and validate the data which indicates an exceedance of the trigger conditions. 4. Notify DP&E, EPA, DPI Water and other relevant agencies as soon as practicable that an exceedance of the trigger level has occurred and investigation will be undertaken. 5. Conduct a preliminary investigation with a review of the monitoring results in conjunction with baseline groundwater monitoring results, groundwater monitoring at nearby locations, the prevailing and preceding meteorological and streamflow conditions and changes to the landuse/ activities being undertaken in the contributing hydrogeological regime including mining activities. 6. Provide a preliminary investigation report to DP&E, EPA, DPI Water and relevant agencies within 7 days of identifying the non-compliance.
Response	• Develop contingency and remedial measures based on the results of the above investigations. Contingency and remedial measures considered practical for implementation may include: o Source alternative water supply whilst affected bore is offline; o Inspect affected bore to ensure it is operating effectively and the monitoring equipment is providing reliable results; o Undertake landholder and government consultation; o Review and refine the GWMP; o Review Site Water Balance and predictive groundwater model; o Review mine plan impacts on alluvial groundwater source.
Plan	• Communicate results of investigation and subsequent contingency and remedial measures to government agencies as required and summarise in the Annual Review. • If required, review and update the WMP and resubmit to DP&E. • Where an investigation determines that an exceedance of the water management performance measures in Table 6 of Development Consent SSD-6764, WCPL would (in accordance with Schedule 5, Condition 2 of Development Consent SSD-6747): o take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur; o consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and o implement reasonable remediation measures as directed by the Secretary.

Table 18
Groundwater Quality TARP

TARP	
Trigger	• Three consecutive monthly water monitoring results, or • Two consecutive quarterly monitoring results, cause water quality impact triggers to be exceeded.
Action	1. Notify the WCPL ECM. 2. Check and validate the data which indicates an exceedance of the trigger conditions. 3. In the event of an apparently anomalous groundwater monitoring result, conduct a resample/retest. 4. Notify DP&E, EPA and other relevant agencies as soon as practicable that an exceedance of the trigger level has occurred and investigation will be undertaken. 5. Conduct a preliminary investigation with a review of the monitoring results in conjunction with site activities being undertaken at the time, baseline groundwater monitoring results, groundwater results at nearby locations, the prevailing and preceding meteorological and streamflow conditions and changes to the landuse/ activities being undertaken in the contributing hydrogeological regime, including mining activities. 6. Provide a preliminary investigation report to DP&E, EPA and relevant agencies within 7 days of identifying the exceedance.
Response	• Where monitoring results indicate values exceeding the relevant threshold of acceptable variance or impact assessment criteria, conduct a further detailed risk based investigation. • Develop/design contingency and remedial measures based on the results of the above investigations. Contingency and remedial measures considered practical for implementation may include: o Notification to local licensed bore water users likely to be impacted; o Provide an alternative water source during the duration of the breach; o Review and refine the GWMP including undertaking additional specific monitoring of private landholder bores; o Review Site Water Balance and predictive groundwater model; o Review mine plan impacts on alluvial groundwater source; o Repair, replace, or construct new water management infrastructure.
Plan	• Communicate results of investigation and subsequent contingency and remedial measures to government agencies as required and summarise in the Annual Review. • If required, review and update the WMP and resubmit to DP&E. • Where an investigation determines that an exceedance of the water management performance measures in Table 6 of Development Consent SSD-6764, WCPL would (in accordance with Schedule 5, Condition 2 of Development Consent SSD-6747): o take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur; o consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and o implement reasonable remediation measures as directed by the Secretary.

9 Annual Review and Improvement of Environmental Performance

The results of groundwater monitoring and groundwater modelling reviews are reported in the Annual Review. Further reporting details are provided in the WMP.

Monitoring parameters and locations will be reviewed and may be altered or discontinued as a result of changes to operations. Any revisions to the monitoring program will also be described in the Annual Review and in future revisions of this GWMP.

10 Responsibilities

Specific responsibilities for personnel in relation to this GWMP are provided in Table 19. General responsibilities for water management are contained within the WMP.

Table 19
Responsibilities

Responsibility	Task	Timing
Environment and Community Manager	Ensure appropriate resources are available for the monitoring of all groundwater parameters to meet regulatory and operational requirements.	As required
	Continue to develop and refine suitable triggers for water quality and level in conjunction with suitably quality experts.	As required
	Review production bore trigger levels prior to the reinstatement of the production bores and on a 12 monthly basis if operational. If necessary adjust the triggers in consultation with DPI Water.	Prior to the reinstatement of the production bores and on a 12 monthly once operational
	Oversee installation of new groundwater bores and licence in consultation with DPI Water.	As required
	Comply with conditions of existing groundwater licences, including reporting requirements.	At all times
	Ensure a coal measure monitoring bore and alluvial monitoring bore are constructed for each additional production bore.	As required
	Maintain sufficient groundwater licences.	As required
Environmental Representative	Coordinate groundwater monitoring program.	Refer Section 6
	Maintain monitoring records in accordance with the WMP.	At all times
	Review monitoring results against triggers in Section 7. Implement Groundwater Response Plan (Section 8) as required.	Refer Section 6 and 7
	Upon receiving a complaint from a landholder, review the relevant data set to determine whether a mine-related impact greater than 2 m has occurred.	Following a complaint
	Ensure cease to pump limits are adhered to (Section 7.1.2).	During pumping
	Coordinate updates, refinements and augmentation of the groundwater model.	Refer Section 6.4

11 References

Australasian Groundwater and Environmental Consultants Pty Limited (2005) *Wilpinjong Coal Project Groundwater Impact Assessment.*

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Barnson Pty Ltd (2014) *Geotechnical Site Assessment Report, Proposed Cumbo Creek Diversion, Wilpinjong Coal Mine, Ulan NSW*.

Geoterra Pty Limited (2004) *Hydrogeological Assessment of the Proposed Wilpinjong Open Cut Coal Mine, Wilpinjong, NSW.*

Geoterra Pty Limited (2005) *Cumbo Homestead Production Bore (PB1) Test Program, Wilpinjong, NSW.*

Groundwater Exploration Services Pty Ltd (2013) *Groundwater Field Investigation - A Groundwater Investigation Status Report for the Wilpinjong Coal Project for Wilpinjong Coal Limited, March 2014.*

Groundwater Imaging (2014) *Cumbo and Wilpinjong Creeks groundwater connection investigation geophysics*.

HydroSimulations (2013) *Wilpinjong Coal Mine Modification Groundwater Assessment.*

HydroSimulations (2015) *Wilpinjong Extension Project Groundwater Assessment*.

HydroSimulations (2016) *Wilpinjong Extension Project – Response to Residual Matters Raised by DPI Water*.

Merrick, N.P. (2005) *Pumping Test Simulation – Wilpinjong Coal Project. Access UTS Pty Ltd.* Report for Wilpinjong Coal Pty Ltd, Project No. C04/44/007, October 2005, 12p.

Murray Darling Basin Commission (1997) *Murray Darling Basin Groundwater Quality Sampling Guidelines.*

WCPL (2005) *Wilpinjong Coal Project Environmental Impact Statement*.

WCPL (2006) *WCPL Baseline Channel Stability Survey for Wilpinjong and Cumbo Creeks*.

WCPL (2015) *Wilpinjong Extension Project Environmental Impact Statement.*

WRM Water and Environment (2015) *Wilpinjong Extension Project Surface Water Assessment*.

Table A1-1
Baseline Water Quality 2004-2005

Site	Bore Type	Site Depth (mbGL)	Landholder	Aquifer System	Field pH	Field EC (µS/cm)
GW078107	Well	5.3	Conden	Cumbo Creek Alluvium (Nile Subgroup)	6.9	1300
GW080121	Bore	60+	Rheinberger	Illawara Coal Measures	6.3	2890
GW080122	Well	4	Rheinberger	Illawara Coal Measures (Wollar Creek Alluvium)	8.3	2400
GW080123	Well	3.7	Rheinberger	Illawara Coal Measures (Wollar Creek Alluvium)	7.2	4100
GW024774	Bore	91.1	Ulan Coal Mines	Illawarra Coal Measures		0 to 500
GW052937	Bore	42.7	King	Illawarra Coal Measures	6.35	5300
WP109	Bore	33.5	McDermott	Illawarra Coal Measures	6.45	5450
WP118	Well	10	WCPL	Illawarra Coal Measures	8.25	1630
WP120	Bore	16.7	Woolford	Illawarra Coal Measures	7.2	5400
GW063717	Well			Illawarra Coal Measures (below Ulan Seam)		0 to 500
GW073038	Bore	42	Batty	Illawarra Coal Measures (below Ulan Seam)	6.65	1600
EW1005	Piezo	49	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	6.35	2500
EW2007	Piezo	51.5	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	5.44	5400
EW4001	Well	48.1	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	7	2700
EW5001	Piezo	33.5	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	5.61	3900
EW5032	Piezo	20	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	6.3	3600
EW5049	Piezo	17	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	11.25	7000
EW5053	Piezo	14	WCPL	Illawarra Coal Measures (Marrangaroo Conglomerate)	6.08	2200
EW1001	Open	79.4	WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	6.63	3000
EW1002			WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	6.14	3400
EW1003			WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	6.25	2800
EW2004			WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	3.34	2800
EW2005			WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	3.59	823

Site	Bore Type	Site Depth (mbGL)	Landholder	Aquifer System	Field pH	Field EC (µS/cm)
EW2009			WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	6.35	3010
GW024775/ERUL27	Open	45.1	WCPL	Illawarra Coal Measures (Overburden / Ulan Seam / Marrangaroo Conglomerate)	8	1020
EW1020	Open	27.4	WCPL	Illawarra Coal Measures (Overburden / Ulan Seam)	6.97	2800
EW1021	Open	18.4	WCPL	Illawarra Coal Measures (Overburden / Ulan Seam)	6.51	3000
GW024779/ERUL77	Open	44.4	WCPL	Illawarra Coal Measures (Overburden / Ulan Seam)	7.6	2630
EW2011	Piezo	12	WCPL	Illawarra Coal Measures (Overburden)	6.3	5200
EW4002	Well	27.6	WCPL	Illawarra Coal Measures (Ulan Seam / Marrangaroo Conglomerate)	7.3	3720
DMCM12				Illawarra Coal Measures (Ulan Seam)	6.6	3390
EW4003	Well	36	WCPL	Illawarra Coal Measures (Ulan Seam)	6.8	2470
EW5052	Piezo	16	WCPL	Illawarra Coal Measures (Ulan Seam)	11.92	7500
GW024776/ERUL59	Open	48.8	WCPL	Illawarra Coal Measures (Ulan Seam)	7.5	1550
GW024777/ERUL67	Open	26.1	WCPL	Illawarra Coal Measures (Ulan Seam)	7.4	2330
GW024778/ERUL72	Open	31.8	WCPL	Illawarra Coal Measures (Ulan Seam)	6.6	1380
WP099	Bore	15	Fields	Mesozoic Laccolith Intrusion / Illawarra Coal Measures	6.5	1900
WP110	Bore	20+	Batey	Mesozoic Laccolith Intrusion / Illawarra Coal Measures	6.9	2550
GW078130	Well	4.7	Parker	Nile Subgroup (Cumbo Creek Alluvium)	5.4	1630
GW080128	Well	4	Robinson	Nile Subgroup (Cumbo Creek Alluvium)	7.15	2830
WP117	Well	2.5	Smith	Wilpinjong Creek Alluvium	8.36	400
WP125	Well	2.5	Patullo		7.09	6470
WP126	Bore	30+	Asmus		6.42	5900

Table A1-2
Baseline EC (µS/cm) 2006-2009

	ALLUVIUM										COAL		
Date	GWa1	GWa2	GWa3	GWa4	GWa5	GWa6	GWa7	GWa8	GWc1	GWc2	GWc3	GWc4	GWc5
20/04/2006	1500	2420	1140	2470	8700	4000		2340	2170	1000	3100	2070	5900
8/05/2006		2600	1000	2600	2600	3300		2400	2100	1000	3000	2100	4600
23/05/2006		2300	1100	2500	4600	3400		2200	2000	1000	3000	2200	3800
10/06/2006		2200	1100	2200	5200	3000		2100	1900	1000	2600	2100	3800
1/07/2006		3000	1500	3100	8300	4400		3100	2700	1400	3800	2700	5400
16/07/2006		3100	1400	2900	9600	4100		2900	2600	1300	3600	2700	5300
30/07/2006		3300	1500	3100	10800	4200		1870	3260	500	2200	2700	6030
26/08/2006		3000	1400	2700	10800	4700		3700	2600	1300	3400	2700	5500
24/09/2006		2600	1300	2800	11100	4400		3600	2300	1300	3600	2700	5300
28/10/2006		2200	1400	2700	8100	3100		3200	2000	1300	3100	2600	4800
26/11/2006		1700	1300	2600	6200	4100		2400	1900	1200	3000	2800	3400
31/12/2006		2000	1300	2400	6300	5200		2800	2300	1400	3200	2500	4500
27/01/2007		1900	1200	2300	6100	5000		2600	2000	1300	2800	2300	4400
1/03/2007		2100	1400	2500	6200	5300		2900	2200	1300	2800	2700	3900
23/04/2007		2010	1250	2420	6590			2950	2020	970	3000	2190	4780
23/05/2007		2190	1270	2410	7910	6960		2890	2120	980	2950	2150	4740
25/06/2007		1790	810	2360	9640	4780		2690	2120	980	3070	2130	4750
20/07/2007		2200	630	2280	10590	6720	1470	2600	2090	950	3020	2120	4680
22/08/2007		2170	830	2290	11550	9340		2910	2080	960	3080	2140	4760
20/09/2007		2390	1300	2910	11700	10140		2940	2120	980	3080	2170	4740
24/10/2007		2100	1780	2400	9630	5870		2470	2270	980	3090	2160	4720
22/11/2007		1890		2410	11710	5930		2560	2250		3160	2150	4030
20/12/2007		1660	1100	1720	12980	5540		2380	2210	880	3150	2150	2430
16/01/2008		1540	1800	1410	12990	5260		2470	2270	1050	3120	1860	4750

	ALLUVIUM											COAL	
Date	GWa1	GWa2	GWa3	GWa4	GWa5	GWa6	GWa7	GWa8	GWc1	GWc2	GWc3	GWc4	GWc5
15/02/2008		1510	1860	2430	11480	8530		2220	2430	1090	3170	2110	4240
19/03/2008		1390	1990	2040	14200	8800		2100	2470	1130	3180	1990	4730
14/04/2008		2560	2020	2370	9640	5420	9700	2550	1280	1160	3190	2150	4790
8/05/2008	7880	1260	1970	2270	9200	4450	8940	2290	2620	1150	3130	2170	4610
19/06/2008		1160	1970	2500	15030	5950	9800	2920	2880	1180	3200	2290	4800
16/07/2008	8010	1150	1910	2430	15200	6030	9760	2750	2880	1170	3140	2330	4730
13/08/2008	8010	1290	2020	2410	15340	6420	9850	2620	3100	1180	3160	2310	4720
3/09/2008	8020	1420	2050	1940	14750	4510	9640	2240	3050	1200	3100	2300	4720
9/10/2008	6280	1470	1260	2230	13720	6810	9710	1870	3070	1210	3100	2320	4680
6/11/2008	6490	1390	1730	2210	13870	6760	10290	1760	3200	1220	3120	2350	4780
4/12/2008	6560	1320	1950	1320	13940	7580	10050	1680	3160	1220	3070	2300	4730
8/01/2009	3560	1260	2050	2090	13480	7950	10130	1280	3170	1150	3080	2340	4730
19/02/2009	1020	1250	2000	2520	10910	6300	10040	1750	3230	1130	3120	2290	4730
11/03/2009	9890	1280	1980	2350	10040	4300	9970	1680	2520	1140	3180	2250	4660
22/04/2009	10760	1210	1940	2560	9240	6150	1000	1700	2230	1150	3330	2370	4730
12/05/2009	11130	1200	1870	2640	8870	5030	9800	1700	2120	1150	3250	2310	4660
19/06/2009		1210	1830	2460	9370	4100	9880	1650	1760	1160	3280	2330	4500
8/07/2009	11900	1260	1810	2490	11240	5150	9880	1710	1750	1170	3330	2340	4720
12/08/2009	12560	1320	1840	2510	14870	5610	10180	1840	1860	1190	3370	2310	4550
7/09/2009	12520	1270	1920	2460	14870	5610	10110	1850	1840	1190	3340	2380	4780
13/10/2009	12540	1230	1970	2410	13980	5290	9910	1890	1920	1220	3280	2350	4730
10/11/2009	12730	1280	1920	2520	14440	5380	10490	2070	1940	1300	3410	2420	4980
4/12/2009		1300	1850	2580	12220	6370	10260	990	1960	1290	3310	2370	4940

Table A1-3
Baseline pH 2006-2009

	ALLUVIUM										COAL		
Date	GWa1	GWa2	GWa3	GWa4	GWa5	GWa6	GWa7	GWa8	GWc1	GWc2	GWc3	GWc4	GWc5
20/04/2006	7.6	6.6	7.0	7.1	6.5	7.8		6.6	6.7	7.4	6.8	6.8	6.7
8/05/2006		6.8	7.3	6.9	6.9	7.6		7.2	7.0	7.4	6.6	6.8	6.5
23/05/2006		6.6	6.9	7.0	7.1	7.4		7.1	6.8	7.3	6.7	6.9	7.1
10/06/2006		6.8	7.5	7.2	7.3	7.8		7.3	7.0	7.5	6.8	7.1	6.6
1/07/2006		6.5	7.3	7.4	6.8	7.6		6.8	7.1	7.1	6.4	6.8	6.8
16/07/2006		6.9	7.2	7.3	6.9	7.6		7.1	6.9	6.9	7.1	6.7	6.9
30/07/2006		7.0	7.1	7.4	7.1	7.4		7.2	6.8	6.9	7.0	7.2	7.1
26/08/2006		6.9	7.4	6.9	7.1	7.4		7.0	7.0	7.6	7.3	7.1	6.6
24/09/2006		7.4	7.3	7.0	7.2	7.8		7.6	7.3	7.7	7.6	7.1	6.6
28/10/2006		7.8	7.5	7.3	7.8	7.3		7.6	7.6	8.0	7.8	7.3	6.8
26/11/2006		7.7	7.3	7.4	7.7	7.8		7.6	7.7	7.8	7.6	7.2	6.7
31/12/2006		6.7	7.3	6.9	6.7	7.4		7.3	7.2	7.8	7.2	6.8	7.0
27/01/2007		7.4	7.8	7.2	6.9	7.7		7.6	7.5	7.9	7.5	7.3	7.4
1/03/2007		7.3	7.7	7.0	6.8	7.7		7.5	7.4	7.7	7.3	7.2	6.9
23/04/2007		7.1	7.3	7.0	7.9			7.2	6.8	7.3	7.3	7.1	7.0
23/04/2007		7.1	7.3	7.0	7.9			7.2	6.8	7.3	7.3	7.1	7.0
23/05/2007		6.8	7.1	6.8	6.4	7.2		7.2	7.2	7.2	6.9	7.0	6.9
25/06/2007		7.5	7.3	6.5	7.0	7.1		7.4	7.7	7.2	7.1	7.0	7.9
20/07/2007		6.4	7.2	6.8	7.3	7.5	7.7	7.4	7.0	7.1	7.0	7.0	6.8
22/08/2007		6.0	7.6	6.9	7.2	7.6		7.3	6.7	7.5	7.4	7.0	6.8
20/09/2007		6.6	7.2	6.9	7.0	7.5		7.3	7.0	7.4	7.3	7.0	6.9
24/10/2007		6.6	7.2	6.9	6.9	7.4		7.3	6.7	7.6	7.3	7.1	6.8
22/11/2007		6.3		7.0	7.0	7.3		7.7	6.2		6.6	7.0	7.0
20/12/2007		6.6	6.9	6.9	6.9	7.3		7.1	7.0	7.5	6.7	7.1	6.9

	ALLUVIUM										COAL		
Date	GWa1	GWa2	GWa3	GWa4	GWa5	GWa6	GWa7	GWa8	GWc1	GWc2	GWc3	GWc4	GWc5
16/01/2008		6.6	7.0	7.1	6.9	7.3		7.1	7.2	7.4	6.6	7.1	6.9
15/02/2008		6.6	6.8	6.9	6.7	7.3		7.4	7.2	7.4	6.6	8.0	7.0
19/03/2008		6.6	6.6	7.0	6.6	7.2		7.2	7.1	7.8	6.6	7.1	6.9
14/04/2008		7.1	6.7	6.9	6.7	7.4	6.9	7.3	6.7	7.7	6.5	7.1	6.8
8/05/2008	6.9	6.8	6.6	6.9	6.7	7.4	6.9	7.2	7.2	7.7	6.9	6.9	6.9
19/06/2008		6.7	6.6	6.9	6.9	7.4	7.0	7.2	7.0	7.5	6.8	7.1	6.8
16/07/2008	6.9	6.7	6.6	6.8	7.1	7.3	7.0	7.3	7.0	7.5	6.9	6.7	6.9
13/08/2008	6.8	6.4	6.8	6.9	7.1	7.4	7.0	7.1	6.8	7.5	6.8	6.8	6.9
3/09/2008	6.9	6.7	6.8	7.2	7.1	7.4	7.1	7.4	7.0	7.5	7.1	6.7	6.9
9/10/2008	7.0	6.5	7.0	6.9	7.1	7.2	7.0	7.0	6.9	7.3	7.3	6.7	6.8
6/11/2008	7.0	6.6	7.0	6.9	7.0	7.4	6.9	7.1	7.0	7.8	7.4	6.7	6.9
4/12/2008	7.0	6.7	6.8	7.2	7.0	7.3	7.0	7.1	7.0	7.2	7.1	6.7	6.9
8/01/2009	7.1	6.6	6.6	6.9	6.8	7.2	6.8	7.2	7.0	7.1	6.6	6.7	6.9
19/02/2009	7.2	6.6	6.6	6.8	6.5	7.2	6.7	7.0	7.0	7.0	6.6	6.8	6.8
11/03/2009	7.2	6.6	6.5	6.8	6.9	7.4	6.7	7.0	6.9	7.0	6.5	6.8	6.9
22/04/2009	7.0	6.8	6.9	6.8	6.5	7.2	6.6	7.0	6.9	7.0	6.5	6.9	6.8
12/05/2009	7.0	6.6	6.5	6.8	6.5	7.2	6.6	7.0	6.9	6.9	6.7	6.9	6.8
19/06/2009		6.8	6.8	6.8	6.8	7.5	6.8	7.2	7.1	7.2	7.0	7.0	7.0
8/07/2009	7.2	6.3	6.3	6.8	6.8	7.2	6.8	7.0	6.6	6.8	6.9	6.8	6.8
12/08/2009	7.2	6.7	6.7	6.8	7.0	7.7	7.0	7.1	7.1	7.2	7.2	6.7	6.9
7/09/2009	7.2	6.5	6.7	6.7	7.0	7.5	6.9	6.8	6.8	7.1	7.1	6.6	6.8
13/10/2009	7.0	6.6	6.6	6.7	7.0	7.5	6.8	6.9	6.9	7.1	7.1	6.6	7.0
10/11/2009	6.9	6.5	6.5	6.6	6.9	7.4	6.7	6.9	6.9	7.0	7.2	6.6	6.7
4/12/2009		6.5	6.6	6.1	6.5	7.3	6.7	6.9	6.9	7.0	7.3	6.5	6.7