

DURALIE COAL MINE Water Management Plan

DURALIE COAL MINE WATER MANAGEMENT PLAN



Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&E/DotE Approval Date
All	WAMP-R01-B	Original	OEH, NOW, DP&I	-
All	WAMP-R02-A	Edits made to: <ul style="list-style-type: none"> reflect amended Project Approval conditions by Order of The Land and Environment Court of NSW dated 10 November 2011; consider recommendations (where relevant) of independent environmental audit dated November 2011; consider any outcomes of the Annual Review for the Duralie Coal Mine (dated September 2011); and reflect conditions of EPL 11701 varied by Notice 1502222 on 30 December 2011. 	OEH, NOW, DP&I	-
All	WAMP-R02-B	Edits made to reflect DP&I and NOW comments.	DP&I	2 August 2012
SWMP	WAMP-R02-C	Edits made to reflect SEWPaC comments.	SEWPaC	15 August 2012
All	WAMP-R02-D	Annual Review Edits made to: <ul style="list-style-type: none"> consider any outcomes of the Annual Review for the Duralie Coal Mine (submitted November 2012); and reflect conditions of EPL 11701 varied by Notice 1508851 on 21 March 2013. reflect conditions of the NSW Project Approval (08_0203) as modified on 1 November 2012. 	DP&I, SEWPAC	27 September 2013
All	WAMP-R03-A	Annual Review (2013) including recommendations from DP&E Audit December 2013	DP&E, DotE	23 June 2015
All	WAMP-R04-A	Annual Review (2014) and Duralie Open Pit Modification (2014)	DP&E	22 July 2016
SWMP	WAMP-R05-A	Edits to reflect DP&E comments on Annual Review 2016. Changes to SWMP only.	DP&E	

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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

The main activities associated with the Duralie Extension Project (as modified) include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum (Mtpa), including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine (SCM) in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- construction of Auxiliary Dam No. 2 to relative level (RL) 100 metres (m) to provide 2,900 megalitres of on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of the permanent Coal Shaft Creek Diversion alignment adjacent to the existing DCM mining area;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The general arrangement of the DCM, showing modifications, is provided in Figure 2.





1.2 PURPOSE AND SCOPE

This Water Management Plan (WAMP) has been prepared by DCPL in accordance with Condition 29, Schedule 3 of Project Approval (08_0203).

This revision of the WAMP has been prepared by DCPL to:

- consider the outcome of the 2013 and 2014 Annual Reviews for the DCM (submitted in October 2013 and August 2014, respectively);
- consider the recommendations from the Department of Planning & Environment (DP&E) Compliance Audit completed on 6 December 2013; and
- incorporate changes associated with the Duralie Open Pit Modification.

No significant changes have been made to this WAMP as a result of the 2013 and 2014 Annual Reviews or DP&E Compliance Audit.

1.3 STRUCTURE OF THE WAMP

The remainder of the WAMP is structured as follows:

- Section 2: Outlines the statutory requirements applicable to the WAMP.
- Section 3: Describes the review and improvement of the environmental performance process.
- Section 4: Outlines the management and reporting of incidents, complaints and non-compliances with statutory requirements.
- Section 5: Lists the references cited.

In accordance with Condition 29, Schedule 3 of the NSW Project Approval (08_0203), the WAMP incorporates three documents (provided as Appendices 1 to 3), namely the:

- Site Water Balance (SWB) (Appendix 1);
- Surface Water Management Plan (SWMP) (Appendix 2); and
- Groundwater Management Plan (GWMP) (Appendix 3).

An Irrigation Management Plan (IMP) is also included as a component of the SWMP.

1.4 SUITABLY QUALIFIED AND EXPERIENCED PERSONS

The DP&E, as delegate for the Director-General, approved the appointment of Mr Lindsay Gilbert (Gilbert & Associates Pty Limited) and Dr Noel Merrick (Heritage Computing Pty Ltd) as suitably qualified and experienced persons for the preparation of the WAMP on 18 February 2011.

Relevant sections/appendices of the WAMP were previously prepared/reviewed by Mr Lindsay Gilbert (i.e. SWB and SWMP). Relevant sections/appendices of the WAMP were previously reviewed by Dr Noel Merrick (i.e. GWMP).

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

These are described below.

2.1 EP&A ACT APPROVAL

Water Management Plan

Condition 29, Schedule 3 of the NSW Project Approval (08_0203), requires the preparation of a WAMP for the DCM. Condition 29 states:

Water Management Plan

29. *The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Secretary. This plan must be prepared in consultation with EPA and NOW by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval.*

In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:

(a) *a Site Water Balance that:*

- *includes details of:*
 - *sources of water supply;*
 - *water use on site;*
 - *water management on site; and*
 - *reporting procedures; and*
- *describes what measures would be implemented to minimise potable water use on site; and*

(b) *a Surface Water Management Plan, that includes:*

- *a detailed description of the water management system on site, including the:*
 - *clean water diversion systems;*
 - *erosion and sediment controls;*
 - *water storages; and*
 - *irrigation system;*
- *an irrigation management plan for the irrigation system under the water management system, which includes:*
 - *salinity trigger levels for controlling discharges from the irrigation areas to Coal Shaft Creek and the unnamed tributary, representing the 80th percentile value of the relevant data set for the creek/unnamed tributary and Mammy Johnsons River in accordance with the methodology in ANZECC/ARMCANZ (2000), Australian Water Quality Guidelines for Fresh and Marine Water Quality, National Water Quality Strategy; and¹*

¹ Condition added by Consequential Order by The Land and Environment Court of NSW dated 10 February 2012.

- *provision of an automated first flush system for the additional irrigation areas. (Northern Areas) shown in the figure in Appendix 4.*
 - *a plan for identifying, extracting, handling, and the long-term storage of potentially acid forming material on site;*
 - *detailed plans, including design objectives and performance criteria, for:*
 - *the reconstruction of Coal Shaft Creek;*
 - *design and management of the final voids;*
 - *reinstatement of drainage lines on the rehabilitated areas of the site; and*
 - *control of any potential water pollution from the rehabilitated areas of the site;*
 - *performance criteria, including trigger levels for investigating any potentially adverse impacts for the following:*
 - *the water management system;*
 - *surface water quality of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River;*
 - *the stream and vegetation health of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; and*
 - *channel stability of the reconstructed Coal Shaft Creek;*
 - *performance criteria for surface water quality attributes relevant to water quality impacts on biological diversity and aquatic ecological integrity, including salinity, heavy metals, sediment load, pH, hardness and biological oxygen demand;*
 - *trigger levels representing the 80th percentile value of the relevant reference data set in accordance with the methodology in ANZECC/ARMCANZ (2000). Australian Water Quality Guidelines for Fresh and Marine Water Quality Management Strategy to determine the levels for investigating any potentially adverse impacts;*
 - *a program to monitor:*
 - *the effectiveness of the water management system;*
 - *surface water flows and quality in the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River including utilization of existing monitoring sites together with an additional monitoring site in Mammy Johnsons River immediately downstream of the mixing zone of the confluence of Coal Shaft Creek and Mammy Johnsons River;*
 - *the stream and riparian vegetation health of the unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; and*
 - *channel stability of the reconstructed Coal Shaft Creek;*
 - *a program of ecotoxicity testing of water in water storages on-site and at selected water monitoring sites in Mammy Johnsons River and macroinvertebrate sampling at selected monitoring sites in Mammy Johnsons River;*
 - *a plan to respond to any exceedences of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the project; and*
- (c) *a Groundwater Management Plan, which includes:*
- *groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;*
 - *a program to monitor :*
 - *groundwater inflows to the open cut mining operations;*
 - *the impacts of the project on:*
 - *the alluvial aquifers including investigating the potential for direct interface between mine spoil and alluvium and assessment of any consequential impact on alluvial and surface water;*
 - *base flows to Mammy Johnsons River;*
 - *any groundwater bores on privately-owned land; and*

- the seepage/leachate from water storages or backfilled voids on site; and
- a program to validate the groundwater model for the project, and calibrate it to site specific conditions; and
- a plan to respond to any exceedances of the assessment criteria, including,
 - if a direct interface between mine spoil and alluvium is identified, development of a trigger action response plan (TARP) for potential salinity impacts on alluvial and surface water sources; and
- a plan to offset the loss of any base flow to Mammy Johnsons River caused by the project.
- *Note: The effectiveness of the Water Management Plan is to be reviewed and audited in accordance with the requirements in Schedule 5. Following this review and audit the plan is to be revised to ensure it remains up to date (see condition 4 of Schedule 5)*

The above requirements are addressed in Appendices 1, 2 and 3 of this WAMP.

Management Plan Requirements

Condition 2, Schedule 5 of the NSW Project Approval (08_0203), outlines the management plan requirements that are applicable to the preparation of the WAMP. Table 1 indicates these components and where they are addressed within this WAMP.

Table 1
Management Plan Requirements

NSW Project Approval (08_0203) Condition	WAMP Section/Appendix
Condition 2, Schedule 5	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	SWB, SWMP, GWMP
b) a description of: <ul style="list-style-type: none"> • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures; 	Section 2, SWB, SWMP, GWMP
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	SWMP, GWMP SWMP, GWMP
d) a program to monitor and report on the: <ul style="list-style-type: none"> • impacts and environmental performance of the project; • effectiveness of any management measures (see (c) above); 	SWB, SWMP, GWMP SWMP, GWMP
e) a contingency plan to manage any unpredicted impacts and their consequences;	SWMP, GWMP
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 3, SWB, SWMP, GWMP
g) a protocol for managing and reporting any: <ul style="list-style-type: none"> • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and 	Section 4 (Refer PIRMP) Section 4 (Refer EMS) Section 4 (Refer EMS) SWMP, GWMP
h) a protocol for periodic review of the plan.	Section 3, SWB, SWMP, GWMP

2.2 EPBC ACT APPROVAL

Of relevance to this WAMP, Conditions 3 and 4 of the Commonwealth Approval (2010/5396) require:

Water Management

3. *The person undertaking the action must ensure that all irrigation and run-off from the Project Area is managed in accordance with the Duralie Coal Mine Irrigation Management Plan (DCPL, 2008) as set out in Referral received on the 11 March 2010 (or as per any amendments approved by this Department, in consultation with the NSW Department of Planning, the NSW Department of Environment and Climate Change and Water and NSW Office of Water), and not otherwise discharged into the MJR*
4. *The release of water into the MJR catchment must only occur when Electricity Conductivity levels do not exceed 400 Micro Siemens ($\mu\text{S}/\text{cm}$) in the MJR at the “High Noon” monitoring site and 1,326 $\mu\text{S}/\text{cm}$ in the Main Water Dam diversion drain sumps; or alternate thresholds as may be advised in writing by the Department.*

As described in the SWMP (Appendix 2), the IMP attached to the SWMP component of this WAMP supersedes the former Irrigation Management Plan (DCPL, 2008b). In accordance with Condition 3 of the Commonwealth Approval (2010/5396), the SWMP was approved (15th August 2012) by the Commonwealth Department of the Environment in consultation with DP&E, the NSW Office of Environment and Heritage (OEH) and the NSW Office of Water (NOW).

The SWMP (Appendix 2) describes the measures that would be implemented to maintain compliance with Condition 4 of the Commonwealth Approval (2010/5396).

In addition to the above, Condition 11 of the Commonwealth Approval (2010/5396) requires:

Mitigation Measures

11. *In order to minimise the impacts of the project on listed threatened species, the person taking the action must implement all measures in the following plans/documents or their subsequent revisions as approved by the Minister:*
 - (a) *The DCM Vegetation Clearance Protocol (DCPL, 2002);*
 - (b) *The DCM Irrigation Management Plan (DCPL, 2008);*
 - (c) *The DCM Site Water Management Plan (DCPL, 2008); and*
 - (d) *The DCM Rehabilitation Management Plan (DCPL, 2007).*

As described in Section 1.2, this amendment to the WAMP supersedes the original Water Management Plan and the former Site Water Management Plan (DCPL, 2008a). In accordance with Condition 11 of the Commonwealth Approval (2010/5396), this amended WAMP (and the SWMP [Appendix 2]) will be submitted for approval by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (or delegate).

2.3 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203) and Commonwealth Approval (2010/5396), all activities at the DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

Key licences, permits and leases pertaining to the DCM include:

- ML 1427 issued under Part 5 of the NSW *Mining Act, 1992* and approved by the NSW Minister for Mineral Resources in April 1998.
- ML 1646 issued under Part 5 of the NSW *Mining Act, 1992* and approved by the NSW Minister for Primary Industries in January 2011.

- EPL 11701 issued under Part 3 of the NSW *Protection of the Environment Operations Act, 1997* (PoEO Act) by the Environment Protection Authority (now the OEH) in September 2002 (as modified by subsequent licence variations).
- Groundwater Licence – Duralie Coal Open Cut (20BL168404) issued under Part 5 of the NSW *Water Act, 1912* by the Department of Land and Water Conservation (now NSW Office of Water) in September 2002 (renewed September 2012).
- DLWC Bore Licence for monitoring bores (20BL168539) dated 31 October 2002. Three bores added on 2 February 2004.
- NSW Office of Water Bore Licence for monitoring bores WR1, WR2 and DB11W (20BL173570, 20BL173568, 20BL173569) dated 5 August 2013.
- Mining Operations Plan approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) Division of Resources and Energy on 18 March 2015.
- Water Supply Works Approval (20WA202053) under the NSW Water Management Act, 2000 issued by the Department of Water and Energy (now NSW Office of Water) on 15 May 2009 for the Coal Shaft Creek diversion and various on-site water management structures².
- Mining and occupational health and safety related approvals granted by DTIRIS-DRE and WorkCover NSW.

2.4 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

In addition to those Acts referred to above (Section 2.3), the following NSW Acts may be applicable to the conduct of the DCM (DCPL, 2010):

- *Contaminated Land Management Act, 1997*;
- *Dangerous Goods (Road and Rail Transport) Act, 2008*;
- *National Parks and Wildlife Act, 1974*;
- *Noxious Weeds Act, 1993*;
- *Roads Act, 1993*;
- *Threatened Species Conservation Act, 1995*;
- *Work Health and Safety (Mines) Act, 2013*;
- *Work Health and Safety Act, 2011*;
- *Crown Lands Act, 1989*;
- *Dams Safety Act, 1978*;
- *Fisheries Management Act, 1994*; and
- *Petroleum (Onshore) Act, 1991*.

Relevant licences or approvals required under these Acts will be obtained as required.

² This approval replaced the previous *Water Act, 1912* Licence 20SL060324 for these structures.

3 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

3.1 ANNUAL REVIEW

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL will conduct an Annual Review of the environmental performance of the DCM by the end of December 2011, and annually thereafter. This will be made publicly available on the Duralie Coal website, in accordance with Condition 10, Schedule 5 of the NSW Project Approval (08_0203).

The Annual Review will specifically address the following aspects of Condition 3, Schedule 5 of the NSW Project Approval (08_0203), that are directly relevant to water management:

- a description of the development implemented in the past year and proposed in the next year;
- a comprehensive review of the monitoring results and complaints records for the DCM over the past year, including a comparison of these results against the:
 - relevant statutory requirements, limits or performance measures/criteria;
 - monitoring results of previous years; and
 - relevant predictions in the Duralie Extension Project Environmental Assessment (EA);
- any non-compliance over the last year, and described what actions were (or are being) taken to ensure compliance;
- any trends in the monitoring data over the life of the DCM;
- any discrepancies between the predicted and actual impacts of the DCM, and analyse the potential cause of any significant discrepancies; and
- what measures to be implemented over the next year to improve the environmental performance of the DCM.

This WAMP is required to be reviewed within three months of the submission of an Annual Review, and revised where appropriate, as described in Section 3.2 below.

3.2 WAMP REVIEW

This WAMP (WAMP-R04-A) is the seventh version prepared under NSW Project Approval (08_0203). The revision status of this WAMP is indicated on the title page of each copy.

In accordance with Condition 4, Schedule 5 of the NSW Project Approval, this WAMP (and its appendices) will be reviewed and if necessary revised to the satisfaction of the Director-General of the DP&E, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit³, in accordance with Condition 8, Schedule 5;
- any modification to the conditions of consent; or
- prior to the commencement of clearing in accordance with the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014).

As outlined in Section 1.2 and in accordance with Condition 4(e), Schedule 5 of the NSW Project Approval, this WAMP has been revised following approval of the Duralie Open Pit Modification.

³ An independent environmental audit was completed in November 2011 (Trevor Brown & Associates, 2011).

This WAMP will be made publicly available on the Duralie Coal website in accordance with NSW Project Approval (08_0203). A hard copy of the WAMP will also be kept at the DCM.

No significant changes have been made to this WAMP as a result of the 2013 and 2014 Annual Reviews, 2013 DP&E Compliance Audit.

4 REPORTING SYSTEMS

In accordance with Condition 2 (g), Schedule 5 of the NSW Project Approval, DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints;
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and/or performance criteria.

The management of incidents is described in the Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the Environmental Management Strategy. The management of exceedances of performance criteria is described in the SWMP and GWMP.

5 REFERENCES

Duralie Coal Pty Limited (2008a) *Site Water Management Plan*. Document SWMP-F.

Duralie Coal Pty Limited (2008b) *Irrigation Management Plan*. Document IMP-F.

Duralie Coal Pty Limited (2010) *Duralie Extension Project Environmental Assessment*.

Duralie Coal Pty Limited (2011) *Duralie Coal Mine Annual Review*. September 2011.

Duralie Coal Pty Limited (2013) *Duralie Coal Mine Pollution Incident Response Management Plan*

Trevor Brown & Associates – Applied Environmental Management Consultants (2011) *Independent Environmental Audit Duralie Coal Mine*, dated November 2011.

APPENDIX 1
SITE WATER BALANCE

DURALIE COAL MINE SITE WATER BALANCE



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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

The main activities associated with the Duralie Extension Project (as modified) include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum (Mtpa), including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine (SCM) in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- construction of Auxiliary Dam No. 2 to relative level (RL) 100 metres (m) to provide 2,900 megalitres (ML) of on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of the permanent Coal Shaft Creek alignment adjacent to the existing DCM mining area;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The general arrangement of the DCM, showing modifications, is provided in Figure 2.





1.2 PURPOSE AND SCOPE

This Site Water Balance (SWB) has been prepared by DCPL in accordance with Condition 29(a), Schedule 3 of Project Approval (08_0203).

This revision of the SWB has been prepared by DCPL to:

- consider the outcomes of the 2013 and 2014 Annual Reviews for the DCM (submitted in October 2013 and August 2014, respectively);
- consider the recommendations from the Department of Planning & Environment (DP&E) Compliance Audit completed on 6 December 2013; and
- incorporate changes associated with the Duralie Open Pit Modification.

No significant changes have been made to this SWB as a result of the 2013 and 2014 Annual Reviews or DP&E Compliance Audit.

1.3 SUITABLY QUALIFIED AND EXPERIENCED PERSONS

The DP&E, as delegate for the Director-General, approved the appointment of Mr Lindsay Gilbert (Gilbert & Associates Pty Limited) and Dr Noel Merrick (Heritage Computing) as suitably qualified and experienced persons for the preparation of the WAMP on 18 February 2011.

The simulated water balance (Section 8) was conducted by Gilbert & Associates Pty Limited (2014).

1.4 STRUCTURE OF THE SWB

The remainder of the SWB is structured as follows:

- | | |
|-------------|--|
| Section 2: | Outlines the statutory requirements applicable to the SWB. |
| Section 3: | Provides detailed baseline data. |
| Section 4: | Provides an overview of the water management system. |
| Section 5: | Includes details of the sources of water for the DCM. |
| Section 6: | Describes the water use and water management on-site for the DCM including measures to minimise water use. |
| Section 7: | Discusses on-site containment capacity. |
| Section 8: | Discusses the simulated performance of the water management system. |
| Section 9: | Describes the review and improvement of the environmental performance process. |
| Section 10: | Describes the management and reporting of incidents, complaints and non-compliances. |
| Section 11: | Lists the references cited. |

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

These are described below.

2.1 EP&A ACT APPROVAL

Site Water Balance

This SWB has been prepared in accordance with Condition 29 (a), Schedule 3 of the NSW Project Approval (08_0203). Table 1 indicates where each component of Condition 29 (a) is addressed within this SWB.

Table 1
Site Water Balance Requirements

NSW Project Approval (08_0203) Condition	SWB Section
<p>Condition 29, Schedule 3</p> <p>29. The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Secretary. This plan must be prepared in consultation with EPA and NOW by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval.</p> <p>In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:</p> <p>a) a Site Water Balance that:</p> <ul style="list-style-type: none"> • includes details of: <ul style="list-style-type: none"> – sources of water supply; – water use on site; – water management on site; and – reporting procedures; and • describes what measures would be implemented to minimise potable water use on site. <p>...</p>	<p>Section 5</p> <p>Section 6</p> <p>Section 6</p> <p>Section 10</p> <p>Section 6.4</p>

In accordance with Condition 29, Schedule 3 of the NSW Project Approval (08_0203), this SWB is included as part of the WAMP for the DCM (i.e. Appendix 1 of the WAMP).

Management Plan Requirements

In addition, Condition 2, Schedule 5 of the NSW Project Approval (08_0203), outlines the requirements that are applicable to the preparation of the management plans. The WAMP indicates where each component of the conditions is addressed within the plans under the WAMP (including this SWB) Table 2 indicates where each relevant component is addressed within this SWB.

Table 2
Management Plan Requirements

NSW Project Approval (08_0203) Condition	SWB Section
Condition 2, Schedule 5	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 3
b) a description of:	Section 2
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Refer to WAMP (Attachments SWMP and GWMP)
• any relevant limits or performance measures/criteria;	Refer to WAMP (Attachments SWMP and GWMP)
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 6
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Refer to WAMP (Attachments SWMP and GWMP)
d) a program to monitor and report on the:	Refer to WAMP (Attachments SWMP and GWMP)
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	Refer to WAMP (Attachments SWMP and GWMP)
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 9
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	
g) a protocol for managing and reporting any:	Refer to WAMP and PIRMP
• incidents;	Refer to EMS
• complaints;	Refer to EMS
• non-compliances with statutory requirements; and	Refer to SWMP and GWMP
• exceedences of the impact assessment criteria and/or performance criteria; and	
h) a protocol for periodic review of the plan.	Section 9

2.2 EPBC ACT APPROVAL

Condition 11 of the Commonwealth Approval (2010/5396) requires:

Mitigation Measures

11. *In order to minimise the impacts of the project on listed threatened species, the person taking the action must implement all measures in the following plans/documents or their subsequent revisions as approved by the Minister:*
- (a) *The DCM Vegetation Clearance Protocol (DCPL, 2002);*
 - (b) *The DCM Irrigation Management Plan (DCPL, 2008);*
 - (c) *The DCM Site Water Management Plan (DCPL, 2008); and*
 - (d) *The DCM Rehabilitation Management Plan (DCPL, 2007).*

In accordance with Condition 11 of the Commonwealth Approval (2010/5396), the WAMP (including this SWB) will be submitted for approval by the Commonwealth Minister for the Environment (or delegate).

2.3 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203), and Commonwealth Approval (2010/5396), all activities at DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

A summary of the key licences, permits and leases pertaining to the DCM is provided in Section 2.3 of the WAMP.

2.4 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

A summary of other NSW legislation that may be applicable to the conduct of the DCM is provided in Section 2.4 of the WAMP.

3 BASELINE DATA

In accordance with Condition 24, Schedule 3 of the NSW Project Approval (08_0203), DCPL maintains an Automatic Weather Station (AWS) on-site. The on-site AWS continuously monitors the following meteorological parameters:

- rainfall;
- temperature;
- relative humidity;
- evapotranspiration;
- net solar radiation;
- wind direction; and
- wind speed.

A summary of relevant meteorological information in the DCM area is provided in the Surface Water Management Plan (SWMP) (included as Appendix 2 of the WAMP).

Baseline data regarding the Site Water Balance is contained the DCM Annual Reviews which provide a review of the status of water managed on site, annually.

4 WATER MANAGEMENT SYSTEM

The objectives of the DCM water management system are to:

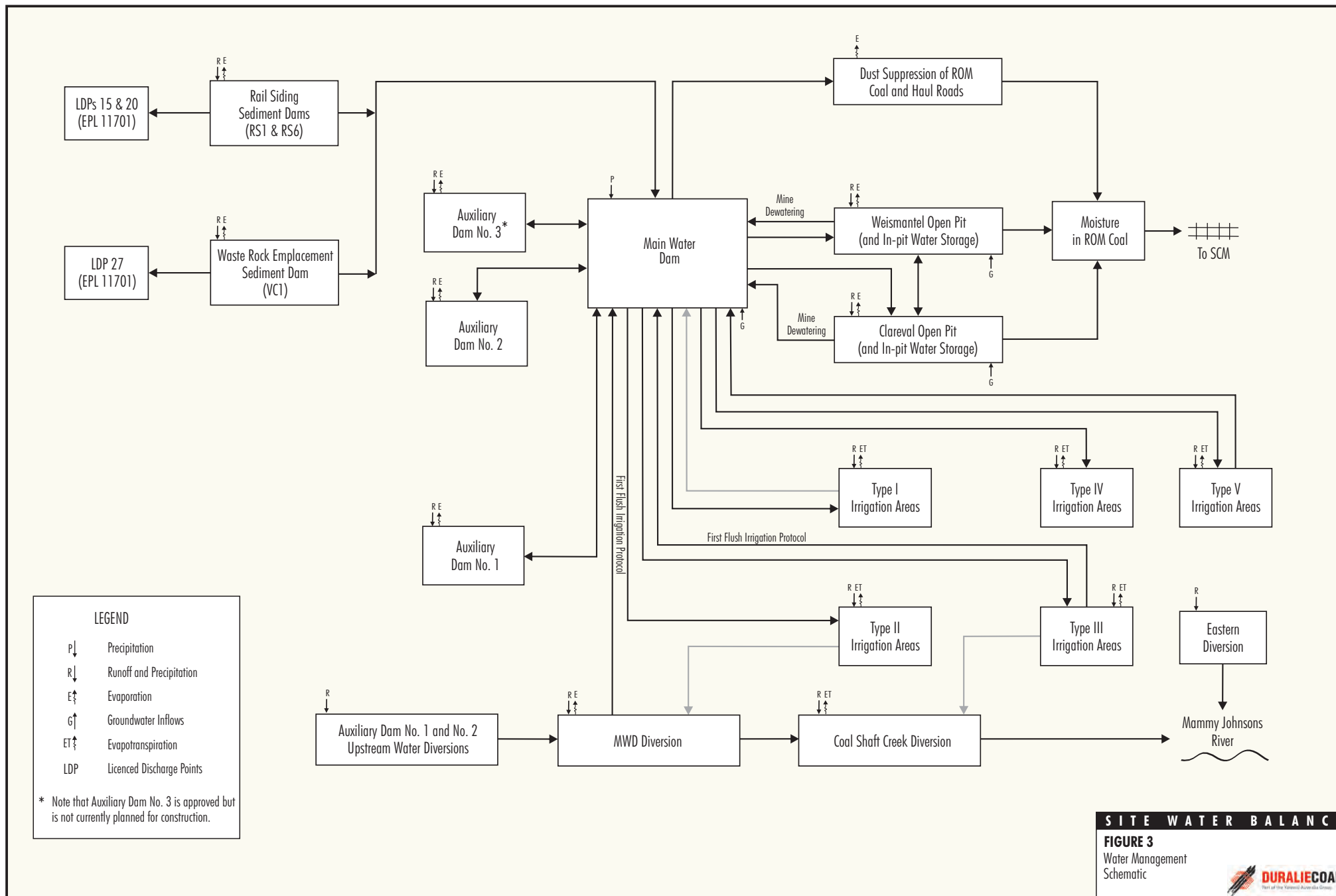
- protect the integrity of local and regional water resources;
- maintain separation between runoff from undisturbed areas and water generated within active mining areas;
- comply with the requirements of EPL 11701;
- continue the beneficial use of water collected from operational areas for on-site irrigation; and
- provide a reliable source of water for on-site mining and coal handling.

The DCM water management system controls waters generated from surface development areas while controlling the capture of surface water runoff by diverting upslope water around such areas (DCPL, 2010). The water management system includes a combination of permanent structures that will continue to operate post closure and temporary structures that will only be required until the completion of rehabilitation works (e.g. sediment control structures) (DCPL, 2010).

The existing water management system at the DCM includes the following components (DCPL, 2010):

- water management storages;
- diversions for runoff from catchment areas upslope of the mine disturbance area (i.e. upslope diversions);
- runoff control structures and devices on disturbed and rehabilitated areas at the mine;
- runoff control structures and devices on infrastructure areas;
- procedures, structures and devices for the control of erosion and sediment movement;
- open pit dewatering equipment;
- procedures and equipment for the disposal of excess water through on-site irrigation; and
- sewage treatment plant and a system for the disposal of effluent.

The water management system is shown in schematic form on Figure 3 and will be progressively developed as water management requirements change over time. The approved DCM water management system is further described in Section 2.8 of the *Duralie Extension Project Environmental Assessment* (EA) (DCPL, 2010) and in the *Duralie Extension Project Surface Water Assessment* (Gilbert & Associates Pty Limited, 2010). Changes to the DCM water management system are further described in the Surface Water Assessment for the *Duralie Open Pit Modification Environmental Assessment* (Gilbert & Associates Pty Limited, 2014b).



5 WATER SOURCES

The water management system aims to maintain separation between water generated in undisturbed areas and water generated within active mining areas.

Water captured from mining related areas includes (Gilbert & Associates Pty Limited, 2014b):

- rainfall within the open pits mixing with particulate matter and relatively saline groundwater;
- groundwater seeping into the open pits;
- rainfall induced runoff and seepage from active sections of the waste rock emplacement;
- rainfall induced runoff from the main infrastructure area;
- rainfall induced runoff from haul roads;
- rainfall induced runoff from areas stripped of topsoil (typically exposing clays);
- rainfall induced runoff from areas yet to adequately revegetate within sediment dam catchments; and
- direct rainfall falling on sediment dams and water management storages.

5.1 OPEN CUT DEWATERING

Excavation of the open pits forms a sink in the groundwater system towards which groundwater flows.

The open pit workings are collection points for incident rainfall, infiltration through mine waste rock emplacements and rainfall runoff (Gilbert & Associates Pty Limited, 2014b). Sumps are excavated in the floor of the active open pits as part of routine mining operations to facilitate efficient dewatering operations and to minimise interruption to mining.

Water that accumulates in the open pit sumps is used for dust suppression over haul roads and active waste rock emplacement surfaces and/or is transferred to the MWD.

Where the potential for initially high groundwater inflows is identified during the life of the DCM, advance dewatering may be conducted using temporary bores ahead of the open pit mining operation.

6 WATER USE AND MANAGEMENT

Water is required for wash-down of mobile equipment and dust suppression on haul roads and at the coal handling area (e.g. ROM coal stockpiles and conveyor systems). Some water is also used for fire fighting and other minor non-potable water uses.

The water consumption requirements and water balance of the system fluctuate with climatic conditions and as the extent of the mining operation changes over time. Fluctuations in water consumption have been accounted for in the site water balance model.

6.1 WATER STORAGEES

Water storages (existing and under construction) at the DCM include (Figure 2):

- MWD, which is located north-west of the main infrastructure area and has a constructed capacity of up to approximately 1,405 ML to the top of the I-Beam, and approximately 1,296 ML to the invert of the spill pipe.
- A smaller bunded area located in the south of the MWD, adjacent to the main infrastructure area.
- Auxiliary Dam No. 1, which is located upslope of the MWD and has a constructed capacity of 462 ML (with an approved capacity up to 500 ML).
- Auxiliary Dam No. 2, which is located upslope of the MWD and has a constructed capacity of 2,724 ML (with an approved capacity up to 2,900 ML).

The DCM has approval to construct Auxiliary Dam No. 3 to an approved capacity of 110 ML, however construction of Auxiliary Dam No. 3 is not planned as a component of the current DCM water management system.

Mining will continue in the Clareval open pit through until its completion in 2017. After which mining would recommence in the Weismantel open pit through the approved DCM mine life. The Weismantel open pit will initially be inactive and available for secure storage of excess water through to mid-2017. Once mining is completed in the Clareval open pit (2017), it will be available for secure storage of excess water. Any excess water in the Weismantel open pit will be removed to the Clareval final void, in advance of recommencement of mining in the Weismantel open pit in early 2018 (Gilbert & Associates Pty Limited, 2014b).

The storage capacity of the Weismantel final void has been estimated at approximately 12,400 ML. The storage capacity of the Clareval final void has been estimated to be approximately 38,000 ML.

6.2 UPSLOPE DIVERSION WORKS

Temporary and permanent upslope diversion bunds/drains and temporary interception dams will continue to be constructed over the life of the DCM, to divert runoff from undisturbed areas around the open pits and waste rock emplacements. The DCM surface water management system includes continued diversion of runoff via the Coal Shaft Creek Diversion (Figure 2). Permanent upslope diversion bunds/drains will remain around final voids.

The upslope diversions have and will be designed for the peak flow generated by 1 in 100 year rainfall event. Permanent diversion(s) including the final Coal Shaft Creek Diversion will be assessed against the probable maximum flood (PMF) event.

Upslope diversions will be designed to be stable at the design flows. Diversion stability will be achieved by providing appropriately sized channel cross-sections and bed gradients; and by incorporating bed and bank treatments such as rock fill and vegetation which will provide erosion resistance.

Upslope diversions and sediment control are described further in the SWMP (Appendix 2 of the WAMP).

6.3 IRRIGATION

Excess water is used in controlled irrigation in accordance with the SWMP.

Irrigation areas, and management and monitoring of irrigation are described further in the Irrigation Management Plan which is included as part of the SWMP (Appendix 2 of the WAMP).

6.4 POTABLE WATER USE

Potable water for the DCM is supplied by MidCoast Water. Potable water is transported to the DCM by a local contractor and is stored on-site in a holding tank at the main infrastructure area.

DCPL minimises potable water use on-site through staff training and awareness. DCPL places signs in all potable water use areas reminding employees and visitors to minimise waste.

7 ON-SITE CONTAINMENT CAPACITY

DCPL maintains a policy of no uncontrolled release of mining-related water off-site. The policy of no uncontrolled release is achieved through:

- controlled irrigation of excess water;
- transfer of water between the MWD and Auxiliary Dam water storages and the open pits;
- maintaining adequate freeboard in the MWD and Auxiliary Dam water storages below spill level for large rainfall events; and
- ensuring adequate pump and pipeline capacity is installed to transfer water between the water storages and to the open pits.

Water storage capacity is provided in Section 6.1.

Table 3 summarises key triggers for transfer between the MWD and Auxiliary Dams. Reference should also be made to the DCM Prescribed Dams Operations and Maintenance Manual Figure 10 TARP Water Levels.

Table 3
Water Transfer Triggers

	Auxiliary Dam No. 1	Auxiliary Dam No. 2
Trigger volume in MWD for pumping to begin to auxiliary dam from MWD (pending auxiliary dam freeboard requirements below). MWD operating level 72.0 RL.	994 ML (71.0 RL)	994 ML (71.0 RL)
Trigger volume in MWD for pumping to begin from auxiliary dam to MWD	800 ML (70.0 RL)	800 ML (70.0 RL)
Auxiliary dam minimum freeboard for pumping from MWD	69 ML (98.0 RL)	133 ML (RL 98.0)
Transfer rate from MWD to auxiliary dam	10 ML/day	27 ML/day
Transfer rate from auxiliary dam to MWD	5 ML/day	27 ML/day

Source: Gilbert & Associates Pty Limited, 2014.

No pumping from the open pits to the MWD will occur when the volume stored in the MWD exceeds 1,298 ML (72.5 RL).

The MWD and Auxiliary Dam water storages are designed and operated to maintain adequate freeboard by irrigation of excess water, cessation of mine dewatering operations during periods of low freeboard levels and by transferring excess water to the open pits. A water transfer system capable of transferring 1 ML/hour (24 ML/day), and 200 millimetre diameter gravity fed transfer pipeline are installed between the MWD and Weismantel open pit. The above system is designed and managed to transfer water in excess of the capacity of the MWD to the open pit during periods of low freeboard levels and/or large rainfall events.

Water balance simulation modelling showed that, using the triggers in Table 3, there was a low risk (equivalent to 0.1%) of uncontrolled release of mining-related water off-site (Gilbert & Associates Pty Limited, 2014b). There was no overflow from the MWD and the open pits during the 1,000 climatic sequences simulated (Gilbert & Associates Pty Limited, 2014b).

With the above triggers and management systems in place, the main consequence of exceeding the design capacity of the water management system will be the transfer of water to the open pits with consequential disruption to mining operations (Section 8). The risk of disruption to mining operations is an operational risk and would have no environmental consequences.

8 WATER MANAGEMENT SYSTEM PERFORMANCE

Water is transferred between the MWD and Auxiliary Dam water storages and the open pits to minimise the disruption to mining and to maintain storm runoff storage capacity needed to achieve a negligible risk of uncontrolled release of mining-related water off-site.

As described in Section 7, water balance simulation modelling of the remaining mine life predicts there is a negligible risk of uncontrolled release of mining-related water off-site at the DCM. This prediction is contingent upon the assumed operating protocols and conditions described in this WAMP and adopted in the predictive modelling being adhered to on-site.

The DCM is operated with the operational risk of disruption to mining as a result of exceedance of the design capacity of the water management systems. The operational risk to the DCM as a result of the water management system has been assessed using the water balance modelling in conjunction with 1,000 climatic sequences each 4.5 years in length and has been determined to be an economically and operationally acceptable risk.

The water balance simulation modelling showed that there were no simulated releases of water from the MWD of the auxiliary dams in any of the 1,000 sequences simulated. This reflects a negligible risk (expected to be less than 0.1% over the mine life) of uncontrolled spill risk if the assumed operational conditions are adhered to (Gilbert & Associates Pty Limited, 2014b).

The water balance simulation model also indicates that there is a low probability (<0.1%) of non potable water shortfall occurring over the remaining mine life, with no shortages being simulated in any of the 1,000 climatic sequences (Gilbert & Associates Pty Limited, 2014).

9 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

9.1 ANNUAL REVIEW

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL conducted an Annual Review of the environmental performance of the DCM prior to the end of December 2011, and annually thereafter. This will be made publicly available from the Duralie Coal website, in accordance with Condition 10, Schedule 5 of the NSW Project Approval (08_0203).

The Annual Review will specifically address the following aspects of Condition 3, Schedule 5 that are directly relevant to water management:

- a description of the development implemented in the past year and proposed in the next year;
- include a comprehensive review of the monitoring results and complaints records for the DCM over the past year, including a comparison of these results against the:
 - relevant statutory requirements, limits or performance measures/criteria;
 - monitoring results of previous years; and
 - relevant predictions in the Duralie Extension Project EA;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the DCM;
- identify any discrepancies between the predicted and actual impacts of the DCM, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the DCM.

This SWB will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, as described in Section 9.2 below.

9.2 SWB REVIEW

In accordance with Condition 4, Schedule 5 of the NSW Project Approval (08_0203), this SWB will be reviewed and if necessary revised to the satisfaction of the Director-General of the Department of Planning and Infrastructure, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit, in accordance with Condition 9, Schedule 5;
- any modification to the conditions of consent; or
- prior to the commencement of clearing in accordance with the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014).

As outlined in Section 1.2 and in accordance with Condition 4(e), Schedule 5 of the NSW Project Approval (08_0203), this SWB has been revised following the approval of the Duralie Open Pit Modification.

This SWB will be made publicly available on the Duralie Coal website in accordance with the NSW Project Approval (08_0203). A hard copy of the SWB will also be kept at the DCM.

A site water balance review will be undertaken on an annual basis to review monitoring of the status of inflows, outflows, site water inventory and consumption (irrigation, dust suppression, vehicle wash-down) and to update the site water balance model predictions. The site water balance review will be used to optimise water management performance and will enable corrective actions to be implemented, if required. The results of the water balance reviews will be reported in the Annual Review (Section 9.1).

There have been no significant changes made to the SWB as a result of the 2013 or 2014 Annual Reviews or the 2013 DP&E Compliance Audit.

10 REPORTING SYSTEMS

In accordance with Condition 2(g), Schedule 5 of the NSW Project Approval (08_0203), DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints;
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and/or performance criteria.

The management of incidents is described in the Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the Environmental Management Strategy. The management of exceedances of performance criteria is described in the SWMP and GWMP.

11 REFERENCES

Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.

Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.

Gilbert & Associates Pty Limited (2010) *Duralie Extension Project Surface Water Assessment*.
Appendix A of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.

Gilbert & Associates Pty Limited (2011) *Updated Water Balance Modelling of Duralie Irrigation Scheme to Assess Implications of Irrigation Area Excision*. Unpublished report for Duralie Coal Pty Ltd.

Gilbert & Associates Pty Limited (2014) *Duralie Coal Mine – 2013 Annual Water Balance Review*.
Unpublished report for Duralie Coal Pty Ltd.

Gilbert & Associates Pty Limited (2014b) *Duralie Open Pit Modification Surface Water Assessment*.
Appendix D of Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*

Heritage Computing (2009) *Duralie Extension Project Groundwater Assessment*. Appendix B of
Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.

APPENDIX 2
SURFACE WATER MANAGEMENT PLAN

DURALIE COAL MINE SURFACE WATER MANAGEMENT PLAN



Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&E/DotE Approval Date
All	SWMP-R01-B	Original.	OEH, NOW, DP&I	-
All	SWMP-R02-A	Edits made to: <ul style="list-style-type: none"> reflect amended Project Approval conditions by Order of The Land and Environment Court of NSW dated 10 November 2011; consider recommendations (where relevant) of independent environmental audit dated November 2011; consider any outcomes of the Annual Review for the Duralie Coal Mine (dated September 2011); and reflect conditions of EPL 11701 varied by Notice 1502222 on 30 December 2011. 	OEH, NOW, DP&I	-
All	SWMP-R02-B	Edits made to reflect DP&I and NOW comments.	DP&I	2 August 2012
All	SWMP-R02-C	Edits made to reflect SEWPaC comments.	SEWPaC	
All	SWMP-R02-D	Annual Review. Edits made to: <ul style="list-style-type: none"> consider any outcomes of the Annual Review for the Duralie Coal Mine (submitted June 2012); reflect conditions of EPL 11701 varied by Notice 1508851 on 21 March 2013 2012; and reflect conditions of the NSW Project Approval (08_0203) as modified on 1 November 2012. 	DP&I	27 September 2013
All	SWMP-R03-A	Annual Review (2013) and recommendations from DP&E Audit December 2013.	DP&E	23 June 2015
All	SWMP-R04-A	Annual Review (2014) and Duralie Open Pit Modification (2014).	DP&E	22 July 2016
Section 8.7	SWMP-R05-A	Edits to reflect DP&E comments on Annual Review 2016. Changes to SWMP only.	DP&E	

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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

The main activities associated with the Duralie Extension Project (as modified) include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum (Mtpa), including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine (SCM) in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- construction of Auxiliary Dam No.2 to relative level (RL) 100 metres (m) to provide 2,900 megalitres (ML) of on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of the permanent Coal Shaft Creek Diversion alignment adjacent to the existing DCM mining area;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The general arrangement of the DCM, showing modifications, is provided in Figure 2.





1.2 PURPOSE AND SCOPE

This Surface Water Management Plan (SWMP) has been prepared by DCPL in accordance with Condition 29(b), Schedule 3 of Project Approval (08_0203).

This revision of the SWMP has been prepared by DCPL to:

- consider the outcomes of the Annual Reviews (2013 and 2014) for the DCM (submitted October 2013 and August 2014, respectively);
- consider the recommendations from the Department of Planning and Environment (DP&E) Compliance Audit completed on 6 December 2013; and
- incorporate changes associated with the Duralie Open Pit Modification.

No significant changes have been made to this SWMP as a result of the 2013 and 2014 Annual Reviews or DP&E Compliance Audit.

1.3 SUITABLY QUALIFIED AND EXPERIENCED PERSONS

The DP&E, as delegate for the Director-General, approved the appointment of Mr Lindsay Gilbert (Gilbert & Associates Pty Limited) and Dr Noel Merrick (Heritage Computing) as suitably qualified and experienced persons for the preparation of the WAMP on 18 February 2011.

The SWMP was previously prepared/reviewed by Mr Lindsay Gilbert.

1.4 STRUCTURE OF THE SWMP

The remainder of the SWMP is structured as follows:

- | | |
|-------------|--|
| Section 2: | Outlines the statutory requirements applicable to the SWMP. |
| Section 3: | Describes the existing surface water hydrology. |
| Section 4: | Provides detailed baseline data. |
| Section 5: | Provides an overview of the water management system. |
| Section 6: | Describes the irrigation system on-site. |
| Section 7: | Describes the surface water management measures. |
| Section 8: | Describes the monitoring programs. |
| Section 9: | Details the measures and indicators that will be used to assess the performance of water management measures of the Duralie Extension Project. |
| Section 10: | Describes the surface water contingency plan. |
| Section 11: | Describes the review and improvement of the environmental performance process. |
| Section 12: | Describes the management and reporting of incidents, complaints and non-compliances. |
| Section 13: | Lists the references cited. |

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

These are described below.

2.1 EP&A ACT APPROVAL

Surface Water Management Plan

This SWMP has been prepared in accordance with Condition 29 (b), Schedule 3 of the NSW Project Approval (08_0203). Table 1 indicates where each component of Condition 29 is addressed within this SWMP.

Table 1
Surface Water Management Plan Requirements

NSW Project Approval (08_0203) Condition	SWMP Section
<p>Condition 29, Schedule 3</p> <p>29. The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Director-General. This plan must be prepared in consultation with EPA and NOW by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval.</p> <p>In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:</p> <p>...</p> <p>b) a Surface Water Management Plan, that includes:</p> <ul style="list-style-type: none"> • a detailed description of the water management system on site, including the: <ul style="list-style-type: none"> – clean water diversion systems; – erosion and sediment controls; – water storages; and – irrigation system; • an irrigation management plan for the irrigation system under the water management system, which includes: <ul style="list-style-type: none"> – salinity trigger levels for controlling discharges from the irrigation areas to Coal Shaft Creek and the unnamed tributary, representing the 80th percentile value of the relevant data set for the creek/unnamed tributary and Mammy Johnsons River in accordance with the methodology in ANZECC/ARMCANZ (2000), Australian Water Quality Guidelines for Fresh and Marine Water Quality, National Water Quality Strategy; and – provision of an automated first flush system for the additional irrigation areas (Northern Areas) shown in the figure in Appendix 4. • a plan for identifying, extracting, handling, and the long-term storage of potentially acid forming material on site; 	<p>Section 5.1</p> <p>Section 7.1</p> <p>Section 5.2</p> <p>Section 6</p> <p>IMP (Attachment A)</p> <p>Section 7.2</p>

Table 1 (Continued)
Surface Water Management Plan Requirements

NSW Project Approval (08_0203) Condition	SWMP Section
<ul style="list-style-type: none"> • detailed plans, including design objectives and performance criteria, for: <ul style="list-style-type: none"> – the reconstruction of Coal Shaft Creek; – design and management of the final voids; – reinstatement of drainage lines on the rehabilitated areas of the site; and – control of any potential water pollution from the rehabilitated areas of the site; • performance criteria, including trigger levels for investigating any potentially adverse impacts, for the following: <ul style="list-style-type: none"> – the water management system; – surface water quality of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; – the stream and vegetation health of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; and – channel stability of the reconstructed Coal Shaft Creek; • performance criteria for surface water attributes relevant to water quality impacts on biological diversity and aquatic ecological integrity, including salinity, heavy metals, sediment load, pH, hardness and biological oxygen demand; • trigger levels representing the 80th percentile value of the relevant reference data set in accordance with the methodology in ANZECC/ARMCANZ (2000), Australian Water Quality Guidelines for Fresh and Marine Water Quality Management Strategy, to determine the levels for investigating any potential adverse impacts; • a program to monitor: <ul style="list-style-type: none"> – the effectiveness of the water management system; – surface water flows and quality in the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; including utilization of existing monitoring sites together with an additional monitoring site in Mammy Johnsons River immediately downstream of the mixing zone of the confluence of Coal Shaft Creek and Mammy Johnsons River; – the stream and riparian vegetation health of the unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; and – channel stability of the reconstructed Coal Shaft Creek; • a program of ecotoxicity testing of water storages on-site and at selected water monitoring sites in Mammy Johnsons River and macroinvertebrate sampling at selected monitoring sites in Mammy Johnsons River; • a plan to respond to any exceedences of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the project; and 	<p>Sections 7.3 and 9</p> <p>Sections 7.5 and 9</p> <p>Sections 7.4 and 9</p> <p>Sections 7.4 and 9</p> <p>Section 9</p> <p>Section 9</p> <p>Section 9</p> <p>Section 9</p> <p>Section 9</p> <p>Section 9 (Attachment B)</p> <p>Section 8</p> <p>Section 8.5</p> <p>Sections 8.6 and 8.8</p> <p>Section 8.8</p> <p>Section 8.7</p> <p>Sections 9 and 10</p>

Management Plan Requirements

Condition 2, Schedule 5 of the NSW Project Approval (08_0203) outlines the requirements that are applicable to the preparation of the management plans. Table 2 indicates where each relevant component is addressed within this SWMP.

Table 2
Management Plan Requirements

NSW Project Approval (08_0203) Condition	SWMP Section
Condition 2, Schedule 5	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Sections 3 and 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 9
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 9
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 5, 6 and 7
d) a program to monitor and report on the:	Sections 8, 10, 11 and 12
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 10
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 10, 11 and 12
g) a protocol for managing and reporting any;	
• incidents;	Refer to WAMP
• complaints;	Refer to WAMP
• non-compliances with statutory requirements; and	Refer to WAMP
• exceedences of the impact assessment criteria and/or performance criteria; and	Section 9
h) a protocol for periodic review of the plan.	Section 11

2.2 EPBC ACT APPROVAL

Of relevance to this SWMP, Conditions 3 and 4 of the Commonwealth Approval (2010/5396) require:

Water Management

- The person undertaking the action must ensure that all irrigation and run-off from the Project Area is managed in accordance with the Duralie Coal Mine Irrigation Management Plan (DCPL, 2008) as set out in Referral received on the 11 March 2010 (or as per any amendments approved by this Department, in consultation with the NSW Department of Planning, the NSW Department of Environment and Climate Change and Water and NSW Office of Water), and not otherwise discharged into the MJR*
- The release of water into the MJR catchment must only occur when Electricity (sic) Conductivity levels do not exceed 400 Micro Siemens ($\mu\text{S}/\text{cm}$) in the MJR at the "High Noon" monitoring site and 1,326 $\mu\text{S}/\text{cm}$ in the Main Water Dam diversion drain sumps; or alternate thresholds as may be advised in writing by the Department.*

Condition 11 of the Commonwealth Approval (2010/5396) requires:

Mitigation Measures

11. *In order to minimise the impacts of the project on listed threatened species, the person taking the action must implement all measures in the following plans/documents or their subsequent revisions as approved by the Minister:*
- (a) *The DCM Vegetation Clearance Protocol (DCPL, 2002);*
 - (b) *The DCM Irrigation Management Plan (DCPL, 2008);*
 - (c) *The DCM Site Water Management Plan (DCPL, 2008); and*
 - (d) *The DCM Rehabilitation Management Plan (DCPL, 2007).*

Attachment A (Irrigation Management Plan) to this SWMP is the latest revision of the DCM Irrigation Management Plan and supersedes the Irrigation Management Plan (DCPL, 2008).

In accordance with Conditions 3 and 11 of the Commonwealth Approval (2010/5396), the WAMP (including this SWMP) will be submitted for approval by the Commonwealth Minister for the Environment (or delegate) in consultation with DP&E, the NSW Office of Environment and Heritage (OEH) and the NSW Office of Water (NOW).

Section 7 describes the measures that will be implemented to maintain compliance with Condition 4 of the Commonwealth Approval (2010/5396).

2.3 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203), and Commonwealth Approval (2010/5396), all activities at DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

A summary of the key licences, permits and leases pertaining to the DCM is provided in Section 2.3 of the WAMP.

2.4 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

A summary of other NSW legislation that may be applicable to the conduct of the DCM is provided in Section 2.4 of the WAMP.

3 DESCRIPTION OF SURFACE WATERS

3.1 REGIONAL HYDROLOGY

A comprehensive description of the local and regional surface water resources is provided in Section 4.4 and Appendix D of the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014). A summary of this information is provided below.

The DCM is situated in the Gloucester Valley which is bounded by Buckleys Range to the east and the Linger and Die Ridge to the west. The area surrounding the DCM has been extensively cleared for grazing on native and improved pastures, and is also used for intensive poultry farming.

The DCM area is situated within the Mammy Johnsons River catchment, a tributary of the Karuah River. The Karuah River, which rises in the Chichester State Forest, drains to Port Stephens some 40 km south of the DCM. The Karuah River is located to the north-west and south of the DCM Area (Figure 1).

Mammy Johnsons River has a similar catchment area and length to the Karuah River above their confluence near the village of Stroud Road (Gilbert & Associates Pty Limited, 2014). The Mammy Johnsons River rises in the Myall State Forest to the east of the DCM and flows generally north out of the State Forest area and then west through the locality of Tereel to its confluence with Wards River some 2.5 km south-east of the township of the same name. From the Wards River confluence the Mammy Johnsons River flows in a generally southerly direction through an undulating landscape which has been extensively cleared for cattle grazing.

Streamflows in the Karuah River and Mammy Johnsons River are characterised by low to moderate flows for long periods, with periods of higher discharge following heavy rains, typical of small and medium sized upland catchments (Gilbert & Associates Pty Limited, 2010). The Karuah River appears to have stronger low flow persistence than Mammy Johnsons River, with zero flow recorded only on 0.8% of days, compared to 5.3% of days for the Mammy Johnsons River (Gilbert & Associates Pty Limited, 2010).

3.2 LOCAL HYDROLOGY

The DCM is situated in the catchment of Coal Shaft Creek, a small tributary which flows into the lower reaches of Mammy Johnsons River, and the catchment of an unnamed minor tributary stream that flows north and east to join the Mammy Johnsons River approximately 4 km upstream of the Coal Shaft Creek confluence (Figure 2).

Coal Shaft Creek has been diverted around the current DCM workings. Tombstone Hill, at an elevation of approximately RL 130 m, and its associated ridgeline, divides the Coal Shaft Creek catchment from the Mammy Johnsons River to the east.

The Coal Shaft Creek diversion comprises an approved, purpose-built diversion channel, which re-joins the original Coal Shaft Creek alignment near the DCM rail spur. The confluence of Coal Shaft Creek with the Mammy Johnsons River is south of the DCM rail loading infrastructure and approximately 10 km upstream of the Mammy Johnsons River/Karuah River confluence.

The upper reaches of Coal Shaft Creek are ephemeral and baseflow contributions in these portions of the creek are likely to be small (Gilbert & Associates Pty Limited, 2014).

4 BASELINE DATA

4.1 CLIMATE

A summary of relevant meteorological information in the DCM area is provided in *Duralie Extension Project Appendix A Surface Water Assessment* and the *Duralie Open Pit Modification Surface Water Assessment* (Gilbert & Associates Pty Limited, 2010 and 2014) available at <http://duraliecoal.com.au/environment/environmental-assessment-documents.php>.

4.2 SURFACE WATER QUALITY

A summary of relevant surface water quality information in the DCM area is provided in *Duralie Extension Project Appendix A Surface Water Assessment* and the *Duralie Open Pit Modification Surface Water Assessment* (Gilbert & Associates Pty Limited, 2010 and 2014) available at <http://duraliecoal.com.au/environment/environmental-assessment-documents.php>.

4.3 IRRIGATION WATER QUALITY

A summary of irrigation water quality information is provided in *Duralie Extension Project Appendix A Surface Water Assessment* and the *Duralie Open Pit Modification Surface Water Assessment* (Gilbert & Associates Pty Limited, 2010 and 2014) available at <http://duraliecoal.com.au/environment/environmental-assessment-documents.php>.

4.4 GEOCHEMISTRY

Results of acid rock drainage (ARD) investigations indicate the presence of potentially acid forming (PAF) waste material above the Weismantel Seam and the Clareval Seam within the extent of the open pits.

Weismantel Seam overburden has been classified as non-acid forming (NAF) except for a PAF horizon within 5 m (perpendicular to bedding) immediately above the coal seam. The Weismantel Seam rock floor is also likely to be mainly PAF. The PAF zone above the coal seam, the overlying thicker NAF zone and the PAF floor rock are identified as continuous and predictable (EGi, 2009).

Partially weathered to fresh overburden for the Clareval Seam includes roughly equal proportions of NAF and PAF/low capacity PAF (PAF-LC), with some indication of thick NAF horizons (EGi, 2009). The continuity and distribution of PAF and NAF horizons for the Clareval overburden is more complex than that for the Weismantel Seam (EGi, 2009).

5 WATER MANAGEMENT SYSTEM

The objectives of the DCM water management system are to:

- protect the integrity of local and regional water resources;
- maintain separation between runoff from undisturbed areas and water generated within active mining areas;
- comply with the requirements of EPL 11701;
- continue the beneficial use of water collected from operational areas for on-site irrigation; and
- provide a reliable source of water for on-site mining and coal handling.

The DCM water management system controls waters generated from surface development areas while controlling the capture of surface water runoff by diverting upslope water around such areas (DCPL, 2010). The water management system includes a combination of permanent structures that will continue to operate post closure and temporary structures that will only be required until the completion of rehabilitation works (e.g. sediment control structures) (DCPL, 2010).

The existing water management system at the DCM includes the following components (DCPL, 2014):

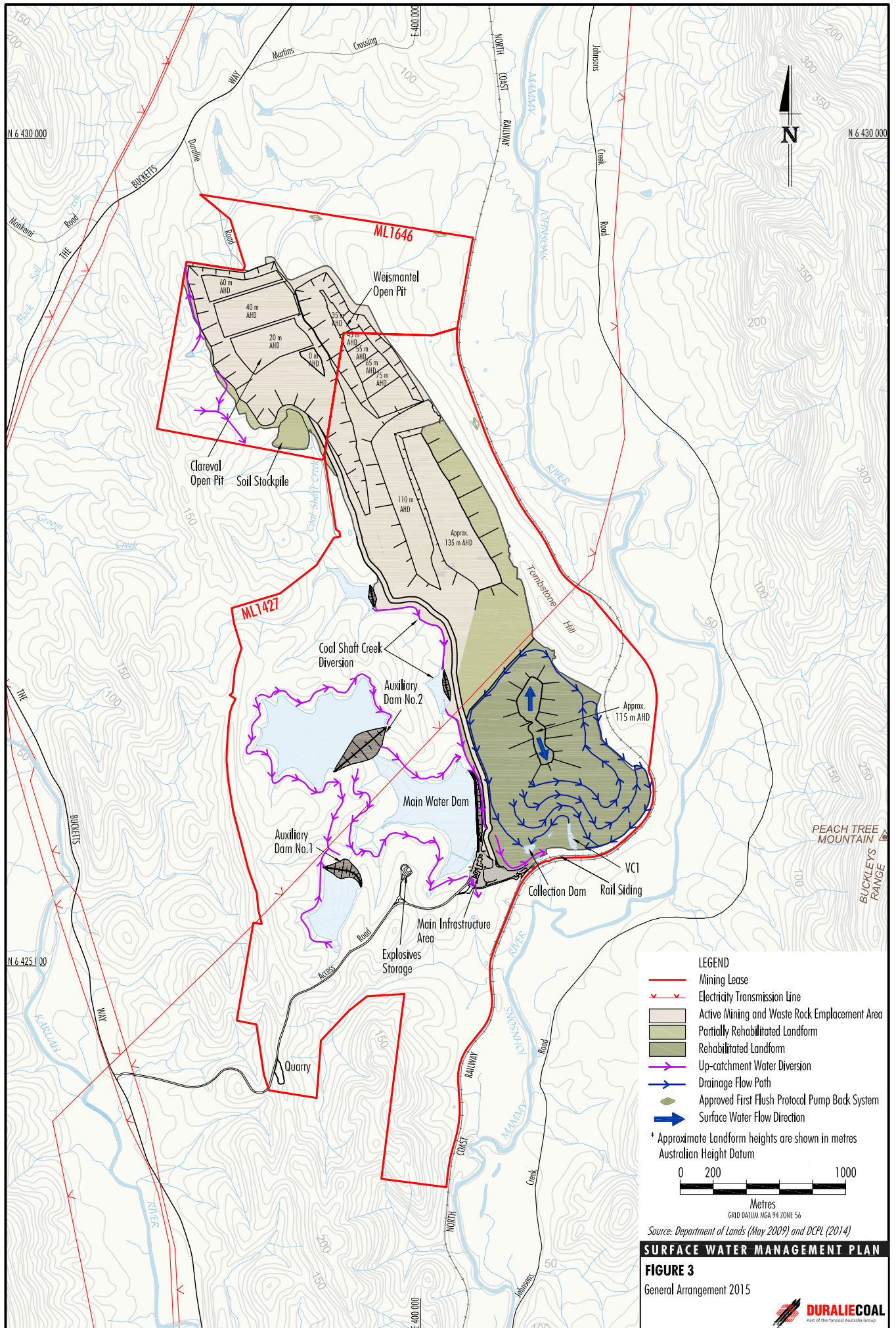
- water management storages;
- diversions for runoff from catchment areas upslope of the mine disturbance area (i.e. upslope diversions);
- runoff control structures and devices on disturbed and rehabilitated areas at the mine;
- runoff control structures and devices on infrastructure areas;
- procedures, structures and devices for the control of erosion and sediment movement;
- open pit dewatering equipment;
- procedures and equipment for the disposal of excess water through on-site irrigation; and
- sewage treatment plant and a system for the disposal of effluent.

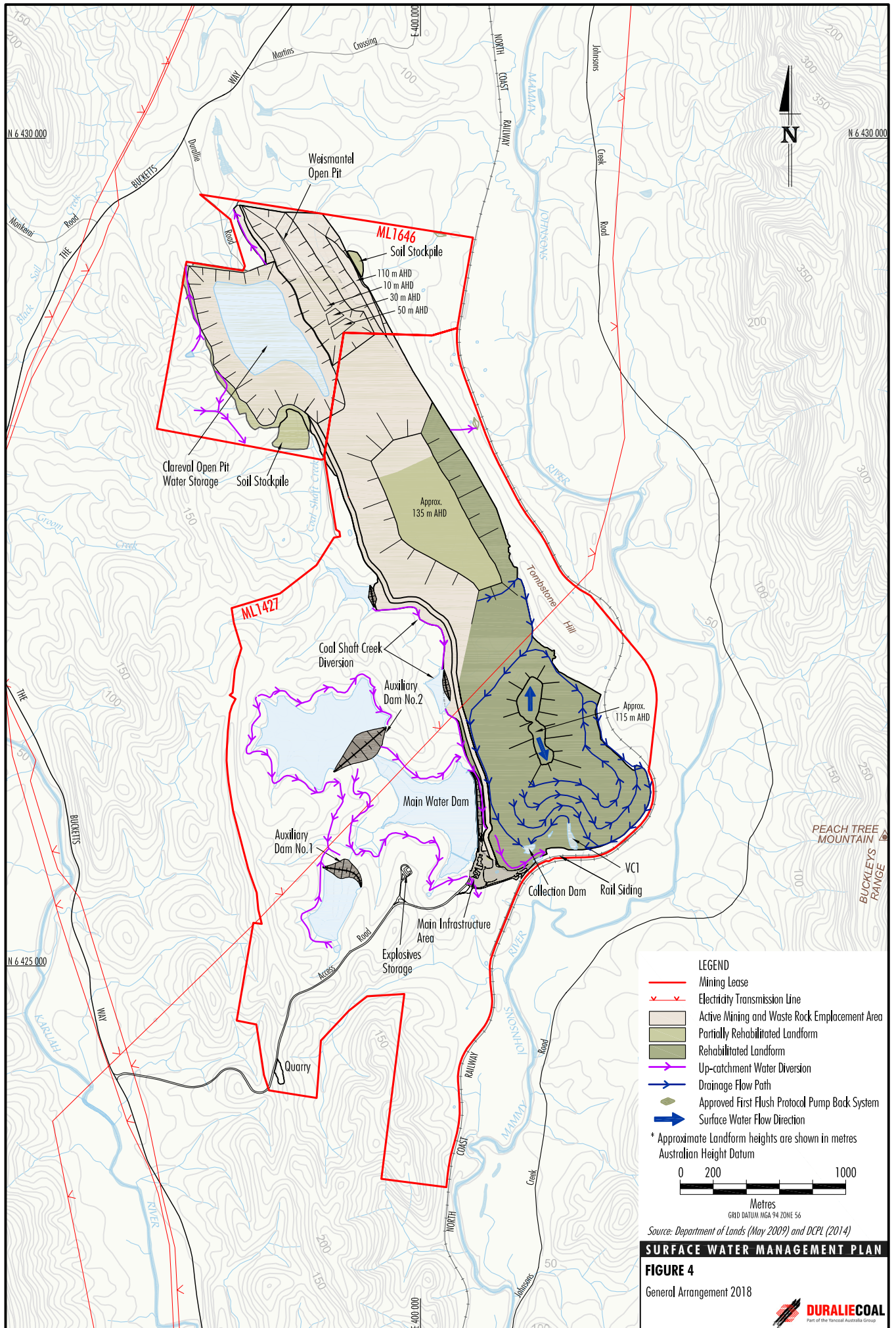
The DCM water management system is described in further detail in the Site Water Balance (Appendix 1 of the WAMP).

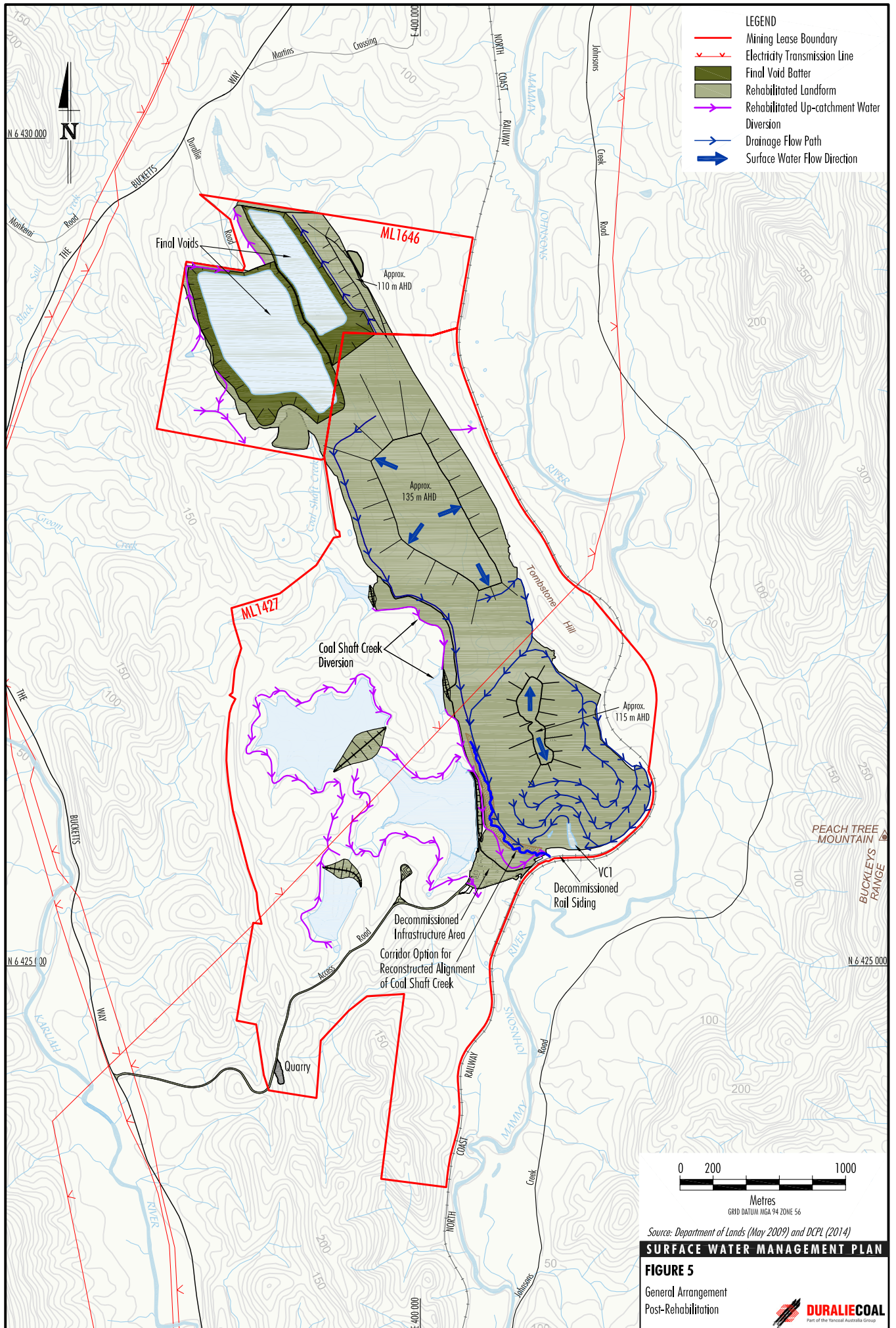
5.1 UPSLOPE DIVERSION WORKS

Temporary and permanent upslope diversion bunds/drains and temporary interception dams will continue to be constructed over the life of the DCM, to divert runoff from undisturbed areas around the open pits and waste rock emplacements. The DCM surface water management system would include continued diversion of runoff via the Coal Shaft Creek Diversion (Figures 3 to 5).

The Coal Shaft Creek Diversion would remain for the DCM life. Small tributaries in the very upper reaches of Coal Shaft Creek would be diverted around the north and west of the Clareval open pit and waste rock emplacement, directing runoff back into the remnant Coal Shaft Creek upstream of the Coal Shaft Creek Diversion (Figures 3 to 5).







Portions of the upper reaches of the Unnamed Tributary will be diverted around the north and west of the Clareval open pit and waste rock emplacement, directing runoff into the Unnamed Tributary (Figures 3 to 5).

Permanent upslope diversion bunds/drains will remain around final voids.

The upslope diversions have and will be designed for the peak flow generated by 1 in 100 year rainfall event. Permanent diversion(s) including the final Coal Shaft Creek Diversion will be assessed against the probable maximum flood (PMF) event.

Diversion stability will be achieved by providing appropriately sized channel cross-sections and bed gradients; and by incorporating bed and bank treatments such as rock fill and vegetation which will provide erosion resistance.

The eastern toe of the backfilled waste rock emplacement will be designed to abut the Tombstone Hill ridgeline. Sediment dams will be constructed on the eastern flank of the Tombstone Hill ridgeline for sediment control whilst the eastern waste rock emplacement batters are undergoing rehabilitation/revegetation. The dams will be retained post-mining for stock watering and to provide stormwater runoff detention from the slightly increased catchment reporting eastwards. The dams will provide adequate runoff detention such that peak flow rates in culverts under the North Coast Railway line will not be increased.

5.2 WATER STORAGES

Water storages (existing and under construction) at the DCM include (Figure 2):

- Main Water Dam (MWD), which is located north-west of the main infrastructure area and has a constructed capacity of up to approximately 1,405 ML to the top of the I-Beam, and approximately 1,296 ML to the invert of the spill pipe.
- A smaller bunded area located in the south of the MWD, adjacent to the main infrastructure area.
- Auxiliary Dam No. 1, which is located upslope of the MWD and has a constructed capacity of 462 ML (with an approved capacity up to 500 ML).
- Auxiliary Dam No. 2, which is located upslope of the MWD and has a designed capacity of 2,724 ML (with an approved capacity up to 2,900 ML).

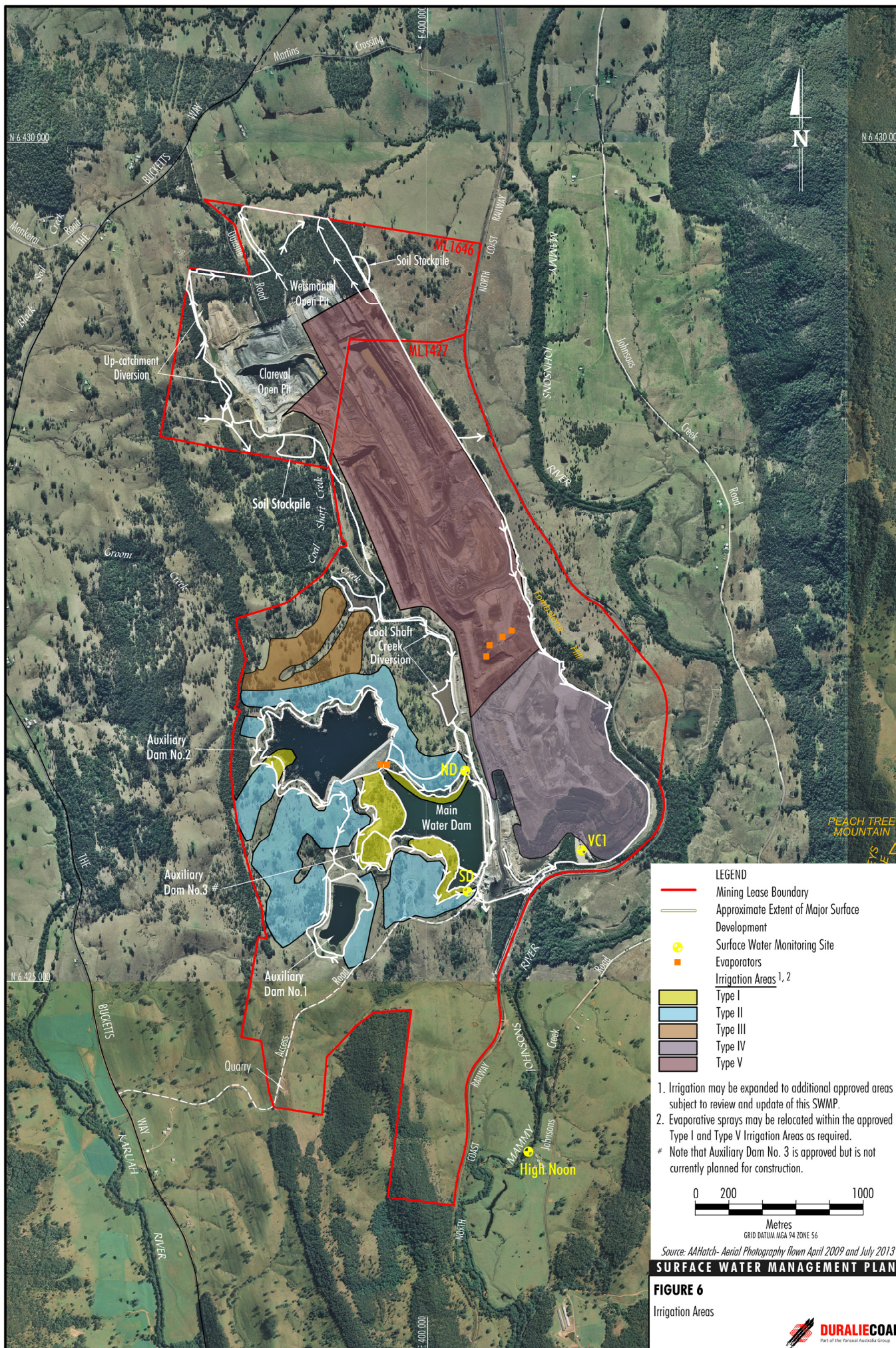
The Weismantel open pit will initially be inactive and available for secure storage of excess water through to mid-2017. Mining will continue in the Clareval open pit through until its completion in 2017, after which mining would recommence in the Weismantel open pit through the approved DCM mine life. Once mining is completed in the Clareval open pit (2017), it will be available for secure storage of excess water. Any excess water in the Weismantel open pit will be removed to the Clareval final void, in advance of commencement of mining in the Weismantel open pit in early 2018 (Gilbert & Associates, 2014).

The storage capacity of the Weismantel and Clareval final voids have been estimated at approximately 12,400 ML and 38,000 ML, respectively (Gilbert & Associates Pty Limited, 2014).

The DCM has approval to construct Auxiliary Dam No. 3 to an approved capacity of 110 ML, however construction of Auxiliary Dam No. 3 is not planned as a component of the current DCM water management system.

6 IRRIGATION

Excess water within the DCM water management system is disposed of through on-site irrigation of water from the MWD. Details of the irrigation scheme and its management are provided in the Irrigation Management Plan - refer Attachment A of this SWMP. Irrigation areas are shown on Figure 6.



7 MANAGEMENT MEASURES

7.1 EROSION AND SEDIMENT CONTROL PLAN

Sources of Erosion

Erosion and sedimentation at the DCM could potentially result directly or indirectly from:

- runoff from areas disturbed in advance of, and during mining;
- runoff from topsoil stockpiles and waste rock emplacements prior to rehabilitation;
- runoff from rehabilitated areas prior to adequate stabilisation of the revegetated surface;
- runoff from infrastructure areas;
- runoff from roads or rail embankments at erosive velocities; and
- runoff from areas where erosion has been exacerbated by irrigation.

In addition to the above, elevated winds may also result in erosion from exposed surfaces. Management measures for wind erosion are provided in the Air Quality and Greenhouse Gas Management Plan required under Condition 23, Schedule 3 of the NSW Project Approval (08_0203).

Erosion and Sediment Control Strategy

The primary objectives of the erosion and sediment control at the DCM are to:

- minimise and control soil erosion and sediment generation in areas disturbed by ongoing mining and associated activities at the DCM (as modified); and
- minimise the potential for sediment generated from site activities to adversely affect the water quality of the Mammy Johnsons River or the Karuah River.

Control strategies for soil erosion and sediment migration include:

- Maximum separation of runoff from disturbed and undisturbed areas.
- Provision of a site drainage system (comprising clean and dirty water drains) which operates at non-erosive velocities at the specified design criteria (refer *Design Criteria* below).
- Construction of sediment dams downstream of disturbed areas sized to contain runoff up to specified design criteria (refer *Design Criteria* below).
- Water shall be treated before being released from the site to achieve:
 - a pH range of 6 to 8;
 - <50 milligrams per litre (mg/L) of suspended solids; and
 - no visible oil and grease.
- Dewatering of sediment dams (subject to water quality criteria listed above) to well-grassed areas between runoff events via grassed buffer areas to further remove entrained sediment and its migration to down-slope watercourses and in accordance with the conditions of EPL 11701. Where a suitable vegetated dewatering area is not available, dewatering of sediment dams for priority re-use, for purposes such as dust suppression and moisture conditioning of earthworks on site.

- Selective use of benign flocculants, such as gypsum, to assist in the settlement of suspended solids in sediment dams if required.
- Construction of silt fences in overland flow areas downslope of disturbed sites.
- Rapid and progressive stabilisation of disturbed surfaces, including:
 - the use of contour banks and furrows;
 - the use of hydromulching techniques; and
 - early revegetation or armouring (i.e. jute mesh and/or compacted rock) of disturbed surfaces.

Erosion and sediment control will be designed and constructed in consideration of the recommendations for site drainage works presented in *“Managing urban storm water – Soils and Construction Volume 1”* (Landcom, 2004) and *“Managing urban storm water – Soils and Construction Volume 2e”* (DECC, 2008).

A description of topsoil management strategies implemented at the DCM is provided in the Rehabilitation Management Plan required under Condition 57, Schedule 3 of the NSW Project Approval (08_0203).

Construction activities will generally occur in the following order:

1. Construction of diversion drains (typically upslope of disturbance areas).
2. Installation of silt fences and temporary sediment traps (e.g. hay bales) in overland flow areas downslope of disturbance areas.
3. Construction of sediment dams on drainage lines downslope of disturbance areas.
4. Construction of collection drains to convey runoff to sediment dams.
5. General construction works would only take place once all erosion and sediment control measures are in place to the satisfaction of the Environmental Officer.

Ongoing mining operations involve clearing and topsoil stripping in advance of overburden removal. Collection bunds and conveyance channels would be constructed in advance of topsoil stripping to direct disturbed area runoff into the pit or to purpose built sediment dam(s). This process would be managed as part of the detailed ongoing mine planning conducted by DCM mining engineers.

Design Criteria

Design criteria for sediment control structures are summarised in Table 3.

Sediment dams will continue to be dewatered to their normal operating level within 5 days of a runoff-generating rainfall event to re-establish the design containment capacity or within 10 days where the dam has been designed with a 125% adjustment factor.

Outlets of collection and diversion drains will be armoured (e.g. compacted rock or jute mesh) in order to prevent localised erosion. Internal and external batters of sediment dams will be revegetated to minimise the potential for erosion of dam batters.

Table 3
Sediment Control Structures – Design Criteria

Sediment Control Structure	Function	Design Capacity
Temporary upslope diversion drains	Reduce runoff from undisturbed areas to disturbed areas	Capable of passing the peak flow generated by the 1 in 20 year 1 hour rainfall event ¹
Downslope collection drains	Intercept and convey disturbed area runoff water to sediment dams	Capable of passing the peak flow generated by the 1 in 20 year 1 hour rainfall event ¹
Sediment dams	Settlement of sediments in runoff from disturbed areas	Volume to be determined in accordance with <i>Managing Urban Stormwater Soils and Construction Volume 2E Mines and quarries</i> (Department of Environment and Climate Change, 2008). ²
Sediment dam spillway channels	Facilitate the passage of flows in excess of the sediment dam storage capacity	Capable of passing the peak flow generated by the 1 in 100 year critical duration rainfall event

- 1 In accordance with Department of Land and Water Conservation (now NOW) conditions of approval received on 10 June 2002 for the superseded Erosion and Sediment Control Plan.
- 2 Sediment dam volume is determined with consideration to site specific soil type, runoff coefficient and designated management period (i.e. 5 or 10 days).

7.2 POTENTIALLY ACID FORMING MATERIAL MANAGEMENT PLAN

PAF waste material is segregated and selectively handled. The location of PAF material is determined by geological modelling, informed by ongoing exploration activities and field sampling. PAF material is mined to the modelled PAF limits before placement in accordance with the PAF Material Management Plan. Confirmation of the thickness of the PAF band is periodically assessed by field sampling and laboratory analysis (utilising net acid generation testing) (DCPL, 2015).

Limestone is selectively placed on the open pit floor and PAF waste rock emplacement lifts/faces to minimise the release of acid rock drainage products. PAF material is stored in two distinct manners at the DCM, both in the out-of-pit waste rock emplacement and in-pit waste rock emplacement.

In the out-of-pit waste rock emplacements at the DCM, the PAF material is encapsulated within appropriately designed and constructed containment cells and capped with a clay capping layer.

For in-pit waste rock emplacement, once PAF material has been placed within the designated PAF management area of the open pit (i.e. below the post-mining water table), a layer of NAF material is placed above the emplaced PAF material. Upon final placement of sufficient NAF material to construct the design profile for the given section of the emplacement area, shaping, drainage construction, topsoil placement and revegetation is undertaken (DCPL, 2015).

Operational controls for treatment and storage of PAF materials at the DCM are as follows (EGi, 2009):

- Limestone treatment on exposed Weismantel Seam floor rock, all final PAF overburden lift surfaces, and interim PAF waste rock dump surfaces likely to be exposed for more than 3 weeks. Limestone application rates are at least 20 tonnes CaCO₃ per ha (t CaCO₃/ha) and average close to 50t CaCO₃/ha. Limestone treatment of Clareval Seam floor is pending further testing and operational monitoring.
- Management supervised segregation and limestone treatment of coal cleanings (in particular 1 to 2 m above Weismantel and Clareval Seams) to prevent ARD during operations.
- Placement of at least 20 m of NAF overburden over PAF materials to provide an oxygen barrier to help control oxidation of PAF materials. NAF cover placement will continue to follow closely behind the advancing PAF waste rock dump face to minimise exposure time of PAF materials.
- After final placement of NAF material, the waste emplacement is shaped to final contour, surface drainage is constructed, and topsoil placement and revegetation is undertaken for the given section of the emplacement area.

- The potential for acid formation in the pit is also controlled by prompt removal of water from pit sump and by shaping dumped materials to minimise infiltration. In the event that significant acid generation did occur in open pit water, there is site capability for treatment (i.e. neutralisation with hydrated lime or limestone).

If the amount of PAF overburden exceeds the maximum disposition level RL, long term control for the PAF material would need to rely on control of infiltration and oxygen diffusion through placement of PAF materials below a designed cover system. The details of the cover system design would require assessment of the hydraulic and physical properties of the various mine materials in conjunction with local climate controls to determine the appropriate type of cover system.

Consistent with the Duralie Coal EIS, DCPL will construct clay cut-off walls along the southern end of the waste rock emplacement toe at Coal Shaft Creek to impede potential groundwater seepage from the toe of the waste emplacement to lower Coal Shaft Creek and Mammy Johnsons River.

Routine monitoring at the DCM will continue to be carried out to provide checks on materials management and effects of ARD. Monitoring includes (EGi, 2009):

- routine sampling and geochemical testing of overburden materials from both seams as required during operations to monitor variations in acid potential and to reconcile the predicted distribution of ARD rock types in overburden;
- water quality monitoring of seepage and runoff from pit surfaces and waste rock dumps to check for ARD generation, to assess the performance of management strategies, and to determine and/or refine limestone treatment requirements (refer to Section 8); and
- routine site water quality monitoring including pH, Electrical Conductivity (EC), acidity/alkalinity, sulphate (SO_4), Aluminium, Copper, Iron, Manganese, Nickel, Zinc and storage volumes and flows to monitor the performance of the ARD control program (refer to Section 8).

Limestone will continue to be applied in pit at a rate of at least 20 tonnes CaCO_3 per ha ($\text{t CaCO}_3/\text{ha}$) and additionally the monitoring results from geochemical testing and water quality will be used to determine the need to increase or decrease the rate of limestone application.

Additional geochemical testing is being conducted in the Weismantel and Clareval Seams overburden to improve knowledge of the occurrence of PAF materials and will continue over the life of the DCM. The results of this geochemical testing will be used to improve PAF material selection and placement locations and will be included in revisions to this SWMP where appropriate.

7.3 DEVELOPMENT OF COAL SHAFT CREEK RECONSTRUCTION PLAN

Following the completion of mining activities at the DCM, a final alignment of Coal Shaft Creek will be established, stabilised and revegetated prior to lease relinquishment.

The final design of the post-mining alignment of the Coal Shaft Creek is documented in the Coal Shaft Creek Reconstruction Plan (CSCR) (Attachment C). The CSCR includes:

- design objectives and performance criteria related to bed and bank stability, bed and bank erosion rates, changes to flow path geometry, vegetation and habitat establishment, and water quality;
- detailed design plans of the post-mining alignment and reconstruction of Coal Shaft Creek informed by geotechnical, hydrological and hydraulic analyses;
- monitoring and maintenance requirements; and
- provisions for development of a contingency plan if performance criteria are not being achieved.

7.4 MANAGEMENT OF REHABILITATION AREA RUNOFF

The proposed post-mining water management strategy is shown on Figure 5. A detailed description of the management of rehabilitation areas is provided in the Rehabilitation Management Plan required under Condition 57, Schedule 3 of the NSW Project Approval (08_0203).

The top surface of the waste rock emplacement will be designed as a ridgeline running parallel to Tombstone Hill and will generally drain towards the south to Coal Shaft Creek. Rock lined channels will be installed along the edge of the top surface to provide a stable means for surface water runoff to drain from the top of the waste rock emplacement.

On the batters of the waste rock emplacement, surface water runoff will flow perpendicularly down the slope to the toe of each batter where it will be re-directed by contour drains to drain-off points. The contour drains will be grass-lined, and wherever practicable, will discharge to the natural ground surface. If required as a contingency measure, hydraulic control structures will be constructed to allow water to be safely discharged down the emplacement batter slope to the existing ground level.

As part of development of the waste rock emplacement, waste rock will be placed against the Tombstone Hill ridgeline to the east of the waste rock emplacement area (Figure 5). In the northern portion of the waste rock emplacement, drainage from the eastern batter of the waste emplacement will drain eastwards towards Mammy Johnsons River.

Rock lined channels will be used at the base of the waste rock emplacement to direct runoff into natural creek lines (e.g. Coal Shaft Creek).

Erosion control will be achieved by the development and implementation of land stabilisation procedures and protocols as outlined in Section 7.1.

Sediment dams downstream of the waste rock emplacement will be maintained until the revegetated surface is stable and the runoff water quality is suitable for release off-site.

Sediment dams may be retained for stockwater, or as passive water control storages.

7.5 MANAGEMENT OF FINAL VOID WATER

A detailed description of the decommissioning of final voids is provided in the Rehabilitation Management Plan required under Condition 57, Schedule 3 of the NSW Project Approval (08_0203).

At the cessation of mining, final voids will remain in the Clareval open pit and Weismantel open pit (Figure 5).

The surface catchment area reporting to the final voids will be reduced to a practicable minimum (Figure 5) by the use of upslope diversions, contour drains around their perimeter and maximising backfilling of voids. The catchment areas of the final voids would be reduced to approximately 1.2 km² (Gilbert & Associates, 2014).

Inflows to the final open pit voids comprise incident rainfall over the void lake surface, runoff and seepage from the sides of the voids and their adjacent contributing catchment and seepage from coal seam groundwater and waste rock emplacement infiltration (Gilbert & Associates Pty Limited, 2014). A final void water balance model was developed by Gilbert & Associates Pty Limited (2014) for the combined final voids to predict the long-term behaviour of the final void water bodies.

Post recovery groundwater seepage rates (including overburden infiltration) to the voids were advised by HydroSimulations (2014). Inflow rates were estimated for different final void water levels (reducing with rising water level).

Spill between the two voids was modelled as occurring at RL 86 m, while the perimeter of the final voids was assumed to be at RL 88 m (Gilbert & Associates Pty Limited, 2014). The long term water level in the Weismantel final void is predicted to be about 76 to 79 m AHD which is some 7 to 10 m below the level at which the water is predicted to spill over into the adjoining Clareval void (i.e. 86 m AHD). The long term water level in the Clareval final void is predicted to be around 60 m AHD as a result of the relatively higher evaporative of the Clareval final void (Gilbert & Associates Pty Limited, 2014).

Model results are shown in Chart 1 and Chart 2 below in terms of predicted final void water levels versus time, showing that the two voids would form an integrated pit lake over time.

Chart 1 and Chart 2 show that predicted water level in the final voids will stabilise after about 80 years at a level approximately 14 m below spill level (88 m Australian Height Datum [AHD]), with fluctuations continuing to occur due to climatic variability (e.g. seasonal changes in rainfall and evaporation) (Gilbert & Associates Pty Limited, 2014). No spill was predicted in the long-term from the final voids.

The final voids will cause a temporary change in groundwater flow direction, often reversal of direction, until mining is completed and the aquifer system recovers to a new equilibrium (HydroSimulations, 2014). The Clareval final void will remain a groundwater sink for some time, and no impacts to groundwater quality are expected during this time as a result of the final void water quality.

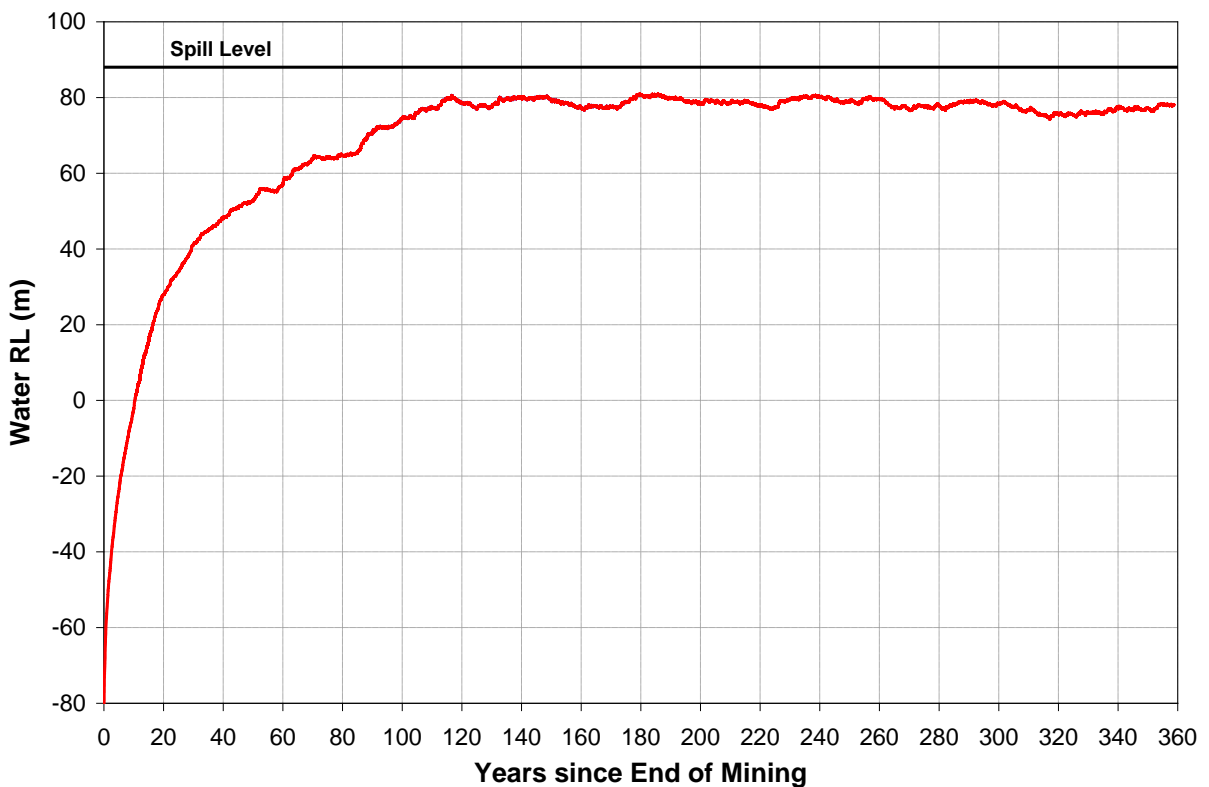
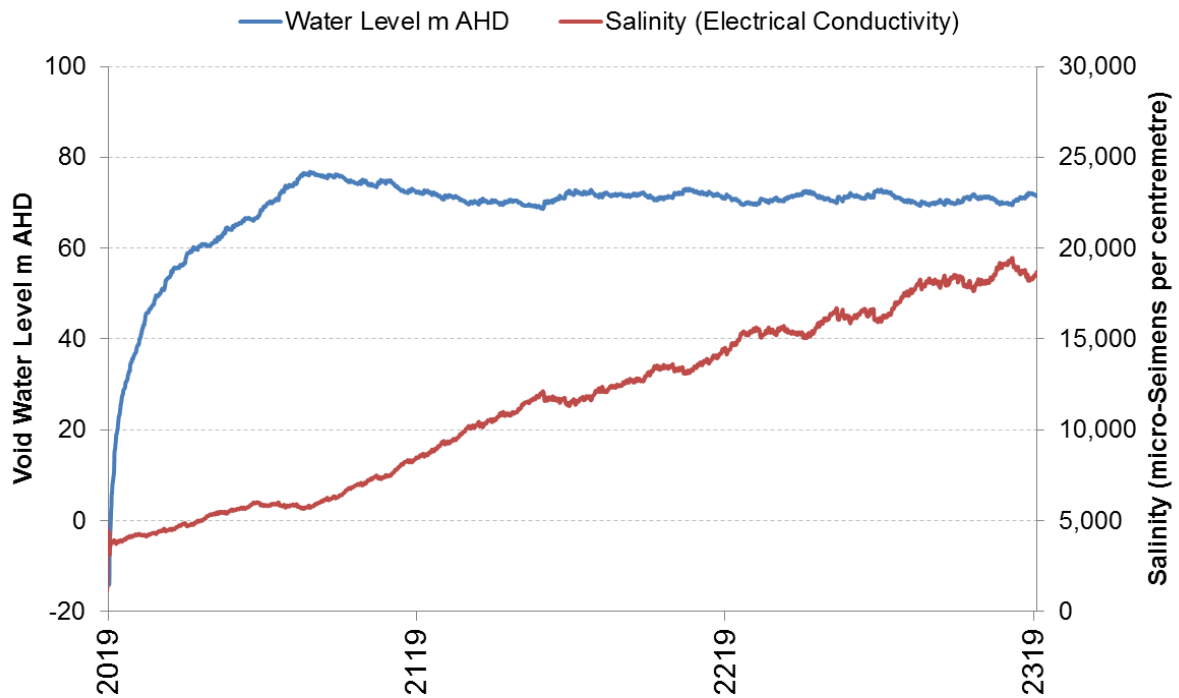
Numerical modelling conducted by HydroSimulations (2014) shows that groundwater flow in the Weismantel final void may, after several decades, be restored to the direction that existed prior to mining. Once the void water levels in the Weismantel final void reach an equilibrium level, the integrated pit lake would not drive groundwater flow, but would form part of a restored pre-mine groundwater flow system.

Minor volumes of groundwater flow would occur into and out of the final voids as the water level fluctuates with climatic variability. Groundwater flow out of the pit lakes would be into the waste rock emplacement and surrounding groundwater system and may include some groundwater transmission to Coal Shaft Creek.

The final void water balance model was also used by Gilbert & Associates Pty Limited (2014) to simulate salinity levels in final void waters. The balance involved tracking the movement of salt (EC) into the final void and estimating changes in salt concentration (EC) in the void over time.

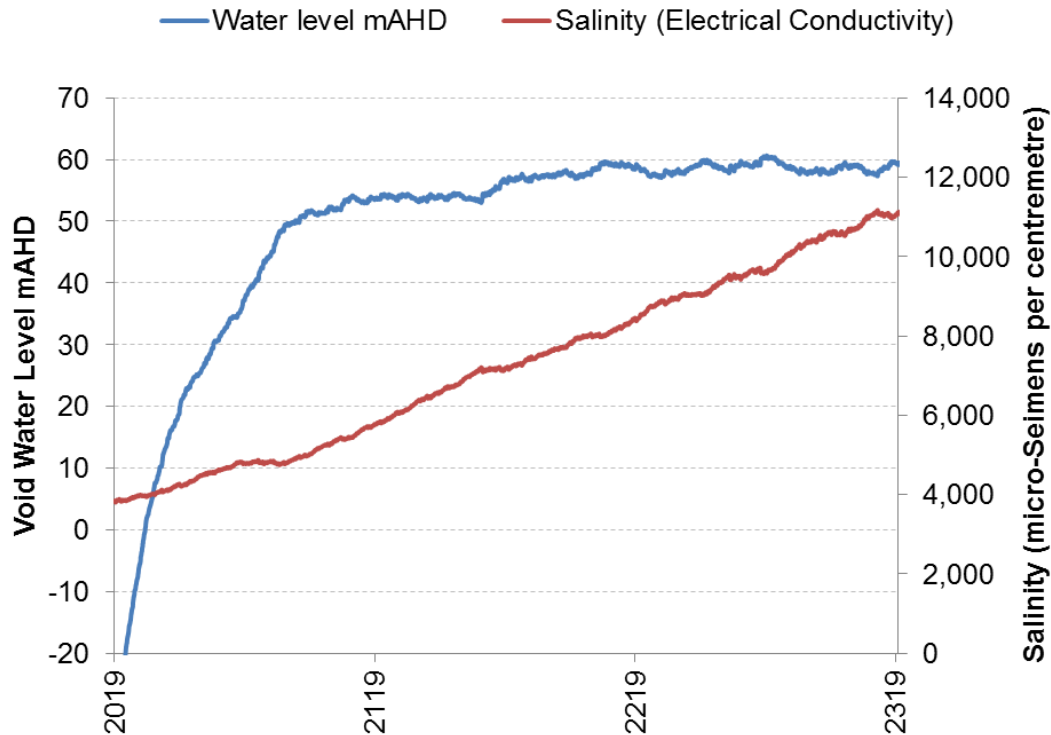
Once the void water levels reach an equilibrium level, HydroSimulations (2014) concluded that there would be no deleterious effect on the groundwater resource or on the quality of the water, because water quality in the surrounding groundwater is in many cases of a poorer quality than what is predicted from the final void, as final void salinity is generally predicted to slowly increase with time (Gilbert & Associates Pty Limited, 2014).

Chart 1
Simulated Water Levels and Salinity – Weismantel Final Void Post Closure



Source: Gilbert & Associates Pty Limited (2014).

Chart 2
Simulated Water Levels and Salinity – Clareval Final Void Post Closure



Source: Gilbert & Associates Pty Limited (2014).

In addition, DCPL will construct clay cut-off walls along the southern end of the waste rock emplacement toe at Coal Shaft Creek to impede potential groundwater seepage from the toe of the emplacement to lower Coal Shaft Creek and Mammy Johnsons River. The final design of the proposed clay cut-off walls (to impede potential groundwater seepage from the toe of the emplacement to lower Coal Shaft Creek and Mammy Johnsons River) will be provided in future revisions of the DCM Mining Operations Plan.

DCPL has installed piezometers in the in-pit waste rock emplacement as described in the Groundwater Management Plan (Appendix 3 of the WAMP) to provide information on groundwater recharge rates and permeability.

The final void water balance will be reviewed, and revised, over the life of the DCM where:

- a site water balance review indicates that refinement of site water balance assumptions are required (as described in Section 8.2);
- results of the groundwater monitoring programme indicate that refinement of the numerical groundwater model is required (as described in the Groundwater Management Plan [Appendix 3 of the WAMP]); and/or
- there is any material modification to the size, location and/or catchment area of the final voids.

8 MONITORING PROGRAMS

8.1 METEOROLOGY

In accordance with Condition 24, Schedule 3 of the NSW Project Approval (08_0203), DCPL maintains an Automatic Weather Station (AWS) on-site. The on-site AWS continuously monitors the following meteorological parameters:

- rainfall;
- temperature;
- relative humidity;
- evapotranspiration;
- net solar radiation;
- wind direction; and
- wind speed.

8.2 WATER MANAGEMENT SYSTEM MONITORING PROGRAM

Table 4 outlines the program that will be implemented at the DCM to monitor the effectiveness of the water management system.

Table 4
Water Management System Monitoring Program

Monitoring Location	Parameter	Frequency
MWD (SW3 [Major])	Water Storage Level.	Continuously.
	pH, EC, Turbidity.	Weekly.
	Suite 2 ¹	Monthly.
	Benzene, Toluene.	Annually.
SW3 (Minor)	Water Storage Level.	Weekly.
	pH, EC.	Weekly.
Auxiliary Dam No. 1 (AD1) and Auxiliary Dam No. 2 (AD2)	Water Storage Level.	Weekly.
	pH, EC.	Weekly.
Open Pit Sump (SW4) and Clareval Pit	pH, EC, Turbidity.	Weekly.
	Suite 1 ¹	Monthly.
Rail Siding Sediment Dams (RS1, RS6)	TSS.	Each overflow event.
	pH, EC (RS6 only).	Monthly.
Waste Rock Emplacement Sediment Dams (VC1)	pH, EC, TSS.	Special Frequency 1 ²
Transfer Pumps	Transfer volumes measured by accumulating flow meters or pump hours .	During each period of pumping.

¹ Suite 1: pH, EC, Turbidity, Total Acidity, Total Alkalinity, Total Suspended Solids (TSS), Chloride, SO₄, Calcium, Magnesium, Aluminium, Iron, Manganese, Zinc, Copper.

Suite 2: pH, EC, Turbidity, Total Acidity, Total Alkalinity, Hardness, TSS, Total Dissolved Solids (TDS), BOD₅, Chloride, SO₄, Carbonate, Bicarbonate, Calcium Carbonate, Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc, Arsenic, Boron, Cadmium, Copper, Lead, Chromium, Mercury, Nickel, Selenium, Silver, Barium, Uranium, Molybdenum, Nitrite, Nitrate, Total Nitrogen, Total Phosphorus, Fluoride and Ammonia.

² Special frequency 1

- A sample taken monthly;
- A sample taken on the first day of any discharges (overflows) from North Drain, South Drain or VC1.

A site water balance review will be undertaken on an annual basis to review monitoring of the status of inflows, outflows, site water inventory and consumption (irrigation, dust suppression, vehicle wash-down) and to update the site water balance model predictions. A review of the site salt balance will also be conducted. The site water balance review will be used to optimise water management performance and will enable corrective actions to be implemented, if required. The results of the water balance reviews will be reported in the Annual Review (Section 11.1).

8.3 IRRIGATION AREA MONITORING PROGRAM

In addition to monitoring of the water management system described in Section 8.2, DCPL will implement monitoring of irrigation rates and areas as described in the Irrigation Management Plan (Attachment A).

8.4 EROSION AND SEDIMENT CONTROL MONITORING PROGRAM

Routine inspections of sediment control structures as well as inspections following rainfall events of 20 mm or more in a 24 hour period are conducted by the Environmental Officer. During these inspections sediment control structures are inspected for loss of capacity due to sediment capture and structural integrity.

The Coal Shaft Creek Diversion is inspected for structural integrity, blockages or other faults after a rain event of >50 mm in seven days or at least every three months. The MWD diversion drain is inspected at least twice per year and following significant rain events (> 50 mm/day).

8.5 SURFACE WATER QUALITY MONITORING PROGRAM

An outline of the surface water quality monitoring program is provided in Table 5. Surface water monitoring locations are shown on Figures 7a and 7b.

The Coal Shaft Creek diversion and in the northern and southern MWD diversions have been equipped with continuous V-notch weirs (Figures 7a and 7b). Flow monitoring will commence at these locations by the end of 2011 (or earlier if practicable).

DCPL monitoring will be used in conjunction with data from NOW gauging stations GS209002 (on the Mammy Johnsons River) and GS209018 (on the Karuah River) (Figure 7a).

Table 5
Surface Water Quality Monitoring Program¹

Monitoring Location	Parameter ¹	Frequency
SW2 (Coal Shaft Creek [Lower])	Suite 1.	Special Frequency 1 ²
SW2(RC) (Coal Shaft Creek [Rail Culvert])	Suite 2.	Special Frequency 2 ²
SW6 (Culvert at Rail Siding)	Suite 1.	Special Frequency 2 ²
SW9 (Fisher-Webster)	Suite 2.	Special Frequency 2 ²
SW10 (Holmes)	Suite 2.	Special Frequency 2 ²
GB1 (Mammy Johnsons River [Upstream])	Suite 2.	Special Frequency 1 ²
	Benzene, Toluene.	Annually
High Noon (Mammy Johnson River)	EC.	Continuous
	Suite 2.	Special Frequency 1 ²
	Benzene, Toluene.	Annually
Site 9 (Karuah River [Stroud Road])	Suite 2.	Special Frequency 2 ²
Site 11 (Mammy Johnsons River [Downstream])	Suite 2.	Special Frequency 2 ²
Site 12 (Mammy Johnsons River [Relton])	Suite 2.	Special Frequency 2 ²
Site 15 (Mammy Johnsons River [Tereel])	Suite 2.	Special Frequency 2 ²
Site 19 (Karuah River [Washpool])	Suite 2.	Special Frequency 2 ²
DDD 2 and DDD 3 (MWD Upslope Diversion)	pH, EC.	Monthly
North Drain [ND] and South Drain [SD]	EC.	Continuous
	pH, TSS.	Special Frequency 1
Units 6, 9, 11	EC.	Continuous
MJR US EC and MJR DS EC	EC.	Continuous
CSC Upstream and CSC Rail Culvert	EC.	Continuous

¹ Suite 1: pH, EC, Turbidity, Dissolved Oxygen (DO), Total Acidity, Total Alkalinity, TSS, Chloride, SO₄, Calcium, Magnesium, Aluminium, Iron, Manganese, Zinc, Copper.

Suite 2: pH, EC, Turbidity, DO, Total Acidity, Total Alkalinity, Hardness, TSS, TDS, BOD₅, Chloride, SO₄, Carbonate, Bicarbonate, Calcium Carbonate, Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc, Arsenic, Boron, Cadmium, Copper, Lead, Chromium, Mercury, Nickel, Selenium, Silver, Barium, Uranium, Molybdenum, Nitrite, Nitrate, Total Nitrogen, Total Phosphorus, Fluoride and Ammonia.

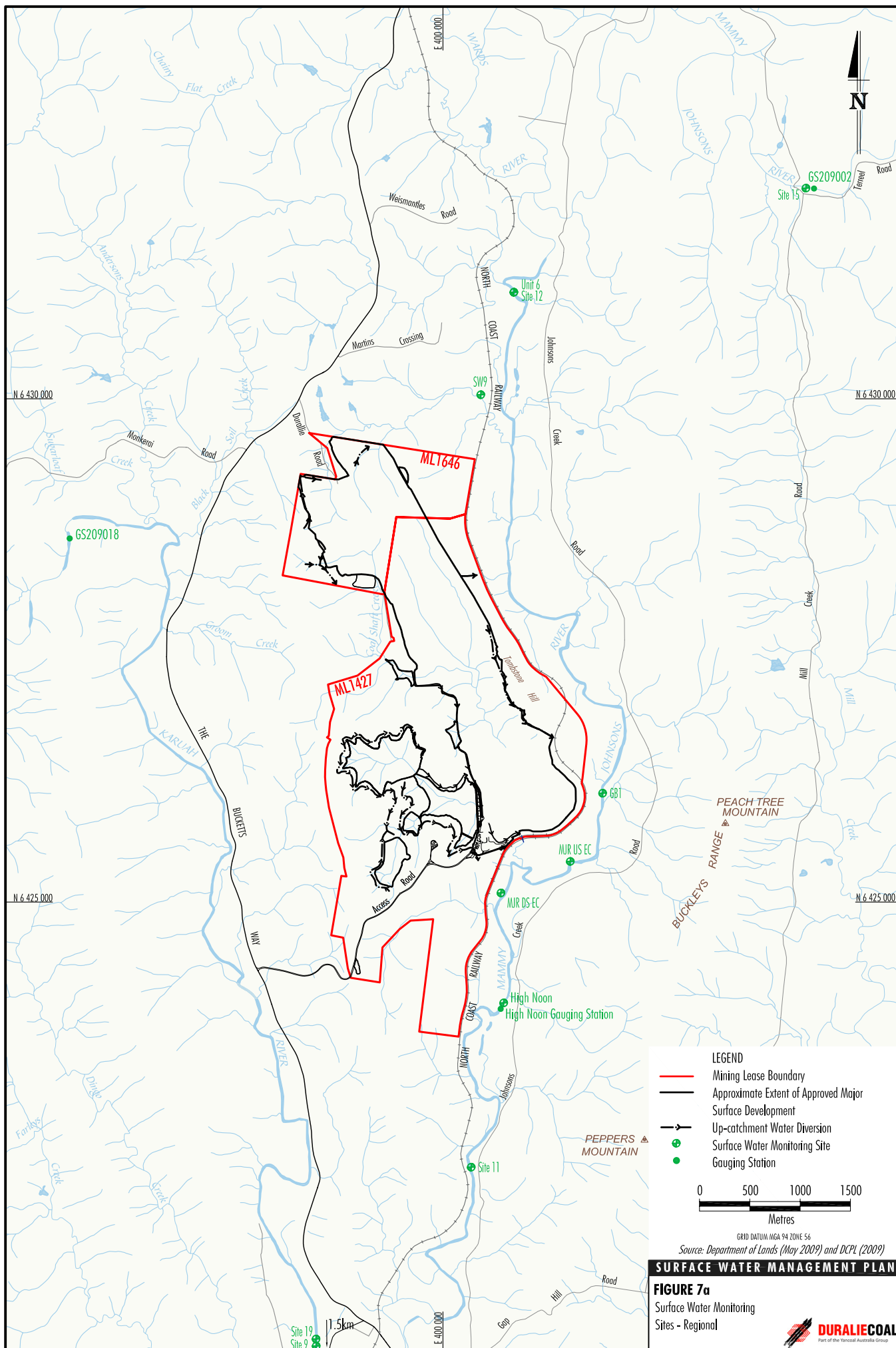
² Special frequency 1

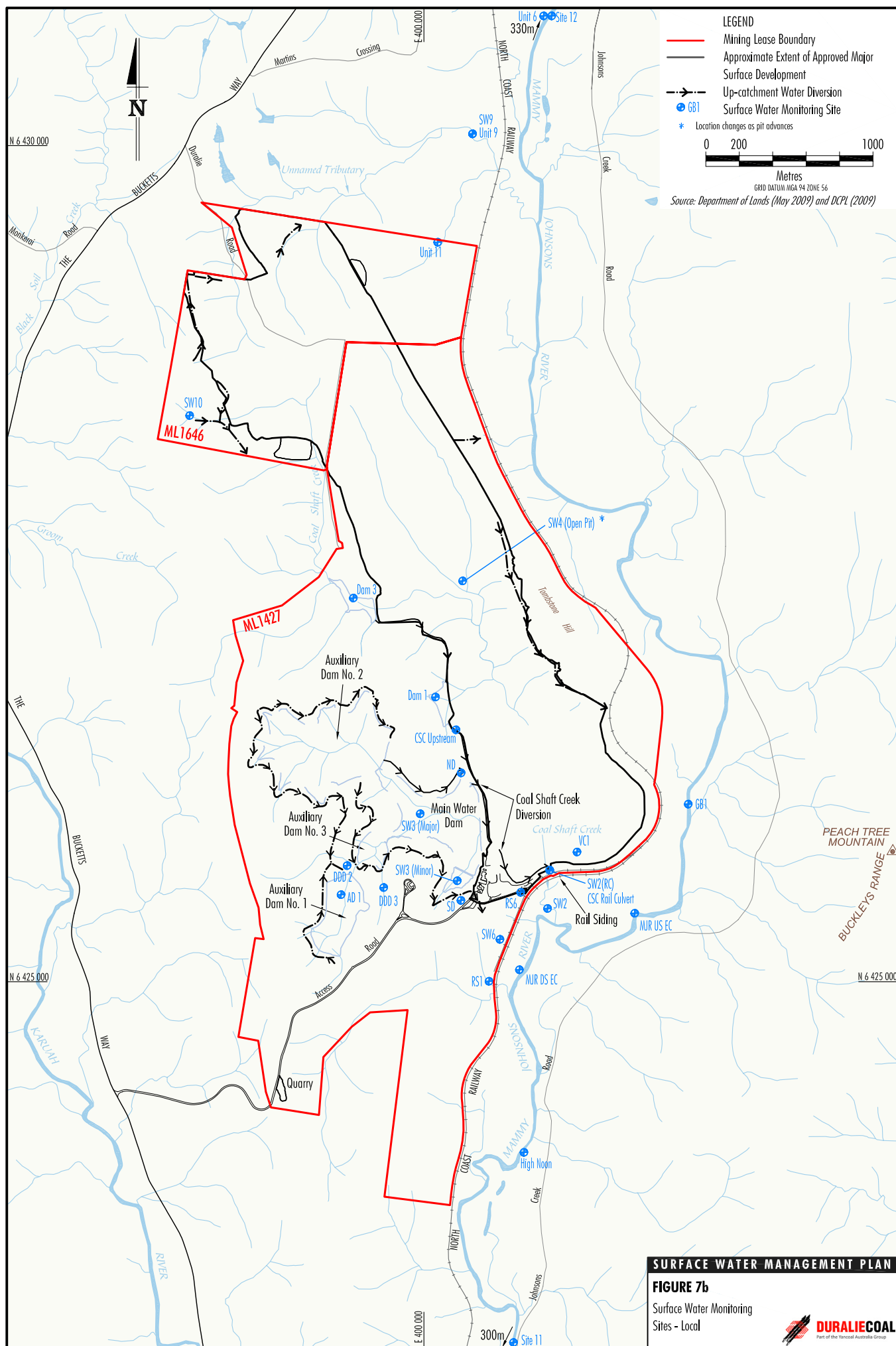
- A sample taken monthly;
- A sample taken on the first day of any discharges (overflows) from North Drain, South Drain or VC1.

³ Special frequency 2

- A sample taken monthly;
- A sample taken on the first day of any discharge from North Drain, South Drain or VC1 and a maximum of 1 sample taken in any 21 day period.

¹ Surface Water Monitoring Locations SW1 and SW2 (U/S) have been removed in accordance with Variation 1508851 to EPL 11701.





8.6 STREAM AND RIPARIAN VEGETATION “HEALTH” MONITORING PROGRAM

Condition 29 (b) of the NSW Project Approval (08_0203), requires macroinvertebrate sampling at selected water monitoring sites in Mammy Johnsons River. Compliance with this condition would be met through the ongoing stream and riparian vegetation “health” monitoring program for Coal Shaft Creek, Unnamed Tributary, Mammy Johnsons River and Karuah River. The objectives of the monitoring program are to:

- collect data on the macroinvertebrate community using the NSW Australian River System (AUSRIVAS) sampling protocols in autumn and spring each year;
- use biotic indices (i.e. SIGNAL HU97, EPT richness, number of families, functional feeding groups and silt tolerant taxa) and community parameters to assess stream “health” following surveys in autumn and spring each year;
- conduct visual monitoring (i.e. photographic) to detect a potential change in the quality and quantity of riparian vegetation annually; and
- sample stream water quality in accordance with the monitoring program outlined in Section 8.5.

Macroinvertebrate sampling locations will be sampled in autumn and spring each year at the locations shown on Figure 8 or at alternate comparable locations within the stream if access to the site is not practicable.

Visual monitoring and photography of vegetation will occur annually along a 100 m length of channel at the locations shown on Figure 8. Vegetation will be monitored for signs of leaf scorching, desiccation and dieback and will include the development of a photographic database of riparian vegetation.

The results of the stream and riparian vegetation health monitoring program are reported in the Annual Review (Section 11.1). Data collected for the stream and riparian vegetation health monitoring program is analysed to provide an overall measurement of the performance of the DCM water management system.

Enhancement of riparian habitat along a length of the Mammy Johnsons River will be undertaken within the DCM offset area (e.g. increasing the width of the riparian vegetation and implementing weed control measures). Monitoring programs for riparian vegetation within the DCM offset area will be described in the Biodiversity Management Plan required under Condition 43, Schedule 3 of the NSW Project Approval (08_0203).

8.7 ECOTOXICITY TESTING PROGRAM

Condition 29 (b) in the NSW Project Approval (08_0203), requires ecotoxicity testing of water in on-site storages and at selected water monitoring sites in Mammy Johnsons River.

The program of ecotoxicity testing described below has been developed in consultation with Dr Barry Noller, Principal Research Fellow at the University of Queensland.

Sample Sites

The sampling regime for the ecotoxicity testing program will be risk based and will be refined during periods when the potential for adverse impacts to aquatic ecology is low (as indicated below).



Ecotoxicity testing of water will be undertaken from the following six (6) sample sites (Figure 8):

- Macroinvertebrate monitoring site M1 on the Mammy Johnsons River some 2 km upstream of the DCM (sampling subject to commencement of irrigation within the Unnamed Tributary catchment).
- The MWD²:
- Macroinvertebrate monitoring sites adjacent and/or downstream of the DCM, including:
 - Site M2 on the Mammy Johnsons River east of the DCM (downstream of the confluence with the Unnamed Tributary);
 - Site M6 on Coal Shaft Creek above the confluence of Mammy Johnsons River (sampling subject to flow of Coal Shaft Creek) (i.e. sampling not required during periods of no flow);
 - Site M3 on the Mammy Johnsons River at the confluence with Coal Shaft Creek (sampling subject to flow of Coal Shaft Creek) (i.e. sampling not required during periods of no flow); and
 - Site M4 on the Mammy Johnsons River some 3 km downstream of the DCM.

Sample Methodology and Water Quality Monitoring

Sampling would be undertaken in accordance with the ANZECC (2000) guidelines for biological and physico-chemical testing. Water quality monitoring would be conducted for nutrients at all sample sites for use in conjunction with ecotoxicity testing.

Ecotoxicity Testing

The following ecotoxicity tests would be undertaken on a range of sensitive aquatic species including:

- 48 hour acute tests using *Ceriodaphnia dubia*;
- 7 day reproductive impairment tests using *Ceriodaphnia dubia*;
- 48 hour acute tests using *Chironomus tepperi*;
- 72 hour algal growth tests using *Selenastrum* sp.;
- 96 hour acute tests using freshwater shrimp; and
- 7 day inhibition tests using freshwater duck weed.

Testing Program Frequency

Sampling and ecotoxicity testing would be undertaken on a quarterly basis during the first year of the program before being reduced to bi-annual monitoring, subject to lack of observed toxicity. Should the results of subsequent ecotoxicity testing demonstrate a continued lack of observed toxicity the frequency of the program would be subject to further rationalisation in consultation with the DP&E.

A review of the ecotoxicity monitoring data was undertaken by the University of Queensland Centre for Mined Land Rehabilitation (Dr Barry Noller) in May 2014 and again in October 2015. The *Summary Interpretation of Duralie Coal Mine Ecotoxicity Testing Results (B Noller, Oct 2015)* indicates a continued lack of observed toxicity at sampling sites in Coal Shaft Creek and Mammy Johnsons River and recommended rationalising the monitoring frequency to annually corresponding with the commencement of summer.

² Note sampling is not undertaken at Auxiliary Dam 2 as all irrigation occurs from the Main Water Dam and Auxiliary Dam 2 only holds water that has been transferred from the Main Water Dam.

Reporting

Results of the ecotoxicity testing program will be reported in the Annual Review as required under Condition 3 of Schedule 5 of the NSW Project Approval (08_0203) as amended by Order of The Land and Environment Court of NSW dated 10 November 2011.

8.8 RECONSTRUCTED COAL SHAFT CREEK MONITORING PROGRAM

As described in Section 7.3, a CSCRP has been developed and is included as Attachment C. A monitoring program will be developed over the life of the DCM. The monitoring program will complement existing monitoring programs and will use existing monitoring locations where possible.

The monitoring program will include monitoring of bed and bank stability, bed and bank erosion rates, changes to flow path geometry, vegetation (cover, density and health) and water quality.

9 ASSESSMENT OF PERFORMANCE INDICATORS AND MEASURES

In accordance with Condition 29 (b), Schedule 3 of NSW Project Approval (08_0203), DCPL has developed:

- performance measures (criteria) and performance indicators (trigger levels) for investigating any potentially adverse surface water impacts for:
 - the water management system;
 - surface water quality, and stream and vegetation health of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River; and
 - channel stability of the reconstructed Coal Shaft Creek³;
- performance criteria for surface water quality attributes relevant to water quality impacts on biological diversity and aquatic ecological integrity, including salinity, heavy metals, sediment load⁴, pH, hardness and biological oxygen demand;
- trigger levels representing the 80th percentile value of the relevant data set in accordance with the methodology in ANZECC/ARMCANZ (2000), to determine the levels for investigating any potentially adverse impacts (Attachment B); and
- a plan to respond to any exceedances of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the DCM (as modified).

DCPL will assess the DCM against the water management and water resource performance indicators and measures outlined in Table 6. Performance assessments will be undertaken on a monthly basis follow the receipt of monitoring results.

Table 6
Summary of Water Management and Water Resource Performance Indicators and Measures

Performance Measure	Performance Indicator(s) for Investigating Potential Adverse Impacts
<i>Water Management System</i>	
Minimal operational disruption while maintaining negligible risk of spill from the MWD and Auxiliary Dams to Mammy Johnsons River and Coal Shaft Creek.	Water levels in the MWD and Auxiliary Dams are above defined operating levels.
<i>Irrigation Areas</i>	
No significant impact on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture).	The pH of the MWD water is less than 6.0. ¹
	The pH of the MWD water is greater than 8.5. ¹
	The EC of the MWD water is greater than 2,500 µS/cm. ^{1,2}
	The RSC of the MWD water is greater than 1.5 meq/L. ¹
	The SAR of the MWD water is greater than 6.0. ¹
<i>Surface Water Quality (including impacts to biological diversity and aquatic ecological integrity)</i>	
No more than a negligible impact on water quality in Mammy Johnsons River, Coal Shaft Creek and the Unnamed Tributary as a result of the DCM.	80 th percentile of reference, indicator water quality data at assessment sampling sites on Mammy Johnsons River, Coal Shaft Creek and Unnamed Tributary (refer Table 7 and Attachment C).

³ Performance criteria and performance indicators for the reconstructed Coal Shaft Creek will be developed over the life of the DCM in conjunction with the Coal Shaft Creek Reconstruction Plan.

⁴ Given the practical difficulties inherent in measuring sediment load (which incorporates both suspended and bed transport components) it is proposed to use the concentration of total suspended solids as a measure of sediment load.

Table 6 (Continued)
Summary of Water Management and Water Resource Performance Indicators and Measures

Performance Measure	Performance Indicator(s) for Investigating Potential Adverse Impacts
<i>Stream and Vegetation Health</i>	
No significant impact on aquatic ecosystems and biota as a result of the DCM.	No statistically significant adverse change in biotic indices (i.e. SIGNAL HU97, EPT richness, number of families, functional feeding groups, silt tolerant taxa - refer Table 7) at M3, M4, M5, M6 and M8 ³ .
No more than a negligible impact on riparian vegetation along Mammy Johnsons River, and Coal Shaft Creek and Unnamed Tributary (downstream of approved mine disturbance areas), as a result of the DCM.	No observations of significant vegetation desiccation and/or dieback at CSC, UNT and MJR2 ³ .

1 Based on Agricultural Water Management (2010).

2 Based on Horizon Soil Survey & Evaluation (2014). The salinity performance indicator for the **MWD** was exceeded in 2013 and 2014. The EC at the **MWD** monitoring site SW3 Major ranged between 1890- 4060 $\mu\text{S}/\text{cm}$ and averaged 3040 $\mu\text{S}/\text{cm}$ during this period. In accordance with Table 16, Assessment of performance indicators and measures, exceeding the salinity performance indicator triggers an assessment of the performance measure to determine whether there has been significant impact on soil properties, or to the suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The Annual Irrigation Monitoring Reports will be provided to DP&E for review.

3 Refer to Figure 8.

RSC = Residual Sodium Carbonate (Bicarbonate), SAR = Sodium Adsorption Rate.

Consistent with the NSW Project Approval (08_0203), the term 'negligible' is defined as *small and unimportant, such as to be not worth considering*.

Statistically significant adverse changes as stated in Table 6 would be determined using univariate statistical analyses (e.g. analysis of variance [ANOVA]) and AUSRIVAS bandings.

Significant impacts on soil properties or suitability of soil as stated in Table 6 would be considered to prevail if the following conditions were to be observed or measured in the irrigation areas:

- Soil pH increases above 7.5.
- Soil pH decreases below 5.5.
- Soil electrical conductivity (EC) increases above 2.5 deciSiemens per metre (dS/m).
- Soil Sodium Adsorption Ratio (SAR) increases above 6.0.
- Leaf scorching.

Reconstructed Coal Shaft Creek

As described in Section 7.3, a CSCRIP has been developed and is included as Attachment C. Performance indicators and measures will be developed over the life of the DCM and documented in the final CSCRIP. The performance measures and indicators will include consideration of monitoring and observations during and following flood events include attributes such as bed and bank stability, bed and bank erosion rates, changes to flow path geometry, vegetation (cover, density and health) and water quality.

Rehabilitated Area Runoff

Sediment dams downstream of the waste rock emplacements will be maintained until the revegetated surface is stable and the runoff water quality is suitable for release off site.

Monthly monitoring data from sediment dams will be compared with values from the Coal Shaft Creek (pre-mine and post-mine up-catchment of the DCM). Examples of runoff water quality will be considered suitable for release off site when the median runoff water quality for 24 months of data is within 10% of the median values of the two control catchments and 25% of the 80th percentile for EC, pH and TSS, and within 25% of the 20th percentile for pH.

Baseflow to Mammy Johnsons River

Performance criteria for baseflow to Mammy Johnsons River and a plan to offset the loss of any baseflow caused by the DCM are included in the Groundwater Management Plan (Appendix 3 of the WAMP).

Riparian Vegetation within DCM Offset Area

Enhancement of riparian habitat along a length of the Mammy Johnsons River will be undertaken within the DCM offset area (e.g. increasing the width of the riparian vegetation and implementing weed control measures). Performance measures for riparian vegetation within the DCM offset area are described in the Biodiversity Management Plan required under Condition 43, Schedule 3 of the NSW Project Approval (08_0203).

Assessment of Performance Measures and Indicators

Section 8 describes the monitoring that will be conducted to inform the assessment of the DCM against the performance indicators and measures for water management and water resources. The monitoring program includes the monitoring of:

- meteorology (Section 8.1);
- water management system performance (Section 8.2);
- irrigation (Section 8.3);
- erosion and sediment control structures (Section 8.4);
- surface water quality and flows (Section 8.5);
- stream and riparian vegetation “health” (Section 8.6);
- ecotoxicity (Section 8.7); and
- reconstructed Coal Shaft Creek (when established) (Section 8.8).

The monitoring results will be used to assess the DCM against the performance indicators and performance measures as detailed in Table 7. If data analysis indicates a performance indicator has been exceeded or is likely to be exceeded, an assessment will be made against the performance measure. If a performance measure is considered to have been exceeded, the Contingency Plan will be implemented (Section 10). If data analysis indicates that the performance measure has not been exceeded, DCPL will continue to monitor.

Table 7
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
Minimal operational disruption while maintaining negligible risk of spill from the MWD and Auxiliary Dams to Mammy Johnsons River and Coal Shaft Creek.	<ul style="list-style-type: none"> MWD, Auxiliary Dam No. 1 and Auxiliary Dam No. 2. 	<ul style="list-style-type: none"> Water storage level. 	<ul style="list-style-type: none"> Continuously. 	<ul style="list-style-type: none"> Water storage levels in MWD, Auxiliary Dam No. 1 and Auxiliary Dam No. 2 compared to defined maximum operating levels on a daily basis, or more frequently during an event. Defined operating levels will be reviewed on an annual basis as a component of the site water balance review. 	<ul style="list-style-type: none"> Water levels in the MWD and Auxiliary Dams are below defined maximum operating levels. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if water storage levels in the MWD and/or Auxiliary Dams exceed defined maximum operating levels. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there is likely to be a greater than minimal risk of operational disruption and or a greater than negligible risk of spill from the MWD and Auxiliary Dams to Coal Shaft Creek and Mammy Johnsons River. 	<ul style="list-style-type: none"> The performance measure is exceeded if water balance modelling indicates that water levels in the MWD and Auxiliary Dams cannot be maintained with negligible risk of spill to Mammy Johnsons River and Coal Shaft Creek and/or without more than minimal disruption to mining operations. The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Cease pit dewatering operations until water levels in MWD and auxiliary dams are below maximum operating levels. Transfer excess water to Weismantel open pit using installed pumping equipment. Review of system maintenance scheduling to ensure adequate performance of water management system components. Installation of additional pipeline and/or pumping capacity. Expansion of irrigation areas within approved irrigation areas or upgrade of irrigation infrastructure (subsequent to amendment of this SWMP) (Attachment A). Installation of additional water storage infrastructure or expansion of irrigation outside approved irrigation areas (subsequent to obtaining appropriate regulatory approvals).

Table 7 (Continued)
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No significant impact on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture).	<ul style="list-style-type: none"> MWD. 	<ul style="list-style-type: none"> pH. 	<ul style="list-style-type: none"> Weekly. 	<ul style="list-style-type: none"> Water quality data analysed monthly. 	<ul style="list-style-type: none"> The pH of the MWD water is greater than 6.0. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates the pH of the MWD water falls below 6.0. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring, (including any additional monitoring and testing), and modelling results confirms that the DCM has resulted in a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Source of acidity will be tracked and rectified. If the source of acidity is attributed to PAF material in the open pit: <ul style="list-style-type: none"> limestone treatment of the open pit floor; and/or alternative waste rock handling techniques (e.g. paddock dump and traffic compacting PAF material) to minimise the risk of accelerated oxidation through convection. Temporary cessation of irrigation activities, if required.
	<ul style="list-style-type: none"> MWD. 	<ul style="list-style-type: none"> pH. 	<ul style="list-style-type: none"> Weekly. 	<ul style="list-style-type: none"> Water quality data analysed monthly. 	<ul style="list-style-type: none"> The pH of the MWD water is less than 8.5. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates the pH of the MWD water exceeds 8.5. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring, (including any additional monitoring and testing), and modelling results confirms that the DCM has resulted in a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Treatment may be required to reduce bicarbonate load. Temporary cessation of irrigation activities, if required.

Table 7 (Continued)
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No significant impact on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture).	• MWD.	• EC.	• Weekly.	• Water quality data analysed monthly.	• The EC of the MWD water is less than 2,500µS/cm.	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates the EC of the MWD water exceeds 2,500 µS/cm. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring, (including any additional monitoring and testing), and modelling results confirms that the DCM has resulted in a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Review of factors likely to affect soil salinity and downstream water quality (note some salts that contribute to water EC may not be harmful to soils). Implementation of additional contingency measures if review determines that increase in salinity likely to deleteriously affect soil or downstream water quality. Review of irrigation rate and soil permeability with the view to increase the leaching fraction through deep ripping or increase evapotranspiration by revegetation or pasture improvement. Temporary cessation of irrigation activities, if required. If irrigation water increases above 9,000µS/cm then prior to further irrigation demonstrate success of irrigation activities in other areas of NSW where high EC irrigation water has been utilised
	• MWD.	• RSC.	• Monthly.	• Water quality data analysed monthly, following the receipt of laboratory data.	• The RSC of the MWD water is less than 1.5 meq/L.	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates the RSC of the MWD water exceeds 1.5 meq/L. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring, (including any additional monitoring and testing), and modelling results confirms that the DCM has resulted in a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Review of salt budgets with particular focus on permeability hazard and determination if treatments to reduce bicarbonate or sodium concentrations are required. Implementation of additional contingency measures if review determines that increase in RSC and/or SAR likely to deleteriously affect soil or downstream water quality. Temporary cessation of irrigation activities, if required.
	• MWD.	• SAR.	• Monthly.	• Water quality data analysed monthly, following the receipt of laboratory data.	• The SAR of the MWD water is less than 6.0.	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates the SAR of the MWD water exceeds 6.0. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring, (including any additional monitoring and testing) and modelling results confirms that the DCM has resulted in a significant impact* on soil properties or suitability of soil in irrigated areas for future agricultural use (i.e. grazing on native pasture). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> As above for RSC.

Table 7 (Continued)
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No more than a negligible impact on water quality in Mammy Johnsons River as a result of the Duralie Extension Project.	<ul style="list-style-type: none"> Site 11. GB1, Site 12. 	<ul style="list-style-type: none"> EC, pH, turbidity, Copper (total), Zinc (total) Aluminium (total). Hardness, TSS, BOD₅, and DO. 	<ul style="list-style-type: none"> Monthly. 	<ul style="list-style-type: none"> Water quality data analysed on a six month basis: <ul style="list-style-type: none"> The 80th percentile concentrations for the relevant water quality indicators⁵ (EC, pH, total copper, turbidity, total zinc, total aluminium, and TSS) will be calculated from data at Site 11, GB1 and Site 12. The 20th and 80th percentile values of pH will be calculated from data at Site 11, GB1 and Site 12. 	<ul style="list-style-type: none"> Water quality at Site 11 is not worse than the pre-irrigation water quality at Site 11 whilst water quality is better at GB1 and Site 12 compared to the pre-irrigation water quality at these sites. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates that the concentration of water quality parameters at Site 11 is greater than the 80th percentile concentration calculated from the data set and the concentration of the same water quality parameter has not also been greater than the 80th percentile concentration at either GB1 or Site 12 compared to the data set at those sites or for pH that it is either above the 80th percentile or below the 20th percentile and that it has not also been either above or below the same measure at either GB1 or Site 12. The performance indicator for dissolved oxygen will be considered to have been exceeded if the dissolved oxygen is below 85% of saturation and is also lower than the dissolved oxygen saturation level measured at either Site 12 or GB1 on the same day. If the performance indicator has been exceeded, the performance measure will be assessed to determine if the change in water quality is a result of the Duralie Extension Project. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring data, (including any additional monitoring and testing), confirms that there has been a more than negligible risk of a decrease in the biodiversity and aquatic ecological integrity of water in the Mammy Johnsons River as a result of the Duralie Extension Project. The above analysis will include consideration of BOD₅ and hardness levels in on-site, upstream, and downstream receiving waters, and ecotoxicity testing and macroinvertebrate sampling in Mammy Johnsons River upstream and downstream of Coal Shaft Creek. The analysis will be undertaken in accordance with the decision tree framework given on Figure 3.4.1 in ANZECC/ARMCANZ (2000) (Attachment B). The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Temporary cessation of irrigation activities, if required. Treatment of MWD water used for irrigation, for example reverse osmosis treatment to reduce salinity. Alteration of irrigation application procedures, for example alteration of soil moisture deficit triggers. Implementation of additional waste rock management techniques. Implementation of additional temporary/permanent erosion control measures. Additional aeration to address low DO concentrations. Offsets.
No more than a negligible impact on water quality in Coal Shaft Creek as a result of the Duralie Extension Project.	<ul style="list-style-type: none"> Site SW2(RC). 	<ul style="list-style-type: none"> EC, pH, turbidity, Copper (total), Zinc (total) Aluminium (total). Hardness, TSS, DO and BOD₅. 	<ul style="list-style-type: none"> Monthly. 	<ul style="list-style-type: none"> Water quality data analysed on a six month basis: <ul style="list-style-type: none"> The 80th percentile concentrations for the relevant water quality indicators (EC, pH, turbidity, total copper, total zinc, total aluminium, and TSS) will be calculated from data at Site SW2 (RC), and Site SW2 (US). The 20th and 80th percentile values of pH will be calculated from data at Site SW2 (RC), and Site SW2 (US). 	<ul style="list-style-type: none"> Water quality at Site SW2 (RC) is not worse than the pre-irrigation water quality at Site SW2 (RC) whilst water quality is better at Site SW2 (US) compared to the pre-irrigation water quality at that site. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates that the concentration of water quality parameters at Site SW2 (RC) is greater than the 80th percentile concentration calculated from the data set and the concentration of the same water quality parameter has not also been greater than the 80th percentile concentration at Site SW2 (US) compared to the data set at that site or for pH that it is either above the 80th percentile or below the 20th percentile and that it has not also been either above or below the same measure at Site SW2 (US). The performance indicator for dissolved oxygen will be considered to have been exceeded if the dissolved oxygen is below 85% of saturation and is also lower than the dissolved oxygen saturation level measured at SW2 on the same day. If the performance indicator has been exceeded, the performance measure will be assessed to determine if the change in water quality is a result of the Duralie Extension Project. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring data, (including any additional monitoring and testing), confirms that there has been a more than negligible risk of a decrease in the biodiversity and aquatic ecological integrity of water in the Coal Shaft Creek as a result of the Duralie Extension Project. The above analysis will include consideration of BOD₅ and hardness levels in on-site, upstream, and downstream receiving waters, and ecotoxicity testing and macroinvertebrate sampling in Mammy Johnsons River upstream and downstream of Coal Shaft Creek. The analysis will be undertaken in accordance with the decision tree framework given on Figure 3.4.1 in ANZECC/ARMCANZ (2000) (Attachment B). The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Temporary cessation of irrigation activities, if required. Treatment of MWD water used for irrigation, for example reverse osmosis treatment to reduce salinity. Alteration of irrigation application procedures, for example alteration of soil moisture deficit triggers. Implementation of additional waste rock management techniques. Implementation of additional temporary/permanent erosion control measures. Additional aeration to address low DO concentrations. Offsets.

⁵ Note: BOD₅ and Hardness are not considered to be aquatic ecosystem stressors – refer ANZECC/ARMCANZ (2000). BOD₅ is a measure of how much dissolved oxygen would be consumed (in a receiving water), in breaking down the organic matter present in water released into the receiving water. The hardness of water affects the toxicity of metals. BOD₅ and hardness will be monitored and used in the interpretation of trigger exceedances for dissolved oxygen and metals respectively.

Table 7 (Continued)
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No more than a negligible impact on water quality in the Unnamed Tributary as a result of the Duralie Extension Project.	<ul style="list-style-type: none"> Site SW9. SW10. 	<ul style="list-style-type: none"> EC, pH, turbidity, Copper (total), Zinc (total) Aluminium (total). Hardness, TSS, DO and BOD₅. 	<ul style="list-style-type: none"> Weekly Weekly/ Monthly 	<ul style="list-style-type: none"> Water quality data analysed on a six month basis: <ul style="list-style-type: none"> The 80th percentile concentrations for the relevant water quality indicators (EC, pH, turbidity, total copper, total zinc, total aluminium, and TSS) will be calculated for the pre-irrigation data at Site SW9, and Site SW10. The 20th and 80th percentile values of pH will be calculated for the pre-irrigation data at Site SW9, and Site SW10. 	<ul style="list-style-type: none"> Water quality at Site SW9 is not worse than the pre-irrigation water quality at Site SW9 whilst water quality at Site SW10 is also better compared to the pre-irrigation water quality at that site. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates that the concentration of water quality parameters at Site SW9 is greater than the 80th percentile concentration calculated from the pre-irrigation data set and the concentration of the same water quality parameter has not also been greater than the 80th percentile concentration at Site SW10 compared to the pre-irrigation data set at that site or for pH that it is either above the 80th percentile or below the 20th percentile at SW9 and that it has not also been either above or below the same measure at Site SW10. The performance indicator for dissolved oxygen will be considered to have been exceeded if the dissolved oxygen is below 85% of saturation and is also lower than the dissolved oxygen saturation level measured at SW2 on the same day. If the performance indicator has been exceeded, the performance measure will be assessed to determine if the change in water quality is a result of the Duralie Extension Project. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring , (including any additional monitoring and testing) confirms that there has been more than a negligible decrease in the biodiversity and aquatic ecological integrity water in the Unnamed Tributary as a result of the Duralie Extension Project. The above analysis will include consideration of BOD₅, and hardness levels in on-site, upstream, and downstream receiving waters, and ecotoxicity testing and macroinvertebrate sampling in Mammy Johnsons River upstream and downstream of Coal Shaft Creek. The analysis will be undertaken in accordance with the decision tree framework given on Figure 3.4.1 in ANZECC/ARMCANZ (2000). (Attachment B). The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Temporary cessation of any irrigation activities in the Unnamed Tributary catchment, if required. Treatment of MWD water used for irrigation, for example reverse osmosis treatment to reduce salinity. Alteration of any irrigation application procedures, for example alteration of soil moisture deficit triggers. Implementation of additional waste rock management techniques. Implementation of additional temporary/permanent erosion control measures. Additional aeration to address low DO concentrations. Offsets.
No significant impact on aquatic ecosystems and biota as a result of the Duralie Extension Project.	<ul style="list-style-type: none"> M1, M2, M3, M4, M5, M6, M8, DDD2. 	<ul style="list-style-type: none"> Biotic indices (SIGNAL HU97, EPT richness, number of families, functional feeding groups, silt tolerant taxa). 	<ul style="list-style-type: none"> Autumn and spring each year. 	<ul style="list-style-type: none"> Biotic indices will be analysed using trend analysis following each survey to determine if a statistically significant change has occurred. 	<ul style="list-style-type: none"> No statistically significant adverse change in biotic indices at M3, M4, M5, M6 and M8. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates a statistically significant adverse change^ in biotic indices at M3, M4, M5, M6 or M8 has occurred. If the performance indicator has been exceeded, the performance measure will be assessed to determine if a significant impact^ on aquatic biota has occurred as a result of the Duralie Extension Project. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the monitoring confirms that there has been a significant impact^ on aquatic biota as a result of the Duralie Extension Project. The above analysis will include consideration of monitoring at M2 (prior to impacts to the Unnamed Tributary) and/or M1 located upstream of the DCM. The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Temporary cessation of irrigation activities, if required. Treatment of MWD water used for irrigation, for example reverse osmosis treatment to reduce salinity. Alteration of irrigation application procedures, for example alteration of soil moisture deficit triggers. Implementation of additional waste rock management techniques. Implementation of additional temporary/permanent erosion control measures. Offsets.

Table 7 (Continued)
Monitoring of Environmental Consequences against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No more than a negligible impact on riparian vegetation along Mammy Johnsons River, Coal Shaft Creek and Unnamed Tributary as a result of the Duralie Extension Project.	<ul style="list-style-type: none"> CSC, UNT, MJR1, MJR2. 	<ul style="list-style-type: none"> Visual signs of vegetation health (vigour, leaf scorching, desiccation, dieback). 	<ul style="list-style-type: none"> Annually. 	<ul style="list-style-type: none"> Riparian vegetation will be monitored annually for observation of significant vegetation desiccation and/or dieback. 	<ul style="list-style-type: none"> No observations of significant vegetation desiccation and/or dieback at CSC, UNT and MJR2. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if significant vegetation desiccation and/or dieback are observed at CSC, UNT or MJR2. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there is a greater than negligible impact on riparian vegetation as a result of the Duralie Extension Project. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the riparian vegetation indicates there is a greater than negligible impact on riparian vegetation as a result of the Duralie Extension Project. The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Temporary cessation of irrigation activities, if required. Treatment of MWD water used for irrigation, for example reverse osmosis treatment to reduce salinity. Alteration of irrigation application procedures, for example alteration of soil moisture deficit triggers. Implementation of additional waste rock management techniques. Implementation of additional temporary/permanent erosion control measures. Offsets.
Negligible long-term risk of spill from the final voids.	<ul style="list-style-type: none"> AWS. Water management system. 	<ul style="list-style-type: none"> Rainfall, temperature, evapo-transpiration. Inflows and outflows. 	<ul style="list-style-type: none"> Continuously. Continuously. 	<ul style="list-style-type: none"> Site water balance and validity of modelling assumptions reviewed annually based on monitoring data. 	<ul style="list-style-type: none"> No significant changes required to site water balance assumptions as a result of review of monitoring data. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if site water balance reviews indicate that modelling assumptions could be significantly improved based on monitoring data. If the performance indicator has been exceeded, the performance measure will be assessed to determine if there is a greater than negligible long-term risk of spill from the final voids as a result of the revised modelling assumptions. 	<ul style="list-style-type: none"> The performance measure is exceeded if analysis of the revised modelling indicates there is a greater than negligible long-term risk of spill from the final voids. The above analysis will be peer reviewed by a specialist approved by the DP&E, if required. The results will be reported to DP&E, NOW and OEH. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Redesign of final voids or final landform water management.

¹ Log transformations (i.e. base 10 logs of the water quality concentrations) may be used to calculate the arithmetic means and standard deviations. Metal concentrations in water quality are measured as a positive value and therefore have a positively skewed distribution. Log transformations can be used to standardise the variance of a sample.

* Significant impacts on soil properties or suitability of soil would be considered to prevail if the following conditions were to be observed or measured in the irrigation areas:

- Soil pH increases above 7.5.
- Soil pH decreases below 5.5.
- Soil electrical conductivity (EC) increases above 2.5 deciSiemens per metre (dS/m).
- Soil Sodium Adsorption Ratio (SAR) increases above 6.0.
- Leaf scorching.

[^] Statistically significant adverse changes would be determined using univariate statistical analyses (e.g. analysis of variance [ANOVA]) and AUSRIVAS bandings.

10 CONTINGENCY PLAN

In the event that water management or water resource performance indicator detailed in Section 9 is considered to have been exceeded, DCPL will implement the following Contingency Plan:

- The Environmental Coordinator will immediately report the exceedance to the General Manager within 24 hours of assessment completion.
- DCPL will report the likely exceedance of the water management or water resource performance measure to the DP&E, NOW and OEH as soon as practicable (i.e. within 7 days) after DCPL becomes aware of the exceedance.
- DCPL will identify an appropriate course of action (e.g. potential contingency measures described in Section 10.1 & Table 7) with respect to the identified impact(s), in consultation with specialists and DP&E, NOW and/or OEH, as necessary.
- DCPL will, on request, submit the proposed course of action to the DP&E for approval.
- DCPL will implement the approved course of action to the satisfaction of the DP&E.

10.1 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures for an exceedance of the water management or water resource performance measures include, but are not necessarily limited to:

- The conduct of additional monitoring (e.g. increase in monitoring frequency or additional sampling) to inform the proposed contingency measures.
- A review of system maintenance scheduling to ensure adequate performance of water management system components.
- Installation of additional pipeline and/or pumping capacity to reduce the risk of spill from the open pits, MWD and Auxiliary Dams to Coal Shaft Creek.
- Expansion of irrigation areas or upgrade of irrigation infrastructure within approved irrigation areas (subsequent to amendment of this SWMP) (Attachment A).
- Installation of additional water storage infrastructure or expansion of irrigation outside approved irrigation areas (subsequent to obtaining appropriate regulatory approvals).
- Treatment of MWD water used for irrigation, for example reverse osmosis treatment, to reduce salinity.
- Implementation of additional waste rock management techniques, for example, limestone treatment of the open pit floor and/or alternative waste rock handling techniques (e.g. paddock dump and traffic compacting PAF material) to minimise the risk of accelerated oxidation through convection.
- Temporary cessation of irrigation within all or a portion of irrigation areas, for example, cessation of irrigation on a particular impacted (e.g. by active erosion or signs of leaf scorching) area, or cessation of irrigation on irrigation areas within the Coal Shaft Creek catchment (i.e. Types II, III and IV) and continuation/commencement of irrigation within the MWD catchment (Type I) and on active waste rock emplacements (Type V).
- Implementation of soil treatment measures, for example, chemical amelioration or cultivation-based renovation.
- Alteration of irrigation application procedures, for example, avoidance of watering during the middle of hot days or alteration of soil moisture deficit triggers.

- Replacement or augmentation of pasture/vegetation with more salt tolerant and/or vigorous species within irrigation areas.
- Implementation of additional temporary/permanent erosion control measures.
- Implementation of revegetation measures to remediate impacts on riparian vegetation.
- Redesign of final voids or final landform water management (e.g. reduction in depth or catchment area of final voids through a redistribution of waste rock), where revised modelling indicates a more than negligible risk of spill from the final voids (subsequent to obtaining appropriate regulatory approvals).

11 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

11.1 ANNUAL REVIEW

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL conducted an Annual Review of the environmental performance of the DCM prior to the end of December 2011, and will annually thereafter. These will be made publicly available from the Duralie Coal website, in accordance with Condition 10, Schedule 5 of the NSW Project Approval (08_0203).

The Annual Review will specifically address the following aspects of Condition 3, Schedule 5 that are directly relevant to water management:

- include a comprehensive review of the monitoring results and complaints records for the DCM over the past year, including a comparison of these results against the:
 - relevant statutory requirements, limits or performance measures/criteria;
 - monitoring results of previous years; and
 - relevant predictions in the Duralie Extension Project EA;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the DCM;
- identify any discrepancies between the predicted and actual impacts of the DCM, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the DCM.

This SWMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, as described in Section 11.2 below.

11.2 SWMP REVIEW

In accordance with Condition 4, Schedule 5 of the NSW Project Approval (08_0203), this SWMP will be reviewed and if necessary revised to the satisfaction of the Secretary of the Department of Planning and Environment, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit, in accordance with Condition 9, Schedule 5;
- any modification to the conditions of consent; or
- prior to the commencement of clearing in accordance with the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014).

This SWMP will be made publicly available on the Duralie Coal website in accordance with the NSW Project Approval (08_0203). A hard copy of the SWMP will also be kept at the DCM.

There have been no significant changes made to the SWMP as a result of the 2013 or 2014 Annual Reviews or the 2013 DP&E Compliance Audit.

12 REPORTING SYSTEMS

In accordance with Condition 2(g), Schedule 5 of the NSW Project Approval (08_0203), DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints; and
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and/or performance criteria.

The management of incidents is described in the Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the Environmental Management Strategy. Management and reporting of exceedances of impact assessment criteria and/or performance criteria are described in This SWMP Section 9.

13 REFERENCES

- Agricultural Water Management (2010) *Duralie Extension Project Irrigation Water – Suitability Assessment*. Attachment AB of Appendix A of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) *Australian Water Quality Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy*.
- Centre for Mined Land Rehabilitation (2015), *Summary Interpretation of Duralie Coal Mine Ecotoxicity Testing Results*.
- Department of Environment and Climate Change (2008) *Managing Urban Stormwater Soils and Construction Volume 2E Mines and quarries*.
- Duralie Coal Pty Ltd (2008) *Irrigation Management Plan*. Document IMP-F.
- Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Duralie Coal Pty Ltd (2015) *Duralie Coal Mine Mining Operations Plan 1 January 2015 to 31 December 2019*.
- EGi (2009) *Duralie Extension Project Geochemical Assessment of Overburden and Floor Rock*. Appendix I of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- Gilbert & Associates Pty Limited (2010) *Duralie Extension Project Surface Water Assessment*. Appendix A of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- Gilbert & Associates Pty Limited (2014) *Duralie Open Pit Modification Surface Water Assessment*. Appendix D of Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Heritage Computing Pty Ltd (2009) *Duralie Extension Project Groundwater Assessment*. Appendix B of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- HydroSimulations (2014) *Duralie Open Pit Modification Groundwater Assessment*. Appendix C of Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Landcom (2004) *Managing Urban Stormwater: Soils and Construction*.

ATTACHMENT A
IRRIGATION MANAGEMENT PLAN

DURALIE COAL MINE IRRIGATION MANAGEMENT PLAN



Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&E/DotE Approval Date
All	IMP-F	Original	OEH, NOW, DP&I	-
All	IMP-R02-A	Edits made to: <ul style="list-style-type: none"> reflect amended Project Approval conditions by Order of The Land and Environment Court of NSW dated 10 November 2011; consider recommendations (where relevant) of independent environmental audit dated November 2011; and consider any outcomes of the Annual Review for the Duralie Coal Mine (dated September 2011). 	OEH, NOW, DP&I	
All	IMP-R02-B	Edits made to reflect DP&I comments.	DP&I	2 August 2012
Sections 4.4 and 4.6	IMP-R02-C	Edits made to reflect SEWP&C comments.	SEWP&C	
All	IMP-R02-D	Annual Review.	DP&I	27 September 2013
All	IMP-R03-A	Annual Review (2013) and recommendations from DP&E Audit December 2013.	DP&E	23 April 2015
All	IMP-R04-A	Annual Review (2014) and Duralie Open Pit Modification (2014).	DP&E	22 July 2016

AUGUST 2017
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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited [YAL]) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

The main activities associated with the Duralie Extension Project (as modified) include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum (Mtpa), including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine (SCM) in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- construction of Auxiliary Dam No. 2 to relative level (RL) 100 metres (m) to provide 2,900 megalitres (ML) of on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of the permanent Coal Shaft Creek Diversion alignment adjacent to the existing DCM mining area;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The general arrangement of the DCM, showing modifications, is provided in Figure 2.



1.2 PURPOSE AND SCOPE

This Irrigation Management Plan (IMP) has been prepared by DCPL in accordance with Condition 29(b), Schedule 3 of Project Approval (08_0203).

This revision of the IMP has been prepared by DCPL to:

- consider the outcomes of the 2013 and 2014 Annual Reviews for the DCM (submitted October 2013 and August 2014, respectively);
- consider the recommendations from the Department of Planning & Environment (DP&E) Compliance Audit completed on 6 December 2013; and
- incorporate changes associated with the Duralie Open Pit Modification.

No significant changes have been made to this IMP as a result of the 2013 and 2014 Annual Reviews or DP&E Compliance Audit.

1.3 SUITABLY QUALIFIED AND EXPERIENCED PERSONS

The DP&E, as delegate for the Director-General, approved the appointment of Mr Lindsay Gilbert (Gilbert & Associates Pty Limited) and Dr Noel Merrick (Heritage Computing) as suitably qualified and experienced persons for the preparation of the WAMP on 18 February 2011.

The IMP was previously prepared/reviewed by Mr Lindsay Gilbert.

1.4 STRUCTURE OF THIS IMP

The remainder of this IMP is structured as follows:

- | | |
|------------|---|
| Section 2: | Outlines the statutory requirements applicable to the IMP. |
| Section 3: | Provides a summary and reference to detailed baseline data. |
| Section 4: | Provides an overview of the Irrigation System. |
| Section 5: | Outlines the sediment and erosion control provisions within irrigation and associated areas. |
| Section 6: | Summarises the Monitoring Program for assessing the Irrigation System. |
| Section 7: | Outlines the procedures for reviewing and improving the environmental performance of the Irrigation System. |
| Section 8: | Outlines the reporting procedures. |
| Section 9: | Lists the references cited. |

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

These are described below.

2.1 EP&A ACT APPROVAL

Irrigation Management

This IMP has been prepared in accordance with Condition 29 (b), Schedule 3 of the NSW Project Approval (08_0203). Table 1 indicates where each relevant irrigation component of Condition 29 (b) is addressed within this IMP.

Table 1
Irrigation System Requirements

NSW Project Approval (08_0203) Condition	IMP Section
<p>Condition 29, Schedule 3</p> <p>29. The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Secretary. This plan must be prepared in consultation with EPA and NOW by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval.</p> <p>In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:</p> <p>...</p> <p>b) a Surface Water Management Plan, that includes:</p> <p>...</p> <ul style="list-style-type: none"> • An irrigation management plan for the irrigation system under the water management system, which includes: <ul style="list-style-type: none"> • salinity trigger levels for controlling discharges from the irrigation areas to Coal Shaft Creek and the unnamed tributary, representing the 80th percentile value of the relevant data set for the creek/unnamed tributary and Mammy Johnsons River in accordance with the methodology in ANZECC/ARMCANZ (2000), Australian Water Quality Guidelines for Fresh and Marine Water Quality, National Water Quality Strategy¹; and • provision of an automated first flush system for the additional irrigation areas (Northern Areas) shown in the figure in Appendix 4; 	<p style="text-align: center;">Section 4.4</p> <p style="text-align: center;">Section 4</p>

¹ Condition added by Consequential Order by The Land and Environment Court of NSW dated 10 February 2012.

In accordance with Condition 29, Schedule 3 of the NSW Project Approval (08_0203, this IMP is included as part of the WAMP for the DCM (i.e. Attachment A in Appendix 2 of the WAMP).

Management Plan Requirements

Condition 2, Schedule 5 of the NSW Project Approval (08_0203) outlines the requirements that are applicable to the preparation of the management plans. Table 2 indicates where each relevant component is addressed within this IMP.

Table 2
Management Plan Requirements

NSW Project Approval (08_0203) Condition	IMP Section
Condition 2, Schedule 5	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 3
b) a description of:	Section 2
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Refer to SWMP
• any relevant limits or performance measures/criteria;	Refer to SWMP
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 4
d) a program to monitor and report on the:	Refer to SWMP
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	
e) a contingency plan to manage any unpredicted impacts and their consequences;	Refer to SWMP
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Refer to SWMP
g) a protocol for managing and reporting any:	
• incidents;	Refer to SWMP
• complaints;	Refer to SWMP
• non-compliances with statutory requirements; and	Refer to SWMP
• exceedences of the impact assessment criteria and/or performance criteria; and	Refer to SWMP
h) a protocol for periodic review of the plan.	Section 8

2.2 EPBC ACT APPROVAL

Condition 11 of the Commonwealth Approval (2010/5396) requires:

Mitigation Measures

11. *In order to minimise the impacts of the project on listed threatened species, the person taking the action must implement all measures in the following plans/documents or their subsequent revisions as approved by the Minister:*
- (a) *The DCM Vegetation Clearance Protocol (DCPL, 2002);*
 - (b) *The DCM Irrigation Management Plan (DCPL, 2008);*
 - (c) *The DCM Site Water Management Plan (DCPL, 2008); and*
 - (d) *The DCM Rehabilitation Management Plan (DCPL, 2007).*

In accordance with Condition 11 of the Commonwealth Approval (2010/5396), the WAMP (including this IMP) will be submitted for approval by the Commonwealth Minister for the Environment (or delegate).

2.3 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203), and Commonwealth Approval (2010/5396), all activities at DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

A summary of the key licences, permits and leases pertaining to the DCM is provided in Section 2.3 of the WAMP.

2.4 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

A summary of other NSW legislation that may be applicable to the conduct of the DCM is provided in Section 2.4 of the WAMP.

3 BASELINE DATA

A summary of relevant meteorological information and irrigation monitoring results in the DCM area is provided in the *Duralie Extension Project Appendix A Surface Water Assessment* and the *Duralie Open Pit Modification Surface Water Assessment* (Gilbert & Associates Pty Limited, 2010 and 2014), available at <http://duraliecoal.com.au/environment/environmental-assessment-documents.php>.

4 IRRIGATION SYSTEM

Irrigation of mine water is conducted at the DCM as part of the water management system. The focus of the mine water management system is on:

- minimisation of mine water generation by the interception and diversion of runoff from undisturbed and rehabilitated landforms around mining activities; and
- collection, treatment (where necessary) containment and irrigation of excess mine water over defined areas within the Project mining leases.

Details of the mine water management system are given in the Surface Water Management Plan (SWMP) (refer Appendix 2 of WAMP). The main components of the system are:

- Dams within the mine, waste emplacement and infrastructure areas to capture runoff from areas disturbed by mining and related activities.
- Clean water diversion system, designed to divert runoff from areas undisturbed by mining around the Project. This includes Coal Shaft Creek and its tributaries.
- Pit dewatering system, which allows transfer of water from a pit sump to a suitable retention dam to allow mining to proceed. In-pit treatment of pit water may be required periodically, depending on its quality.
- Main Water Dam (MWD) and associated Auxiliary Dams to which all mine water collected in dams and the pit is pumped. Waters that accumulate within the MWD will be primarily used for dust suppression, with excess mine water disposed of via the Project irrigation system.

The following subsections provide a description of the irrigation system, including mitigation measures to minimise downstream impacts (i.e. first flush protocol) and management measures for irrigation areas including erosion and weed control and pasture preparation.

4.1 SUITABILITY OF MINE WATER FOR IRRIGATION

Mine water comprises runoff from the open pit, coal handling and fuel storage areas, seepage from non-rehabilitated waste rock emplacement areas, groundwater inflows to the open pit and rainfall runoff from the MWD catchment. An assessment of the suitability of mine water for irrigation was undertaken for the Duralie Open Pit Modification by Horizon Soil Survey & Evaluation (2014).

Horizon Soil Survey & Evaluation (2014) concluded that irrigation at the DCM is sustainable and the predicted irrigation water salinities for the Duralie Open Pit Modification would not cause soil structural degradation or inhibit plant growth in irrigation areas.

4.2 OPERATION OF IRRIGATION SCHEME

The irrigation system is operated such that soil moisture levels are maintained below field capacity such that saturation will only occur during rainfall. Under such conditions evapotranspiration and plant growth will be maximised and surface runoff, due to irrigation, will be avoided.

Irrigation water is applied to maintain a 10 millimetre (mm) soil moisture deficit before, during and immediately following irrigation application. Soil moisture deficit is measured using soil moisture sensors.

Irrigation is also subject to the following restrictions:

- irrigation is only to be conducted in areas that avoid significant drainage lines; and
- irrigation is to be conducted in areas that provide a set back from clean water diversion systems sufficient to allow interception of “first flush” waters (Section 4.4).

The continued effective performance of the irrigation system is influenced by the quality of contained water used for irrigation. The quality of irrigation water is expected to vary as a result of the natural variability of rainfall and other water balance variables (e.g. quality of open pit inflows).

Current irrigation water quality is not a risk to soils and plant growth in the irrigation areas at the DCM and predicted irrigation water salinities in Gilbert & Associates (2014) are not expected to cause soil structural degradation or inhibit plant growth in irrigation areas (Horizon Soil Survey & Evaluation, 2014).

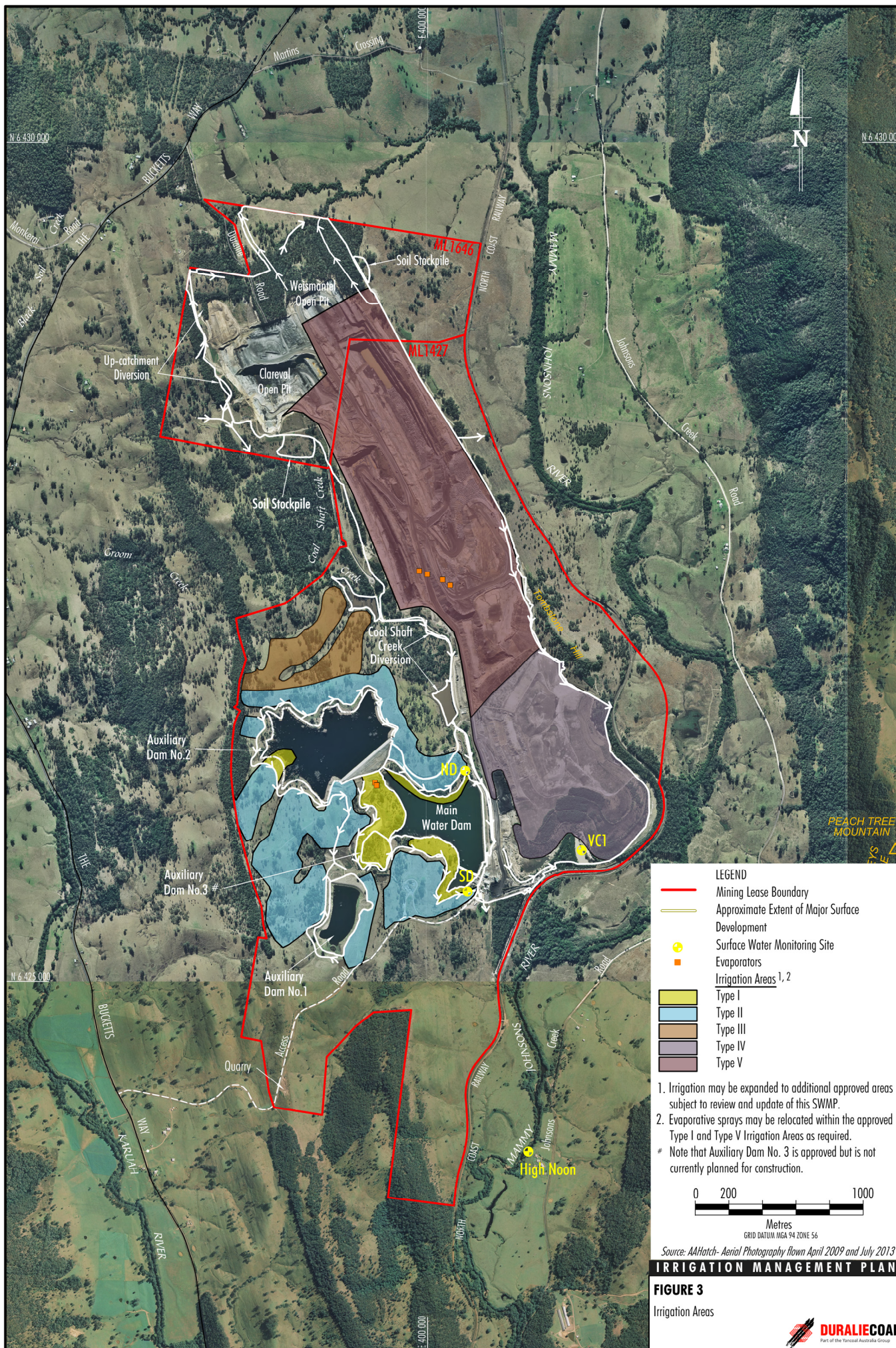
Irrigation is operated and monitored to maintain matching of available water to vegetation needs for evapotranspiration, control of salt build up and avoiding direct runoff of irrigation water.

In addition to the conventional irrigation methods, evaporative sprays (Figure 3) are used at the DCM on areas of inactive waste rock emplacement which drain back to the open pit and areas in the mine water storage footprints. Evaporative sprays are located to maximise separation from clean water areas and are positioned within earthen bunds. The operation of evaporative sprays at the DCM considers the ambient meteorological conditions including humidity, wind speed and direction and inversion strength. The operation of the evaporative sprays aims to maximise the evaporative efficiency and minimise the potential impacts of spray drift. Evaporative sprays are only operated in areas which drain directly to mine water areas and therefore no first flush system is required.

4.3 IRRIGATION AREAS

In accordance with Condition 28, Schedule 3 of the NSW Project Approval (08_0203), DCPL will only conduct irrigation within the areas shown in the Duralie Open Pit Modification Environmental Assessment (EA) (DCPL, 2014) over the life of the DCM and in accordance with the irrigation system, including this IMP, in the SWMP.

This IMP includes management and monitoring measures for the irrigation areas shown on Figure 3, which are a subset of those areas shown in the Duralie Open Pit Modification EA (DCPL, 2014). No irrigation activities in the Unnamed Tributary catchment are proposed for the period of this IMP. No irrigation activities have commenced in the additional irrigation areas described in the Duralie Extension Project EA or Duralie Open Pit Modification.



Irrigation within additional irrigation areas will require the review and update of this IMP in consultation with the relevant government agencies and stakeholders.

This IMP includes management and monitoring measures for five types irrigation areas delineated based on location, including:

- *Type I* – Irrigation areas between the MWD diversions and the water storage inundation area of the MWD.
- *Type II* – Irrigation areas located upslope of the MWD diversions within ML 1427.
- *Type III* – Irrigation areas located upslope of the northern extent of the open pits, including the upper reaches of Coal Shaft Creek. Type III irrigation areas have not been established to date.
- *Type IV* – Irrigation areas located on partially rehabilitated and rehabilitated areas of the waste rock emplacement.
- *Type V* – Irrigation areas located on inactive (but not yet topsoiled or rehabilitated) areas of the waste rock emplacement.

A mixture of pasture, woodland and cropping occurs within the irrigation areas (with the exception of Type V irrigation areas).

4.4 DEVELOPMENT OF NEW IRRIGATION AREAS

As discussed above, prior to commencing irrigation outside the irrigation areas shown on Figure 3 this IMP will be reviewed and updated in consultation with the relevant government agencies and stakeholders.

Prior to amendments of the NSW Project Approval (08_0203) by Order of The Land and Environment Court of NSW dated 10 November 2011, irrigation of new areas in the Northern Areas within the mine expansion which do not drain to Coal Shaft Creek were proposed. As a consequence of the Order, automated first flush systems for return of first flush water from these areas will be required.

First flush protocols for these areas would be developed for EC based on procedures in ANZECC/ARMCANZ (2000). Specifically the 80th percentile EC values would be calculated from the composite pre-irrigation data set from sampling site SW9¹. Release of first flush from irrigation in any Northern Areas within the Unnamed Tributary catchment would only be permitted when the EC of the water draining off the irrigation areas was less than the 80% trigger EC and if the EC as measured in Mammy Johnsons River at High Noon was less than 400 $\mu\text{S}/\text{cm}$.

In the event that the results of the Giant Barred Frog monitoring (as described in the Giant Barred Frog Management Plan) identify a decline of 20% or more (in comparison with the highest average results obtained from the September to April 2010-2011 surveys and then subsequently in combination with the 2011-2012 surveys) in the Giant Barred Frog population, the first flush protocol for the new irrigation areas would be modified.

¹ With data up until the end of 2011, the 80th percentile EC at SW9 was 461 $\mu\text{S}/\text{cm}$ (based on 17 sample occasions). The data set will continue to be added to progressively prior to irrigation to develop the trigger. Prior to irrigation within the catchment of the Unnamed Tributary, the trigger will be included in an update of this IMP.

Prior to commencing irrigation in a new area, an assessment of the area will be undertaken by an experienced irrigation and soil expert. The assessment will include consideration of soils, vegetation and topography and other natural features which may influence irrigation outcomes. Results of the assessment will be used to set parameters for the irrigation system design in each area including the delineation of buffer areas and drainage controls. The assessment will identify the need for any soil amelioration or vegetation management measures that will need to be incorporated into the design and preparation works. The assessment will also provide the basis for first flush capture system design and the design of other drainage control works if required in new areas. These works would be completed prior to commencement of irrigation in new areas.

4.5 IRRIGATION SYSTEMS

The current irrigation system in the Type I, Type II and III areas comprises a series of banks with 8-10 fixed sprinkler heads which operate on a 14 minute run time. Irrigation on the Type IV areas is also undertaken with fixed spray operating from banks of 4 fixed sprays that operate for a 15 minute run time. Irrigation on the Type V areas is undertaken using evaporative sprays. Travelling irrigators are also used in the irrigation areas, however their use has been progressively been phased out by fixed spray and evaporative irrigation.

Water applications from fixed and travelling irrigators are managed according to soil moisture deficit which is measured using soil moisture sensors which comprise a combination of:

- manual readings of gypsum block soil moisture sensors (MEA² Gbugs) located within the irrigation areas at different depths; and/or
- automatic readings of an EnviroPro® probe with sensors every 10 centimetres (cm)³.

Irrigation rates are controlled by telemetry using continuous soil moisture readings linked to automated control valves, to maintain a minimum 10 mm soil moisture deficit immediately following irrigation application. An automated system is used in Type I, II and III areas to cycle through the banks of fixed sprays. Individual applications are equivalent to about 2 mm.

The current irrigation system in the Type V area comprises 4 evaporative sprays and two evaporative sprays are also located in the Type I area. Irrigation with the Type V area may be expanded as required as this area drains the open pit. No soil moisture monitoring is conducted in Type V irrigation areas as only evaporative sprays are used in these irrigation areas.

4.6 FIRST FLUSH PROTOCOL

The first flush protocol is designed to collect initial (or “first flush”) rainfall runoff from Type II, Type III and Type IV irrigation areas. The first flush protocol described below is consistent with the protocol described in DCPL (2014) and Condition 4 of the Commonwealth Approval (2010/5396).

² Measurement Engineering Australia Pty Ltd.

³ Note that EnviroPro® probes also measures temperature and salinity.

In accordance with Condition 5 of the Commonwealth Approval (2010/5396):

In the event that the results of Giant Barred Frog monitoring required under Condition 8 identify a decline of 20% or more (in comparison with the highest average results obtained from September to April 2010-11 surveys and then subsequently in combination with 2011-2012 surveys) in the Giant Barred Frog population, the proponent may only release water into the MJR catchment when Electrical Conductivity levels are less than 400 $\mu\text{S}/\text{cm}$ in Mammy Johnsons River (as measured at the High Noon site) and less than 810 $\mu\text{S}/\text{cm}$ in Coal Shaft Creek (as measured at Coal Shaft Creek monitoring site SW2 [RC]), until otherwise advised by the Department.

Note: For clarity regarding Condition 5, the mine water to be released during this time must not exceed 810 $\mu\text{S}/\text{cm}$, as measured at monitoring site point SW2 (RC).

4.6.1 Type I and Type V Irrigation Areas

Type I irrigation areas are within the MWD catchment area and Type V irrigation areas drain to the open pit workings, and therefore no first flush protocol is required for these areas.

4.6.2 Type II Irrigation Areas

Sensors measuring EC have been installed in the MWD diversion southern and northern drains (Figure 3) to monitor runoff from the Type II irrigation areas. The first flush system for the Type II irrigation areas generally operates as follows:

- When EC readings in the MWD diversion drain sumps are equal to or greater than 1,326 $\mu\text{S}/\text{cm}$, or if the EC reading at High Noon in the Mammy Johnsons River (approximately 1.3 km south of the confluence with Coal Shaft Creek) is equal to or greater than 400 $\mu\text{S}/\text{cm}$, motorised butterfly valves in pipelines at the downstream end of the MWD diversion northern and southern drains are left in their default, open position directing runoff from the irrigation areas to the MWD.
- When the EC readings in the MWD diversion drain sumps are below 1,326 $\mu\text{S}/\text{cm}$ and the EC reading in the Mammy Johnsons River (at High Noon) is below 400 $\mu\text{S}/\text{cm}$, the valves close, allowing the runoff in the MWD diversion to report to the Coal Shaft Creek Diversion and Mammy Johnsons River downstream of the DCM.

4.6.3 Type III Irrigation Areas

Irrigation areas upslope of the northern extent of the open pits have ceased due to pit advancement. The irrigation area in the Coal Shaft creek catchment upslope of CSC Dam 3 is proposed for future irrigation. The first flush system would be established as described below:

- When water accumulates in the Temporary Diversion Dam to levels above minimum operating level a valve in the base of the diversion dam is opened.
- If the EC reading in the Temporary Diversion Dam is equal to or greater than 1,326 $\mu\text{S}/\text{cm}$ or if the EC reading in the Mammy Johnsons River at High Noon is at or above 400 $\mu\text{S}/\text{cm}$ the water is pumped to the MWD.

If the EC reading in the Temporary Diversion Dam is below 1,326 $\mu\text{S}/\text{cm}$ and the EC reading in the Mammy Johnsons River at High Noon is below 400 $\mu\text{S}/\text{cm}$ the water is released to the Coal Shaft Creek diversion.

4.6.4 Type IV Irrigation Areas

As the waste rock emplacement areas expand and are rehabilitated, irrigation occurs on these areas (Type IV irrigation areas). Runoff from these areas is collected in the collection dam in the south-west corner of the waste rock emplacement (VC1) which overflows to Coal Shaft Creek.

Where the measured EC in the collection dam is equal to or greater than 1,326 $\mu\text{S}/\text{cm}$, or if the EC reading in the Mammy Johnsons River at High Noon is equal to or greater than 400 $\mu\text{S}/\text{cm}$, the accumulated water in the collection dam will be pumped out to the MWD. Where the EC reading in the VC1 is below 1,326 $\mu\text{S}/\text{cm}$ and the EC reading in the Mammy Johnsons River at High Noon is below 400 $\mu\text{S}/\text{cm}$ the water is released to the Coal Shaft Creek diversion.

5 EROSION CONTROL AND CONTOUR BANK/DRAIN CONSTRUCTION

Prior to new irrigation areas (with the exception of Type V areas) being developed, the areas will be inspected and logged for the presence of apparent active areas of erosion within the areas to be irrigated. Any such areas will be ameliorated by:

- trimming back the sides of steep erosion scours;
- infilling with soil borrowed from a suitable mine source (e.g. topsoil stockpile) matching, as closely as possible, the soils of the area;
- contour ripping the infilled area;
- diverting upslope runoff using contour banks/drains;
- seeding with pasture species and fertilising;
- provision of lime for acidic soils (where required);
- construction of silt fences downslope of infilled areas;
- exclusion of stock during pasture establishment period (fencing); and
- monitoring to check on-going stability.

Effective irrigation has the potential to enhance vegetative cover and reduce erosion rates, particularly following prolonged dry weather. On the other hand, erosion in irrigation areas has the potential to be exacerbated by irrigation due to soil moisture increases leading to increased runoff. This is managed by avoiding steep areas and drainage lines. The possible effect of irrigation on increased erosion is monitored in downstream gully lines (Section 8.3 of the SWMP). In the event that erosion is exacerbated by irrigation the contingency response would include review of intensity and rates of irrigation application, construction of contour banks and drains and planting trees to enhance soil stability and erosion resistance.

Any earthworks associated with irrigation area preparation (e.g. contour banks) would be conducted in accordance with the erosion and sediment control strategies outlined in Section 7.1 of the SWMP.

5.1 WEED CONTROL

Six weed species listed as noxious under the NSW *Noxious Weeds Act, 1993* in the Great Lakes local government area (Great Lakes Council, 2008) have been recorded at the DCM, viz. Noogoora Burr, Bittou Bush, Blackberry, Crofton Weed, Giant Parramatta Grass and Lantana.

The proposed vegetation disturbance and irrigation associated with the DCM have the potential to act as catalysts for weed incursion and, if management measures are not in place, proliferation of weeds could occur (DCPL, 2014).

To prevent the spread of weeds, DCPL will undertake the following management measures:

- irrigation areas will be managed such that a vegetation cover is maintained as much as possible to suppress the establishment of weeds;
- identification of weeds via regular site inspections and communication with landholders and regulatory authorities;

- mechanical removal of identified weeds and/or the application of approved herbicides in authorised areas;
- follow-up site inspections to determine the effectiveness of eradication programs; and
- minimisation of seed transport from the site through the use of the site's vehicle wash bay.

5.2 PREPARATION OF PASTURES

Existing areas of thriving pasture within the irrigation areas will continue to be protected from disturbance wherever practicable. The major native grass species present within the DCM area are Blady Grass (*Imperata cylindrica* var. *major*), Kangaroo grass (*Themeda australis*), *Aristida* species, Common couch (*Cynodon dactylon*), Tufted hedgehog grass (*Echinopogon caespitosus* var. *caespitosus*) and Wiry Panic (*Entolasia stricta*). The vigour and coverage of pasture in irrigated areas will continue to be monitored.

Irrigation areas that contain existing pasture in a poor condition will be improved by establishment species drawn from the list below (note that species used is subject to seasonal seed availability, market prices, etc.):

- | | | |
|-------------------------------|------------------------|----------------------|
| • Phalaris; | • Cocksfoot; | • Paspalum; |
| • Browntop Bent Grass; | • White Clover; | • Wheat Grass; |
| • Wallaby Grass; | • Red Grass; | • Kangaroo Grass; |
| • Red-anthered Wallaby Grass; | • Subterranean Clover; | • Strawberry Clover; |
| • Lucerne; | • Ryegrass; | • Weeping Grass; and |
| • Rhodes Grass; | • Kikuyu; | • Couch. |

The management of pastures will consider the retention of a minimum of 70% ground cover in order to protect the soil surface from erosion (as recommended for highly erodible soils in Hunter-Central Rivers Catchment Management Authority [2007]).

Areas of native pasture form a valuable component of the available pasture used for stock production and may be grazed (in a sustainable manner).

The establishment of improved pasture is an important component of the progressive rehabilitation programme at the DCM. It is proposed to rehabilitate waste rock emplacement (Type IV irrigation areas) to a combination of woodland and pasture. The selection of pasture species and varieties, fertilisers/ameliorants and application rates, and stocking rates will be influenced by experience at the DCM and the nearby SCM. Further details are provided in the Rehabilitation Management Plan required under Condition 57, Schedule 3 of the NSW Project Approval (08_0203).

6 MONITORING PROGRAM

DCPL's Environmental Officer is responsible for irrigation monitoring and implementation of further measures (Section 5) if the monitoring programme indicates some remedial action or further investigation is required. Details of the monitoring undertaken in support of the IMP are included in Section 8.3 of the SWMP and are reproduced in Table 3.

Table 3
Irrigation Monitoring Program

Monitoring Component	Parameter	Frequency
Irrigation Water Volume Monitoring	Application rates.	During irrigation application.
	Application times.	During irrigation application.
	Application durations.	During irrigation application.
	Application areas.	During irrigation application.
Soil Moisture Monitoring	Soil moisture deficit.	Before and after irrigation and application.
Soil Characteristics Monitoring	Soil salinity, permeability and cumulative contaminant loading.	Annually.
Irrigation Area Visual Monitoring	Signs of runoff, waterlogging and/or active erosion in gullies downstream of irrigation areas.	After each irrigation application.
	Signs of active erosion in contour banks and drains.	Monthly in new irrigation areas and every six months.
	Photographic recording of plant vigour and signs of general disturbance of groundcover species and erosion at fixed photo points.	Every six months.
Vegetation Monitoring	Pasture condition in terms of biomass, species composition and ground cover.	Annually.
	Grazing levels (where relevant).	
	Harvesting (where relevant).	
	Rotation of irrigation areas.	
Water Quality Monitoring	Refer Tables 12 and 14 of SWMP.	Refer Tables 12 and 14 of SWMP.

As described in Table 3, soil characteristic monitoring will be conducted annually with analysis of samples in accordance with Section 4.2.6 of ANZECC & ARMCANZ (2000). Soil characteristic monitoring will incorporate:

- Fixed sampling sites, where practicable, to provide consistent locations for taking soil samples over time. Each site will cover approximately 100 square metres, and each set of samples will be taken from different positions across the sampling site.
- Five samples at each sampling site to allow for the effect of local variation. The samples will be bulked to provide one sample for analysis (from each sampling site).
- Samples taken from a constant depth, of approximately 0 – 30 cm, where practicable. All plant material, including roots, will be removed from the samples.
- Sampling of reference sites (minimum of two) which are chemically similar to the irrigation areas.

The independent environmental audit (Trevor Brown & Associates, 2011) concluded that the monitoring program (including irrigation) was '*considered adequate to provide data for assessment of the Duralie operations in relation to the MCoA [Minister's Conditions of Approval] and EPL requirements and to assess consistency with the predictions in the EIS, Environmental Assessments and Statements of Environmental Effects.*'

7 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

7.1 ANNUAL REVIEW

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL conducted an Annual Review of the environmental performance of the DCM prior to the end of December 2011, and will annually thereafter. These will be made publicly available from the Duralie Coal website, in accordance with Condition 10, Schedule 5 of the NSW Project Approval (08_0203).

The Annual Review will specifically address the following aspects of Condition 3, Schedule 5 that are directly relevant to water management:

- include a comprehensive review of the monitoring results and complaints records for the DCM over the past year, including a comparison of these results against the:
 - relevant statutory requirements, limits or performance measures/criteria;
 - monitoring results of previous years; and
 - relevant predictions in the Duralie Extension Project EA;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the DCM;
- identify any discrepancies between the predicted and actual impacts of the DCM, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the DCM.

This IMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, as described in Section 7.2 below.

7.2 IMP REVIEW

This IMP has been prepared in accordance with NSW Project Approval (08_0203). The revision status of this IMP is indicated on the title page of each copy.

In accordance with Condition 4, Schedule 5 of the NSW Project Approval (08_0203), this IMP will be reviewed and if necessary revised to the satisfaction of the Secretary of the Department of Planning and Infrastructure, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit, in accordance with Condition 9, Schedule 5;
- any modification to the conditions of consent; or
- prior to the commencement of clearing in accordance with the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014).

This IMP will be made publicly available on the Duralie Coal website in accordance with the NSW Project Approval (08_0203). A hard copy of the IMP will also be kept at the DCM.

As described in Section 4.3, a review of the IMP will be undertaken prior to commencing irrigation in new irrigation areas (i.e. within the Unnamed Tributary catchment) in consultation with the relevant government agencies and stakeholders.

8 REPORTING SYSTEMS

In accordance with Condition 2 (g), Schedule 5 of the NSW Project Approval (08_0203), DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints; and
- non-compliances with statutory requirements.

The management of incidents is described in the Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the Environmental Management Strategy (available at <http://duraliecoal.com.au/environment/environmental-assessment-documents.php>).

9 REFERENCES

- Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) *Australian Water Quality Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy*.
- Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Environment Protection Heritage Council, the National Resource Management Ministerial Council and the Australian Health Ministers' Conference (2006) *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*.
- Gilbert & Associates Pty Limited (2014) *Duralie Open Pit Modification Surface Water Assessment*. Appendix D of Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Great Lakes Council (2008) *Noxious Weeds*.
Website: <http://www.greatlakes.local-e.nsw.gov.au/environment/74341/74371.html>
Date Retrieved: 16 September 2009.
- Horizon Soil Survey & Evaluation (2014) *Irrigation Area Management Review Duralie Coal Mine (ML1427 & 1646), Buckets Way, GLOUCESTER NSW*. Attachment B of Appendix D of Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.
- Hunter-Central Rivers Catchment Management Authority (2007) *Hunter-Central Rivers Catchment Action Plan*.
- Trevor Brown & Associates – Applied Environmental Management Consultants (2011) *Independent Environmental Audit Duralie Coal Mine*. November 2011.

ATTACHMENT B

DEVELOPMENT OF WATER QUALITY TRIGGER LEVELS FOR THE DURALIE
EXTENSION PROJECT

Development of Water Quality Trigger Levels for the Duralie Extension Project

1.0 Introduction

A Water Management Plan is required as part of the approval conditions for the Duralie Extension Project (NSW Project Approval [08_0203 (herein referred as the Project Approval). Specifically:

Water Management Plan

29. *The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Director-General. This plan must be prepared in consultation with OEHL and NOW by suitably qualified and experienced persons whose appointment has been approved by the Director-General, and submitted to the Director-General within 3 months of the date of this approval.*

In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:

...

- (b) *a Surface Water Management Plan, that includes:*

...

- *performance criteria, including trigger levels for investigating any potentially adverse impacts for the following:*

...

- *surface water quality of the Unnamed Tributary, Coal Shaft Creek and Mammy Johnsons River;*

...

- *performance criteria for surface water quality attributes relevant to water quality impacts on biological diversity and aquatic ecological integrity, including salinity, heavy metals, sediment load, pH, hardness and biological oxygen demand;*
- *trigger levels representing the 80th percentile value of the relevant reference data set in accordance with the methodology in ANZECC/ARMCANZ (2000). Australian Water Quality Guidelines for Fresh and Marine Water Quality Management Strategy to determine the levels for investigating any potentially adverse impacts;*

...

This paper deals with development of trigger levels for the purposes of consultation and inclusion in the Surface Water Management Plan, as part of the Duralie Coal Mine Water Management Plan, and provides a rationale for the:

- performance criteria including trigger levels for investigating potentially adverse surface water quality impacts (Section 2);
- performance criteria for surface water quality attributes (Section 2.2); and
- 80th percentile trigger levels (Section 2.2).

2.0 Performance Criteria and Associated Trigger Levels

The term 'performance criteria' has not been defined in the Project Approval and is not used in ANZECC/ARMCANZ (2000) (the guidelines). However it appears to be synonymous with the term 'water quality objective' used in the guidelines which is defined as "a numerical concentration limit or narrative statement that has been established to support and protect the designated uses of water at a specified site. It is based on scientific criteria or water quality guidelines but may be modified by other inputs such as social or political constraints"¹.

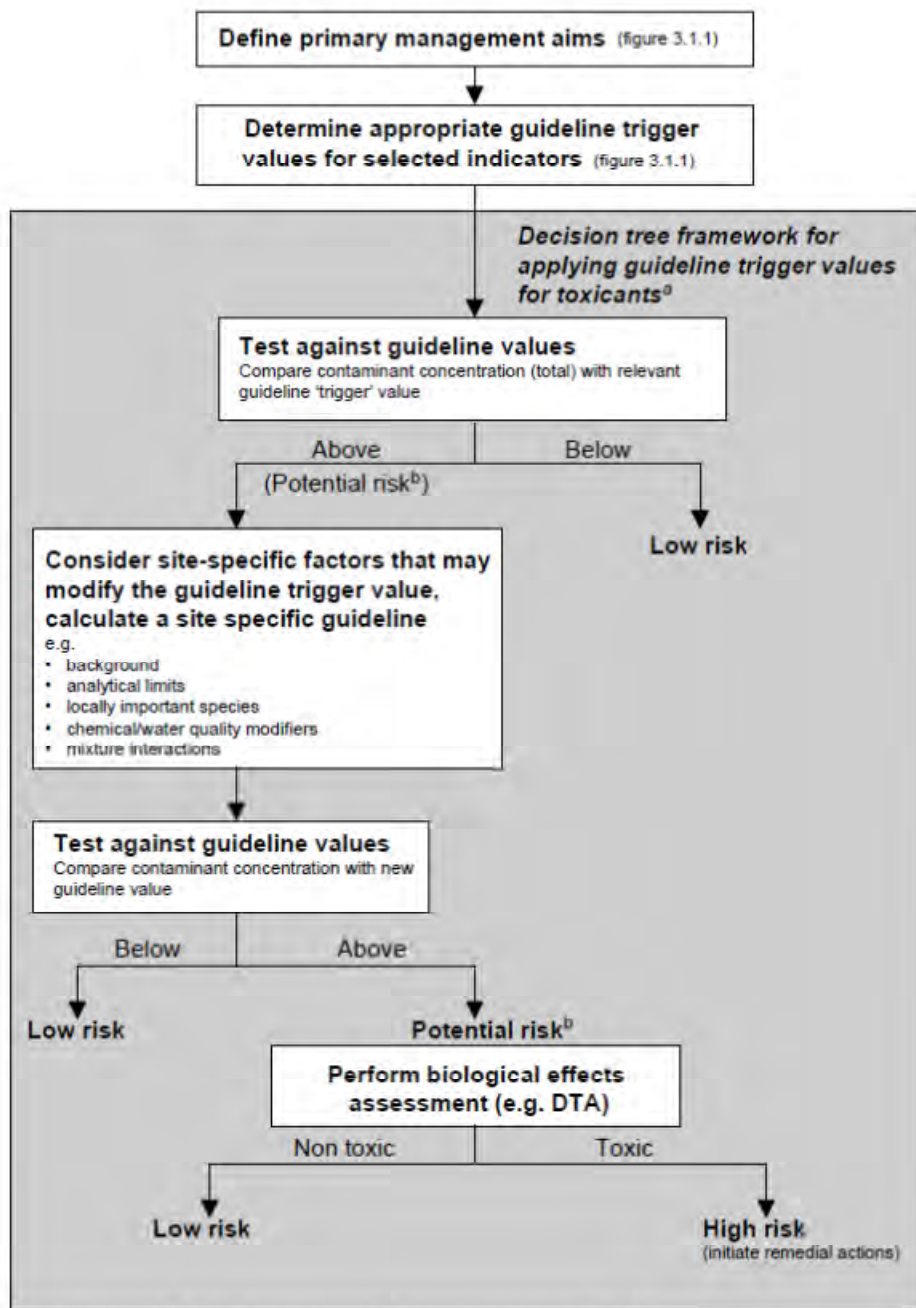
The performance criteria (water quality objectives) adopted for Mammy Johnsons River (MJR), Coal Shaft Creek (CSC) and the Unnamed Tributary (UT), are based on maintenance of existing environmental values. The existing environmental values of MJR, Coal Shaft Creek and the UT have been taken to be:

- aquatic ecosystems;
- primary industries - irrigation and general water uses, stock drinking water; and
- recreation and aesthetic.

Gloucester Coal's water management objective of preserving these environmental values would be met if there is a no more than negligible impact on water quality as a result of the Duralie Extension Project. In line with the guidelines for protection of aquatic ecosystem low risk triggers are used, if exceeded, to trigger further investigations. Trigger levels are defined in the guidelines as "concentrations (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of adverse impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions"². An example of the application of triggers in the assessment of toxicants in ambient waters is given in Figure 3.4.1 of the guidelines – refer below.

¹ ANZECC/ARMCANZ (2000) "Australian and New Zealand Guidelines for Fresh and Marine Water Quality", Appendix 1, October 2000. Note that the definition given in ANZECC/ARMCANZ (2000) for 'water quality guideline' and 'water quality objective' are, in most respects, the same.

² ANZECC/ARMCANZ (2000) "Australian and New Zealand Guidelines for Fresh and Marine Water Quality"



^a Local biological effects data not required in the decision trees (see section 3.1.5)

^b Further investigations are not mandatory; users may opt to proceed to management/remedial action.

Figure 3.4.1 Simplified decision tree for assessing toxicants in ambient waters

Development and quantification of trigger levels for the Duralie Extension Project has involved:

- identifying a suite of surface water quality indicators relevant to identifying impacts on biological diversity and aquatic ecological integrity; salinity, heavy metals, sediment load, pH, hardness and biological oxygen demand (BOD) have been included in this suite as required under the Project Approval Condition 29(b)s;
- identifying what is the relevant data set from which triggers should be determined; and
- developing trigger levels for the water quality indicators that would trigger an investigation of any potentially adverse impact based on the methodology in the guidelines. Where possible trigger levels represent the 80th percentile value³ of the relevant data set has been used. Where this has not been possible, due to data limitations, interim default triggers values taken from the guidelines have been used.

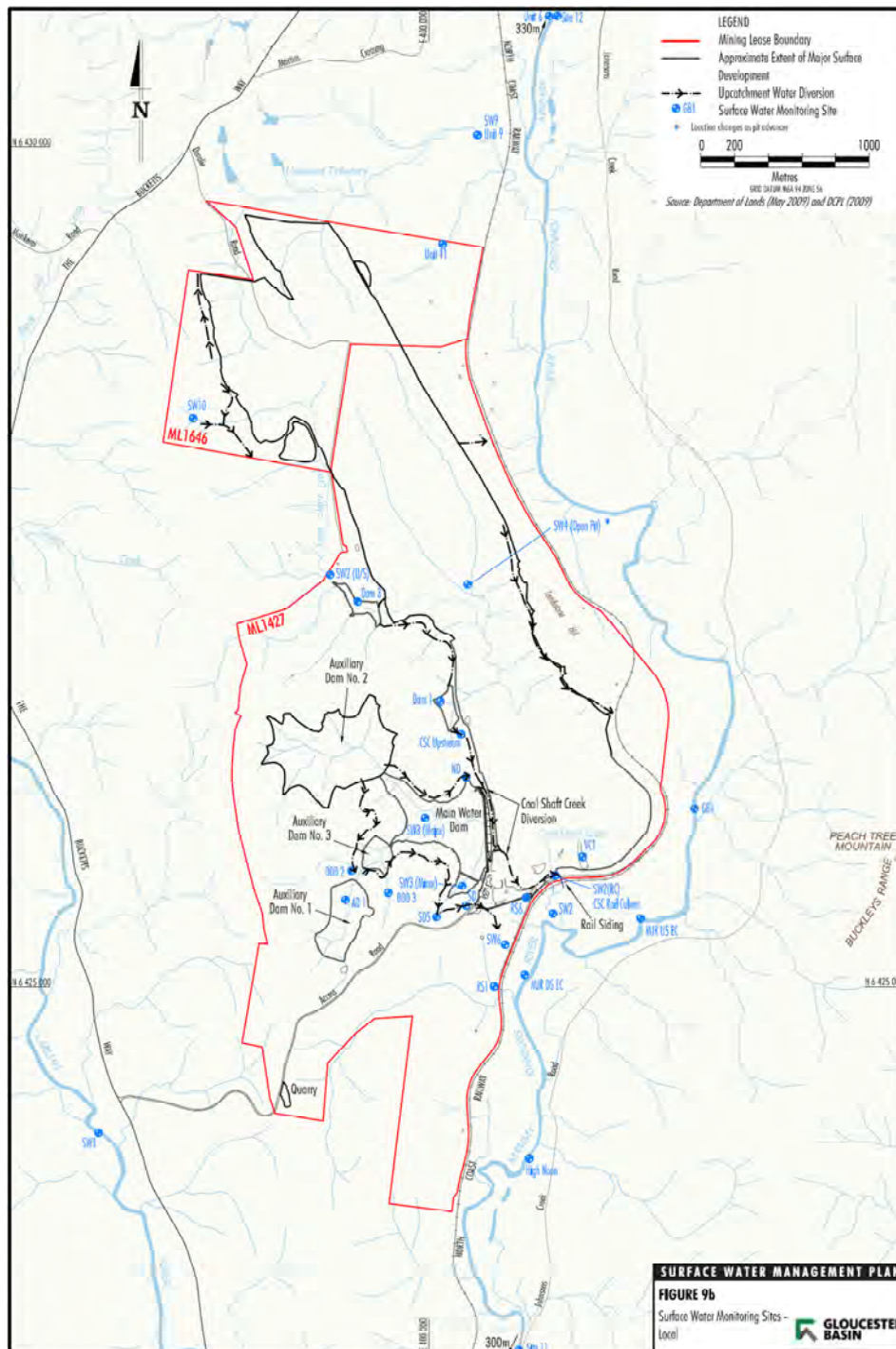
2.1 Identification of the Relevant Monitoring Sites and Reference Data Sets

The water quality data set used in the determination of trigger values comprises all data collected up until the end of December 2011.

The surface water quality monitoring sites at the Duralie Coal Mine site are shown on Figure 1 below (Figure 9b reproduced from the SWMP).

³ For parameters where low values have the potential to cause environmental harm (e.g. pH) the 20th percentile value has been used.

Figure 1 - Monitoring Site Figure



The following sampling sites would be used in the assessment⁴ of water quality objectives:

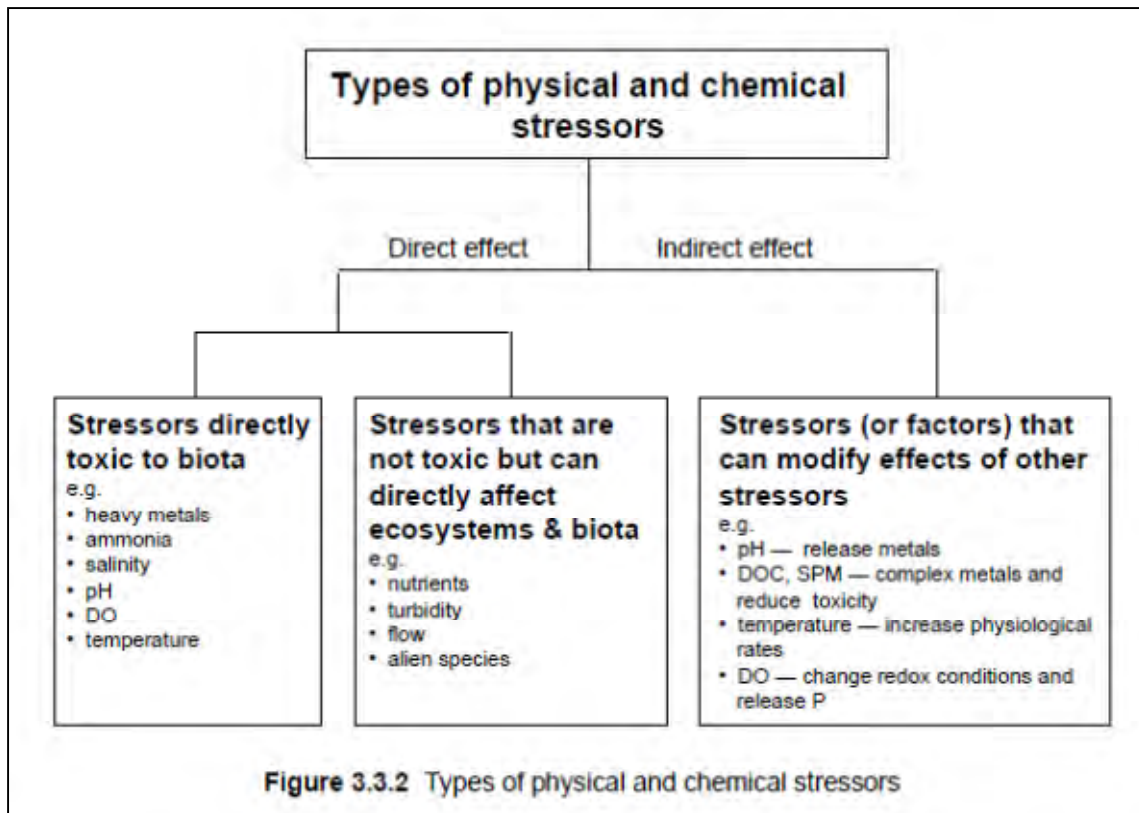
- Mammy Johnsons River:
 - Site 12 and GB1, which are upstream of the Coal Shaft Creek confluence; and
 - Site 11, which is downstream of the Coal Shaft Creek confluence.
- Coal Shaft Creek:
 - Site SW2 US, which is upstream of mining⁵;
 - Site SW2 RC, which is at the entrance of the railway culvert, downstream of the existing Duralie Coal Mine and inflows to Coal Shaft Creek, and
 - Site SW10, which is on an upper arm of Coal Shaft Creek which is unaffected by drainage from the Duralie Extension Project disturbance area.
- Unnamed Tributary:
 - Site SW9, which is on the Unnamed Tributary downstream of the Duralie Extension Project disturbance area.

2.2 Identification of Water Quality Indicators and Development of Trigger Levels

Water quality indicators are defined in the guidelines as parameters that can be used to provide a measure of the quality of water or the condition of an ecosystem. Water quality indicators relevant to biological diversity and aquatic ecosystem integrity have been selected based on parameters having a direct effect (toxic and non-toxic stressors) (refer Figure 3.3.2 of the guidelines reproduced below).

⁴ Note sampling sites which are upstream of mine disturbance areas would form reference sites for the interpretation of water quality data. Trigger levels would apply to sampling sites downstream of mine affected areas.

⁵ Note runoff from a recently constructed mine road may have a small effect on water flow and quality at SW2 US.



The water quality indicators comprise heavy metals, ammonia, salinity, pH, dissolved oxygen (DO), temperature, nutrients, turbidity, flow, alien species, sediment load, hardness and BOD⁶.

⁶ Including the parameters nominated in Project Approval Condition 29(b)

- a) Heavy metals aluminium (total), chromium (total), copper (total) and zinc (total) have been selected as water quality indicators because of their history of being recorded at elevated concentrations in MJR, CSC and UT - relative to the default trigger values in the guidelines for 95% species protection). Specifically

“Elevated aluminium and zinc concentrations are regularly recorded in the Karuah River, Mammy Johnsons River, Coal Shaft Creek and the unnamed tributary to Mammy Johnsons River (SW8 and SW9), including sites both upstream and downstream of DCM. The elevated aluminium concentrations recorded may be a function of the colloidal fraction rather than the metal in solution. Concentrations of copper and chromium have also been recorded on occasions above the ANZECC/ARMCANZ aquatic ecosystems guideline in these watercourses.”⁷

Based on the available periods of record, the following site specific trigger levels for the other heavy metals are proposed:

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80 th ile)			
			Total Aluminium (mg/L)	Total Chromium (mg/L)	Total Copper (mg/L)	Total Zinc (mg/L)
MJR	Site 11	7/95 – 28/11/11	1.24	0.001	0.002	0.011
CSC	SW2 (RC)	22/3/04 – 28/12/11	3.02	0.002	0.003	0.064
UT	SW9	7/95 – 28/12/11	2.96	0.002	0.004	0.024

⁷ Refer Gilbert & Associates (2010), Appendix A “Surface Water Assessment” in “Duralie Extension Project Environmental Assessment”, 2010, January.

b) Ammonia

Based on the available periods of record, the following site specific trigger levels for ammonia are proposed:

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80 th ile)
			Ammonia (mg/L)
MJR	Site 11	7/95 – 28/11/11	0.06
CSC	SW2 (RC)	22/3/04 – 28/12/11	0.05
UT	SW9	7/95 – 28/12/11	0.13

c) Salinity (measured by electrical conductivity [EC]) and pH are proposed to be used as representative water quality performance indicators. Based on the available periods of record, the following site specific trigger values are proposed:

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80 th ile)		
			pH (20 th ile)	pH (80 th ile)	EC (µS/cm)
MJR	Site 11	7/95 – 28/12/11	7.1	7.6	370
CSC	SW2 (RC)	22/3/04 – 28/12/11	7.1	7.9	544
UT	SW9	7/95 – 28/12/11	6.4	7.1	461

d) Dissolved oxygen (DO) has not been routinely measured at the Duralie Coal Mine and there is insufficient data to define site specific trigger values. Default values of 85 to 110% of saturation have been proposed in ANZECC/ARMCANZ (2000) (refer Table 3.3.2 reproduced below) and will be used as the default trigger values.

Table 3.3.2 Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types. Data derived from trigger values supplied by Australian states and territories. Chl *a* = chlorophyll *a*, TP = total phosphorus, FRP = filterable reactive phosphate, TN = total nitrogen, NO_x = oxides of nitrogen, NH₄⁺ = ammonium, DO = dissolved oxygen.

Ecosystem type	Chl <i>a</i>	TP	FRP	TN	NO _x	NH ₄ ⁺	DO (% saturation) ⁱ		pH	
	(µg L ⁻¹)	(µg P L ⁻¹)	(µg P L ⁻¹)	(µg N L ⁻¹)	(µg N L ⁻¹)	(µg N L ⁻¹)	Lower limit	Upper limit	Lower limit	Upper limit
Upland river	na ^a	20 ^b	15 ^b	250 ^c	15 ⁿ	13 ⁱ	90	110	6.5	7.5 ^m
Lowland river ^d	5	50	20	500	40 ^o	20	85	110	6.5	8.0
Freshwater lakes & Reservoirs	5 ^e	10	5	350	10	10	90	110	6.5	8.0 ^m
Wetlands	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
Estuaries ^g	4 ^f	30	5 ^j	300	15	15	80	110	7.0	8.5
Marine ^p	1 ⁿ	25 ⁿ	10	120	5 ^k	15 ^k	90	110	8.0	8.4

na = not applicable;

a = monitoring of periphyton and not phytoplankton biomass is recommended in upland rivers — values for periphyton biomass (mg Chl *a* m⁻²) to be developed;

b = values are 30 µg L⁻¹ for Qld rivers, 10 µg L⁻¹ for Vic. alpine streams and 13 µg L⁻¹ for Tas. rivers;

c = values are 100 µg L⁻¹ for Vic. alpine streams and 480 µg L⁻¹ for Tas. rivers;

d = values are 3 µg L⁻¹ for Chl *a*, 25 µg L⁻¹ for TP and 350 µg L⁻¹ for TN for NSW & Vic. east flowing coastal rivers;

e = values are 3 µg L⁻¹ for Tas. lakes;

f = value is 5 µg L⁻¹ for Qld estuaries;

g = value is 5 µg L⁻¹ for Vic. alpine streams and Tas. rivers;

h = value is 190 µg L⁻¹ for Tas. rivers;

i = value is 10 µg L⁻¹ for Qld. rivers;

j = value is 15 µg L⁻¹ for Qld. estuaries;

k = values of 25 µg L⁻¹ for NO_x and 20 µg L⁻¹ for NH₄⁺ for NSW are elevated due to frequent upwelling events;

l = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability (see Section 3.3.3.2);

m = values for NSW upland rivers are 6.5–8.0, for NSW lowland rivers 6.5–8.5, for humic rich Tas. lakes and rivers 4.0–6.5;

n = values are 20 µg L⁻¹ for TP for offshore waters and 1.5 µg L⁻¹ for Chl *a* for Qld inshore waters;

o = value is 60 µg L⁻¹ for Qld rivers;

p = no data available for Tasmanian estuarine and marine waters. A precautionary approach should be adopted when applying default trigger values to these systems.

- e) Temperature (water temperature) outside its natural range is considered a potential stressor. Release of warm water from industrial cooling systems or cold water from low levels in deep water supply storages has been known to have had detrimental effects on aquatic life. It is not expected however that mining activities could result and any change to the thermal loading of downstream water courses and temperature is not considered relevant to the Project. It is therefore not proposed to develop trigger values for water temperature. Ambient water temperatures will however be included in the field monitoring regime for their relevance in DO measurement.

f) Nutrients and Indicators of Eutrophication

Total Nitrogen and Total Phosphorous and Chlorophyll α have been selected as indicators of the major nutrient relevant to eutrophication. Chlorophyll α has not been routinely monitored at the Duralie Coal Mine and a trigger value of 0.005 mg/L based on the relevant default trigger values given in ANZECC/ARMCANZ (2000) – refer Table 3.3.2 reproduced above, is proposed.

Based on the available periods of record, the following site specific trigger values for Total Nitrogen and Total Phosphorous are proposed:

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80 th %ile)	
			Total Nitrogen (mg/L) (80 th %ile)	Total Phosphorous (mg/L) (80 th %ile)
MJR	Site 11	7/95 – 28/12/11	0.8	0.15
CSC	SW2 (RC)	22/3/04 – 28/12/11	1.2	0.08
UT	SW9	7/95 – 28/12/11	2.6	0.68

g) Turbidity

Based on the available periods of record, the following site specific trigger values are proposed:

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80 th %ile)
			Turbidity [NTU] (80 th %ile)
MJR	Site 11	7/95 – 28/12/11	24
CSC	SW2 (RC)	22/3/04 – 28/12/11	119
UT	SW9	7/95 – 28/12/11	94

- h) Flow is highly variable naturally ranging from zero to very large rates. The Surface Water Assessment in the Environmental Assessment predicts changes to flows in all three watercourses (UT, CSC and MJR) as a result of capture and reuse of drainage from mine catchment areas. It is assumed that inclusion of flow as a parameter relevant to biological diversity and aquatic ecological integrity means a trigger is needed for “unnatural flow regime” leading to “habitat change - % wetted area” (refer Table 3.3.1 ANZECC/ARMCANZ [2000] reproduced below). Applying this to MJR would seem to imply a criterion based on a change to the flow duration curve which could only be

assessed using long periods of data or using a predictive model where model results should show a non-negligible change to catchment behaviour (i.e. modelled to monitored data using a model calibrated to pre-impact data). These assessments would be undertaken as part of the annual review process and no specific flow trigger value is proposed.

- i) Alien species are recognised as a potential stressor however it is not considered that alien species could be introduced as a result of the Project and it is not proposed to develop triggers for alien species.

Table 3.3.1 Summary of the condition indicators, performance indicators, and location of default trigger value tables, for each issue

Issue	Condition indicator/target	Performance indicators	Preferred method for obtaining trigger values ^a	Default trigger value for each ecosystem-type	Consider ecosystem-specific modifiers
1. Nuisance aquatic plants	Species composition Cell numbers Chlorophyll a conc	TP conc TN conc Chl a conc	Reference data Reference data Reference data	Tables 3.3.2, 3.3.4, 3.3.6, 3.3.8, 3.3.10	Yes — Section 3.3.3.1
2. Lack of DO	Reduced DO conc Species composition/abundance	DO conc	Reference data	Tables 3.3.2, 3.3.4, 3.3.6, 3.3.8, 3.3.10	Yes — Section 3.3.3.2
3. Excess of SPM	Species composition/abundance	SPM conc	Reference data	Tables 3.3.3, 3.3.5, 3.3.7, 3.3.9, 3.3.11	Yes — Section 8.2.3.2
4. Unnatural change in salinity	Species composition/abundance	EC (salinity)	Reference data	Tables 3.3.3, 3.3.5, 3.3.7, 3.3.9, 3.3.11	No
5. Unnatural change in temperature	Species composition/abundance	Temperature	Reference data	> 80%ile < 20%ile	No
6. Unnatural change in pH	Species composition/abundance	pH	Reference data	Tables 3.3.2, 3.3.4, 3.3.6, 3.3.8, 3.3.10	No
7. Poor optical properties	Species composition/abundance	Turbidity Light regime	Reference data Reference data	Tables 3.3.3, 3.3.5, 3.3.7, 3.3.9, 3.3.11	No
8. Unnatural flow regime	Species composition/abundance Habitat change % wetted area	Flow regime			

^a Where local biological and ecological effects data are unavailable.

- j) Sediment load, per se, is not dealt as a stressor in ANZECC/ARMCANZ (2000) rather turbidity as a surrogate for suspended particulate matter or total suspended solids is listed as a stressor. It is proposed to use total suspended solids (TSS) concentration as a trigger for sediment load.

Monitoring Site (Figure 9b)		Period of Record	Proposed Water Quality Trigger Level (80th%ile) Total Suspended Solids (mg/L) (80 th %ile)
MJR	Site 11	7/95 – 28/12/11	15
CSC	SW2 (RC)	22/3/04 – 28/12/11	80
UT	SW9	7/95 – 28/12/11	57

- k) Hardness and BOD are not defined as stressors in ANZECC/ARMCANZ (2000). BOD is a measure of how much DO would be consumed during the process of breaking down organic matter present in water released into the receiving water (i.e. it is a potential causal factor for reduced DO). The hardness of water affects the toxicity of metals (refer Tables 3.4.3 and 3.4.4 of ANZECC reproduced below). BOD (as BOD₅) and hardness will be monitored and used as 'modifying factors' in the interpretation of any trigger exceedences for DO and heavy metals above respectively.

Table 3.4.3 General form of the hardness-dependent algorithms describing guideline values for selected metals in freshwaters

Metal	Hardness-dependent algorithm
Cadmium	$HMTV = TV (H/30)^{0.89}$
Chromium(III)	$HMTV = TV (H/30)^{0.62}$
Copper	$HMTV = TV (H/30)^{0.85}$
Lead	$HMTV = TV (H/30)^{1.27}$
Nickel	$HMTV = TV (H/30)^{0.85}$
Zinc	$HMTV = TV (H/30)^{0.85}$

HMTV, hardness-modified trigger value ($\mu\text{g/L}$); TV, trigger value ($\mu\text{g/L}$) at a hardness of 30 mg/L as CaCO_3 ; H, measured hardness (mg/L as CaCO_3) of a fresh surface water ($\leq 2.5\%$). From Markich et al (in press).

Table 3.4.4 Approximate factors to apply to soft water trigger values for selected metals in freshwaters of varying water hardness^a

Hardness category ^b (mg/L as CaCO_3)	Water hardness ^c (mg/L as CaCO_3)	Cd	Cr(III)	Cu	Pb	Ni	Zn
Soft (0–59)	30	TV	TV	TV	TV	TV	TV
Moderate (60–119)	90	X 2.7	X 2.5	X 2.5	X 4.0	X 2.5	X 2.5
Hard (120–179)	150	X 4.2	X 3.7	X 3.9	X 7.6	X 3.9	X 3.9
Very hard (180–240)	210	X 5.7	X 4.9	X 5.2	X 11.8	X 5.2	X 5.2
Extremely hard (400)	400	X 10.0	X 8.4	X 9.0	X 26.7	X 9.0	X 9.0

^a Trigger values from table 3.4.1;

^b Range of water hardness (mg/L as CaCO_3) for each category as defined by CCREM (1967);

^c Mid-range value of each water hardness category. For example, a copper trigger value of 1.4 $\mu\text{g/L}$ (from table 3.4.1) with 95% protection level chosen (e.g. slightly–moderately disturbed system) is applied to a site with very hard water (e.g. 210 mg/L as CaCO_3) by multiplying the trigger value by 5.2 to give a site-specific trigger value of 7.3 $\mu\text{g/L}$. If the hardness is away from the mid-range, it may be preferable to use the algorithm.

ATTACHMENT C

COAL SHAFT CREEK RECONSTRUCTION PLAN

DURALIE COAL MINE
COAL SHAFT CREEK RECONSTRUCTION PLAN



Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	Submission Date
All	CSCR-P-R01-A	Original	DP&I, NOW	December 2012

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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited [Yancoal]) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

DCPL was granted approval for the Duralie Extension Project under Section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (Project Approval [08_0203]) and under Sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (EPBC 2010/5396). On 10 November 2011, the Project Approval was amended by Order of The Land and Environment Court of NSW.

The main activities associated with the Duralie Extension Project include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum, including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel Extension open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval North West open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- raising of the existing approved Auxiliary Dam No. 2 from relative level (RL) 81 metres (m) to approximately RL 100 m to provide significant additional on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of permanent Coal Shaft Creek alignment adjacent to the existing DCM mining area;
- ongoing surface monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.



DCPL subsequently made an application to the NSW Minister for Planning and Infrastructure under Section 75W of the EP&A Act to modify the Project Approval to extend the approved rail hours for the Duralie shuttle train. The application was accompanied by the *Duralie Rail Hours Modification Environmental Assessment* (DCPL, 2012). Approval to modify the Project Approval to extend the approved rail hours was granted by the NSW Planning Assessment Commission (under delegation of the NSW Minister for Planning and Infrastructure) on 1 November 2012.

A copy of the Project Approval (as modified on 1 November 2012) is available on the DCPL website (www.duraliecoal.com.au).

1.1 PURPOSE AND SCOPE

This Coal Shaft Creek Reconstruction Plan (CSCRPlan) has been prepared by DCPL in accordance with the requirements of Condition 29(b), Schedule 3 of the NSW Project Approval (08_0203) and to satisfy the commitments made in the *Duralie Extension Project Environmental Assessment* (EA) (DCPL, 2010) viz.:

Coal Shaft Creek - Reconstruction

DCPL Commitment

Following the completion of mining activities at the DCM, a final alignment of Coal Shaft Creek will be established, stabilised and revegetated prior to relinquishment of ML 1427. DCPL commits to a final alignment with the following components:

- *a reworked section of the existing Coal Shaft Creek Diversion channel;*
- *a reconstructed meandering channel within a corridor over the in-pit waste rock emplacement; and*
- *a drop-down section between the two above components.*

DCPL commits to the development of a Surface Water Management Plan that documents the final design of the post-mining alignment of Coal Shaft Creek.

In accordance with Condition 29, Schedule 3, DCPL prepared the Duralie Coal Mine Water Management Plan (including a Surface Water Management Plan [SWMP]) in February 2012, which was subsequently approved by the NSW Department of Planning and Infrastructure (DP&I) on 2 August 2012.

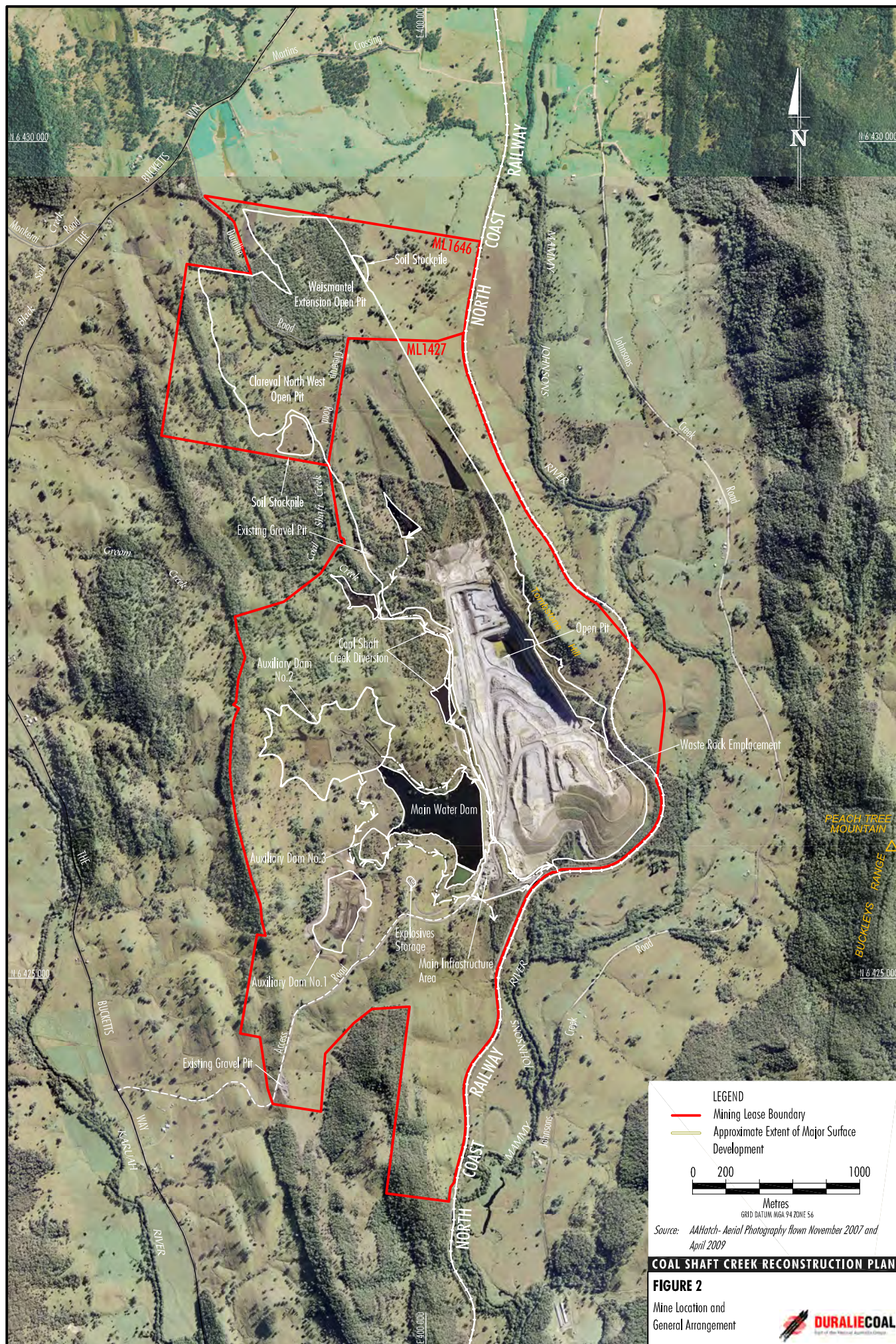
As provided for in Condition 14, Schedule 2 of the NSW Project Approval (08_0203), the Coal Shaft Creek Reconstruction Plan was not included in the approved version of the SWMP. The SWMP described that the CSCRPlan would be developed and subsequently included in the SWMP prior to the end of 2012.

1.2 MINE PLANNING CONTEXT

Coal Shaft Creek has been diverted around the existing Weismantel open pit to allow mining at the DCM. The Project surface water management system will include the continued use of the Coal Shaft Creek Diversion (Figure 2).

Following the completion of mining activities at the DCM, a final alignment of Coal Shaft Creek will be established, stabilised and revegetated prior to relinquishment of ML 1427.

Throughout the mine life, further analyses will be conducted into the geotechnical, hydrological and hydraulic design of the final alignment focussing on long-term stability, seepage management and the creation of habitat. The outcomes of these analyses will inform the final detailed design of the post-mining alignment and reconstruction of Coal Shaft Creek.



Following the completion of detailed design, this CSCRП will be revised and submitted to the Director-General of the DP&I for approval (herein referred to as the final CSCRП).

This CSCRП does however provide a framework for the development of the final CSCRП, which will be submitted including all of the relevant requirements of Condition 29(b), Schedule 3 of the NSW Project Approval (08_0203).

The final CSCRП will be submitted for approval in consultation with the NSW Office of Water (NOW), prior to the scheduled reconstruction of Coal Shaft Creek, which is not required until the completion of mining activities at the DCM.

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

Statutory requirements relevant to this CSCR are described below.

2.1 EP&A ACT APPROVAL

This Plan has been prepared in accordance with Condition 29(b), Schedule 3 of the NSW Project Approval (08_0203) which states:

Condition 29, Schedule 3

29. *The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Director-General. This plan must be prepared in consultation with DECCW and NOW by suitably qualified and experienced persons whose appointment has been approved by the Director-General, and submitted to the Director-General by the end of May 2011.*

In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:

...

b) a Surface Water Management Plan, that includes:

...

- *detailed plans, including design objectives and performance criteria, for:*
 - *the reconstruction of Coal Shaft Creek;*

...

In accordance with Condition 29, Schedule 3 of the NSW Project Approval (08_0203), this Plan will form part of the SWMP for the DCM.

2.1 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203) and Commonwealth Approval (2010/5396), all activities at DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

Key licences, permits and leases pertaining to the DCM include:

- ML 1427 issued under Part 5 of the NSW *Mining Act, 1992* and approved by the NSW Minister for Mineral Resources in April 1998.
- ML 1646 issued under Part 5 of the NSW *Mining Act, 1992* and approved by the NSW Minister for Primary Industries in January 2011.
- Environment Protection Licence 11701 issued under Part 3 of the NSW *Protection of the Environment Operations Act, 1997* by the Environment Protection Authority (now the Office of Environment and Heritage) in September 2002 (as modified by subsequent licence variations).

- Groundwater Licence – Duralie Coal Open Cut (20BL168404) issued under Part 5 of the NSW *Water Act, 1912* by the Department of Land and Water Conservation (now NOW) in September 2002 (renewed September 2007).
- Mining Operations Plan submitted to NSW Industry and Investment (now Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy [DTIRIS-DRE]) for approval in December 2010.
- Water Supply Works Approval (20WA202053) under the NSW *Water Management Act, 2000* issued by the Department of Water and Energy (now NOW) on 15 May 2009 for the Coal Shaft Creek diversion and various on site water management structures¹.
- Mining and occupational health and safety related approvals granted by DTIRIS-DRE and WorkCover NSW.

2.2 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

In addition to those Acts referred to above (Section 2.3), the following NSW Acts may be applicable to the conduct of the DCM (DCPL, 2010):

- *Contaminated Land Management Act, 1997*;
- *Dangerous Goods (Road and Rail Transport) Act, 2008*;
- *National Parks and Wildlife Act, 1974*;
- *Noxious Weeds Act, 1993*;
- *Roads Act, 1993*;
- *Threatened Species Conservation Act, 1995*;
- *Coal Mine Health and Safety Act, 2002*;
- *Crown Lands Act, 1989*;
- *Dams Safety Act, 1978*;
- *Fisheries Management Act, 1994*; and
- *Petroleum (Onshore) Act, 1991*.

Relevant licences or approvals required under these Acts will be obtained as required.

¹ This approval replaced the previous *Water Act, 1912* Licence 20SL060324 for these structures.

3 COAL SHAFT CREEK WATER CONTROL SYSTEM

The Coal Shaft Creek Diversion channel allows for the flow of up-catchment runoff reporting to Coal Shaft Creek to traverse the DCM site and avoid the open pit, waste rock emplacement and infrastructure areas. The diversion is required until the watercourse is re-established at the cessation of mining. The diversion was approved by Approval Number 20WA202053 under the Karuah River Water Sharing Plan and has a design capacity to safely pass the 100-year ARI peak flow event (Gilbert & Associates Pty Limited, 2010).

The existing Coal Shaft Creek Diversion comprises a series of diversion dams (Dams 1 to 5), connected with open channels and flowing in a general north to south direction. The open channels are constructed as cut-to-fill channels and bunds (Gilbert & Associates Pty Limited, 2010). In the upper reaches of the diversion, the channels are generally grassed or lined with rockfill (with grass and shrubs now established through the rockfill). In the lower reaches of the diversion, channels are either excavated in rock or are lined with rockfill mattresses. Most of the diversion (upper reaches) is constructed at higher levels than the original Coal Shaft Creek. This necessitated the construction of three drop structures on the lower reaches of the diversion, in the form of engineered stepped cascades, to dissipate flow energy and lower the elevation of the diversion back down to the elevation of the original Coal Shaft Creek channel into which the diversion discharges near the rail siding at the southern end of the DCM (Gilbert & Associates Pty Limited, 2010).

The majority of the Coal Shaft Creek Diversion would remain for the life of the DCM. The upper (northern) reaches of the diversion would be consumed by the advancing mine open pits and waste rock emplacement areas (refer Figure 2). Small tributaries in the very upper reaches of Coal Shaft Creek would be diverted around the Clareval North West open pit and waste rock emplacement, directing runoff back into the remnant Coal Shaft Creek upstream of the Coal Shaft Creek Diversion (Gilbert & Associates Pty Limited, 2010).

4 DESIGN SPECIFICATIONS AND CONSTRUCTION PROGRAM

The reconstruction of Coal Shaft Creek is not required until the completion of mining activities at the DCM. Therefore, detailed design of the relocation corridor has not yet commenced. Detailed design specifications and drawings of the relocation corridor and a construction program will be provided in the final CSCR. Notwithstanding, a proposed conceptual design for the post-mining alignment of Coal Shaft Creek is provided below.

A conceptual final alignment of Coal Shaft Creek was presented in the Surface Water Assessment (Gilbert & Associates Pty Limited, 2010) prepared for the EA and is reproduced on Figure 3. Preliminary design work undertaken since the EA has refined the conceptual design as shown in Attachment 1.

The proposed design concept for the post-mining alignment of Coal Shaft Creek currently comprises a reworked section of the existing Coal Shaft Creek diversion channel, a drop-down section outside the in-pit waste rock emplacement, and reconstructed section of the creek within a corridor within the in-pit waste rock emplacement at the southern end of the Weismantel open pit extent. The confirmation of the conceptual and final design of the reconstructed Coal Shaft Creek will be based on geotechnical, hydrological and hydraulic characteristics of similar natural drainage systems with particular emphasis on stream channel and bank stability, seepage management and habitat creation. Analyses into the post-mining alignment and reconstruction of Coal Shaft Creek will use information collected from similar natural features surrounding the DCM area to inform the final design of the channel, including:

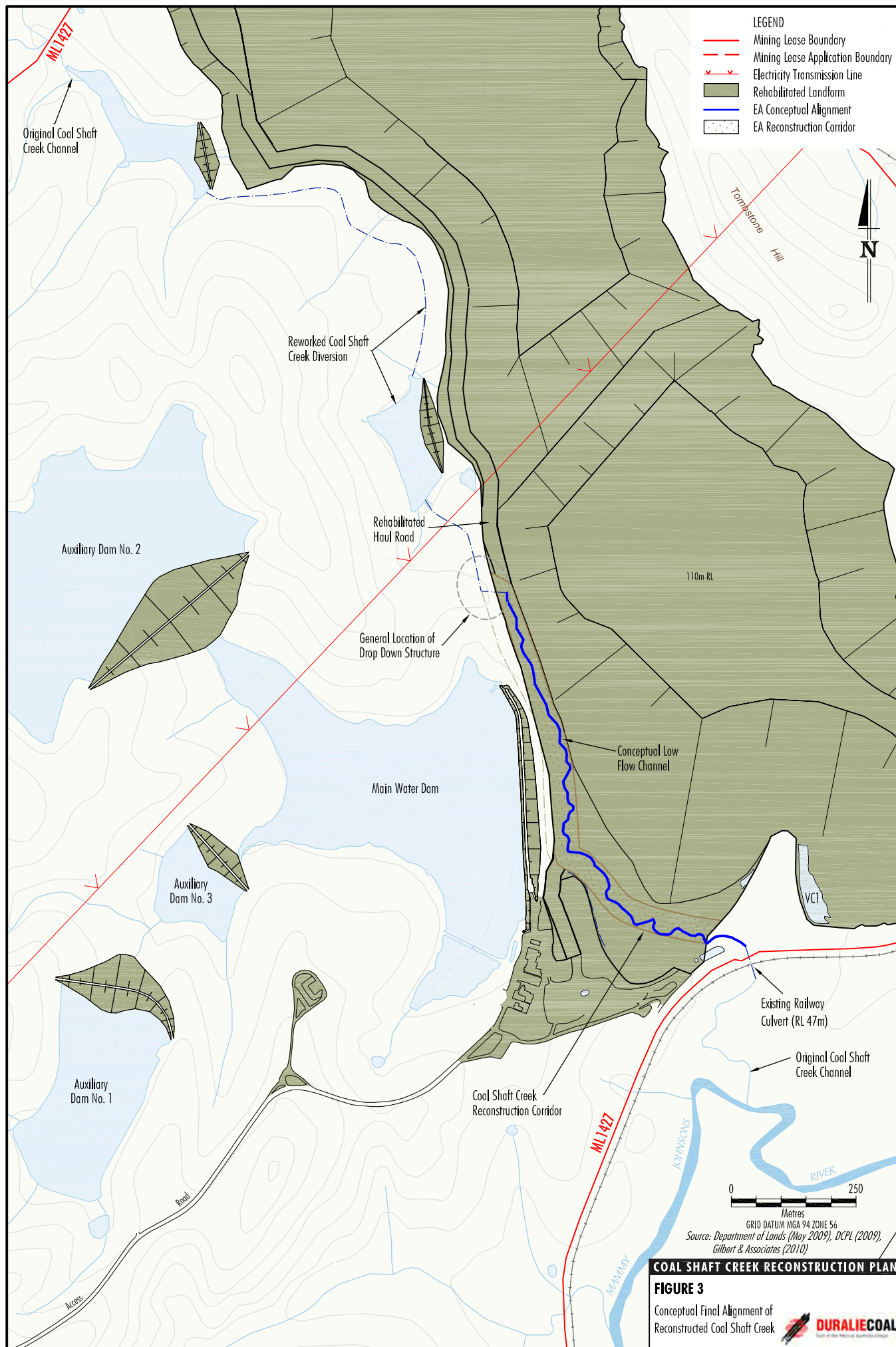
- stream energy, stream power and critical tractive stress;
- energy relationships at bankfull stage and at peak flow;
- channel longitudinal profiles and cross-sections;
- upstream and downstream controls;
- bed and bank material, including critical entrainment and destabilisation thresholds;
- changes in energy profiles and constriction and resultant changes in afflux through, past and over structures; and
- natural mechanisms of bedload transport.

A description of the components of the proposed design for the reconstructed Coal Shaft Creek is provided below.

Reworked Section of Existing Diversion Channel

Photographs of the existing Coal Shaft Creek Diversion are shown on Plate 1.

The main elements of the upper section of the Coal Shaft Creek diversion will be retained as a primarily engineered structure, depending on the outcome of the geomorphic, hydraulic and geotechnical analyses. Sediments and vegetation will establish within the channel over time (Gilbert & Associates Pty Limited, 2010). The banks of the diversion will continue to be revegetated and maintained throughout the mine life and during rehabilitation to enhance stability and create fauna habitat. The performance of the diversion channel will continue to be assessed following significant flow events.





Coal Shaft Creek Diversion Looking Upstream



Coal Shaft Creek Diversion Looking Downstream



Coal Shaft Creek Diversion Looking Downstream to Dam 1



Coal Shaft Creek Diversion Looking Upstream from Haul Road Culvert

COAL SHAFT CREEK RECONSTRUCTION PLAN

PLATE 1

Existing Coal Shaft Creek
Diversion (2009)



Following the completion of mining, the upper section of the existing Coal Shaft Creek diversion channel will be reworked, if required, to improve its longer-term stability (e.g. minor reinforcement and other maintenance) and geomorphologic and ecological function. The objective of any reworking will be to transform the existing engineered diversion channel into a more natural and self-sustaining form which has geomorphologic and hydraulic characteristics consistent with other watercourses and features in the surrounding area.

Drop-Down Section

DCPL will undertake a study into the long-term geotechnical stability and maintenance requirements of the proposed drop-down section of the reconstructed Coal Shaft Creek as a component of the development of this Plan. The study will seek input from hydrologists and geotechnical engineers and will be conducted in consultation with the NOW. The results of this study will be used to confirm the viability of this component of the conceptual design and would be incorporated into the final design and post-mining alignment of the reconstructed Coal Shaft Creek to be documented in the final CSCR.

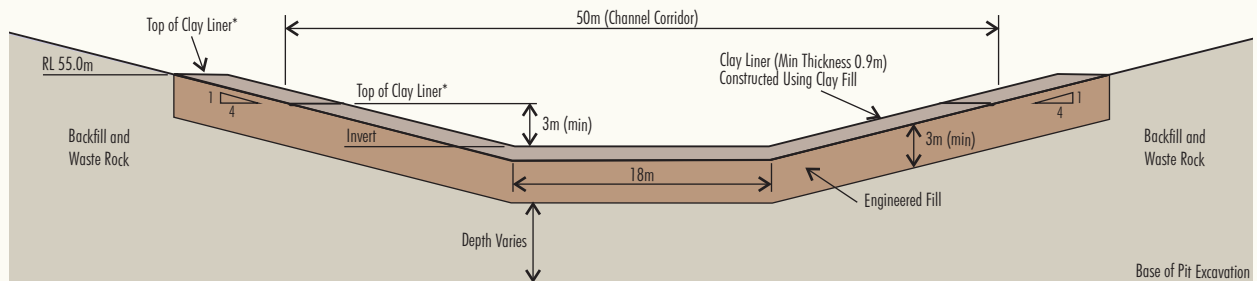
Reconstructed Section of Coal Shaft Creek

The creek will be designed with a meandering channel contained within a reconstructed 50 m wide corridor, which will generally replicate the original meandering geometry. The reconstructed creek design will aim to be similar to pre-mining (surveyed) creek cross-sections as far as practicable and adopt a design with a “main” flow channel, with overbank areas for large flows. The main channel will be sized appropriately to drain expected catchment yields such that channel stability is not compromised, habitat is created and seepage is managed (Figure 4).

The design channel profile will comprise a regular plan form which oscillates between right and left hand dominant profiles with right and left bends transitioning to a symmetrical profile in the straight sections between meander bends (Figure 4). The design bed slope will involve a regular pattern of flatter sections in bend areas and steeper sections in straighter sections between bends. The channel will be designed with similar hydraulic and geomorphic characteristics as the southern reach of the original creek channel. For example, the channel profile will be designed to have a similar stream power as the modelled stream power for the original Coal Shaft Creek.

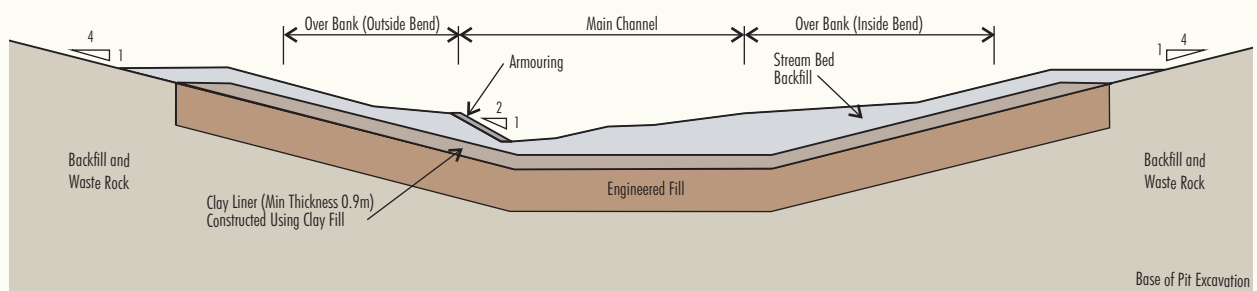
The stability of the original creek was dependent on relatively dense vegetation along the creek banks and it is envisaged that short-term stability of the outer banks of the reconstructed channel will be enhanced by selective armouring using rocky backfill or large timber debris (Gilbert & Associates Pty Limited, 2010).

The geotechnical requirements for the bulk fill and engineered fill (Figure 4) will be determined as part of further analyses and will include control over the engineering properties and placement of waste rock material in the reconstructed Coal Shaft Creek corridor. In areas where the channel would be formed over backfilled waste material the channel would incorporate an engineered low permeability liner (Figure 4) to restrict the movement of water between Coal Shaft Creek and the waste rock emplacement. As part of the final detailed design, seepage analysis, geotechnical testing and modelling will be undertaken to confirm an appropriate liner material, thickness and extension above the channel invert.

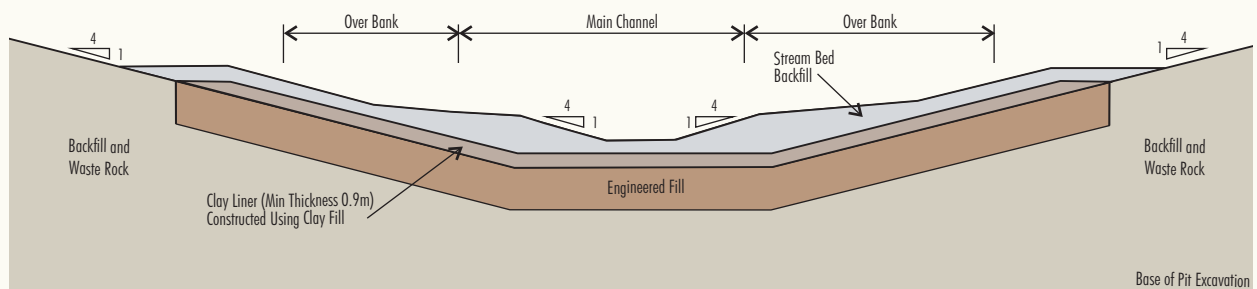


*Channel Corridor Clay Liner to extend up batters to RL 55m or 3m(min) vertically from corridor invert (whichever is greater).

Typical Channel Corridor Section



Typical Section - Reconstructed Creek (Bend)



Typical Section - Reconstructed Creek (Straight)

Source: Allan Watson Associates (2006)

COAL SHAFT CREEK RECONSTRUCTION PLAN

FIGURE 4

Coal Shaft Creek Reconstruction
(Typical Sections)



Whilst the design concepts are based on characteristics of the original creek, the reconstructed creek is expected to be dynamic and to evolve over time. This will inevitably result in preferential erosion and deposition in some sections which may be initially greater than might be expected in the natural creek, depending on the pattern of flows experienced post commissioning (Gilbert & Associates Pty Limited, 2010). Selection of final form and alignment of the creek channel will be subject to a detailed hydraulic analysis, as part of final design, together with an assessment of the likelihood of bed/bank erosion on the outside of bends under a range of flow conditions. Examples of habitat in the existing Coal Shaft Creek Diversion are shown on Plate 1.

The conceptual longitudinal channel profile will also include habitat creation initiatives such as the provision of irregular pool and riffle sequences, use of material recovered from the existing channel or some other suitable source, placement of large boulders and/or timber to form pools upstream and promote aquatic habitat and planting of riverine vegetation on banks to enhance stability.

The channel would be formed progressively from south to north and creek flows would not be reinstated until the completion of mining and/or when vegetation was well established throughout. In concept, the creek would be constructed by:

- forming the 50 m wide corridor in the waste rock material;
- constructing the clay liner to control leakage from the reconstructed creek to the
- waste rock and seepage from the waste rock emplacement to the creek;
- forming the channel and banks using material recovered from the existing channel or
- some other suitable source;
- placement of large boulders and/or timber to form pools upstream and promote
- aquatic habitat; and
- planting of riverine vegetation on banks to enhance stability.

5 MONITORING PROGRAM

A monitoring program will be developed over the life of the DCM and documented in the final CSCR to assess the performance of the reconstructed Coal Shaft Creek against the performance criteria (Section 6). The monitoring program will complement existing monitoring programs and will use existing monitoring locations where possible.

The monitoring program will include monitoring of bed and bank stability, bed and bank erosion rates, changes to flow path geometry, vegetation (cover, density and health) and water quality.

Baseline and control monitoring will be conducted in three comparable creek systems identified in the Gloucester Valley to develop and monitor performance against performance measures and indicators.

6 ASSESSMENT OF PERFORMANCE INDICATORS AND MEASURES

Performance indicators and measures will be developed over the life of the DCM and documented in the final CSCR. The performance measures and indicators will include consideration of monitoring and observations during and following flood events include attributes such as bed and bank stability, bed and bank erosion rates, changes to flow path geometry, vegetation (cover, density and health) and water quality.

The performance measures and indicators will be based on demonstrating substantial achievement of equivalent stability and geomorphic and ecological function as exist in other comparable creek systems (identified through the baseline and control monitoring described in Section 5) to the original Coal Shaft Creek.

7 CONTINGENCY PLAN

A Contingency Plan will be developed in the final CSCR to be implemented by DCPL in the event that the performance indicators (to be developed as described in Section 6) demonstrate that equivalent stability and geomorphic and ecological function (as exist in other comparable creeks systems) is not being substantially achieved.

8 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL will conduct an Annual Review of the environmental performance of the DCM by the end of December 2011², and annually thereafter.

In accordance with Condition 4, Schedule 5 of the NSW Project Approval (08_0203), the SWMP (including the requirements relevant to this CSCR) will be reviewed and if necessary revised to the satisfaction of the Director-General of the DP&I, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit³, in accordance with Condition 9, Schedule 5; or
- any modification to the conditions of consent.

The review procedures are described further in the SWMP.

9 REPORTING SYSTEMS

In accordance with Condition 2(g), Schedule 5 of the NSW Project Approval (08_0203), DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints; and
- non-compliances with statutory requirements.

These protocols are described further in the SWMP.

10 REFERENCES

Duralie Coal Pty Limited (2010) *Duralie Extension Project Environmental Assessment*.

Gilbert & Associates Pty Limited (2010) *Duralie Extension Project Surface Water Assessment*.
Appendix A of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.

² The Duralie Coal Mine Annual Review (DCPL, 2011) was completed in September 2011. No changes were made to the SWMP as a result of the 2011 Annual Review.

³ An independent environmental audit was completed in November 2011 (Trevor Brown & Associates, 2011).

ATTACHMENT 1

CONCEPTUAL FINAL ALIGNMENT OF RECONSTRUCTED COAL SHAFT CREEK –

DECEMBER 2012



APPENDIX 3
GROUNDWATER MANAGEMENT PLAN

DURALIE COAL MINE GROUNDWATER MANAGEMENT PLAN



Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&I Approval Date
All	GWMP-R01-B	Original	OEI, NOW, DP&I	-
All	GWMP-R02-A	Edits made to: <ul style="list-style-type: none"> reflect amended Project Approval conditions by Order of The Land and Environment Court of NSW dated 10 November 2011; consider recommendations (where relevant) of independent environmental audit dated November 2011; and consider any outcomes of the Annual Review for the Duralie Coal Mine (dated September 2011). 	OEI, NOW, DP&I	-
All	GWMP-R02-B	Edits made to reflect DP&I and NOW comments.	DP&I	2 August 2012
All	GWMP-R02-C	Annual Review	DP&I	27 September 2013
All	GWMP-R03-A	Annual Review (2013) and recommendations from DP&E Audit December 2013	DP&E	23 April 2015
All	GWMP-R04-B	Annual Review (2014) and Duralie Open Pit Modification (2014).	DP&E, DotE	22 July 2016

AUGUST 2017
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1 INTRODUCTION

1.1 DURALIE COAL MINE

The Duralie Coal Mine (DCM) is an existing mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC) on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

The main activities associated with the Duralie Extension Project (as modified) include:

- continued development of open cut mining operations at the DCM to facilitate a total run-of-mine (ROM) coal production rate of up to approximately 3 million tonnes per annum (Mtpa), including:
 - extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel open pit) within Mining Lease (ML) 1427 and ML 1646; and
 - open cut mining operations in the Clareval Seam (i.e. Clareval open pit) within ML 1427 and ML 1646;
- ongoing exploration activities within existing exploration tenements;
- progressive backfilling of the open pits with waste rock as mining develops, and continued and expanded placement of waste rock in out-of-pit waste rock emplacements;
- increased ROM coal rail transport movements on the North Coast Railway between the DCM and the Stratford Coal Mine (SCM) in line with increased ROM coal production;
- continued disposal of excess water through irrigation (including development of new irrigation areas within the existing ML 1427 and ML 1646);
- raising of the existing approved Auxiliary Dam No.2 from relative level (RL) 81 metres (m) to approximately RL 100 m to provide significant additional on-site storage capacity to manage excess water on-site;
- progressive development of dewatering bores, pumps, dams, irrigation infrastructure and other water management equipment and structures;
- development of new haul roads and internal roads;
- upgrade of existing surface facilities and supporting infrastructure as required in line with increased ROM coal production;
- continued development of soil stockpiles, laydown areas and gravel/borrow pits;
- establishment of permanent Coal Shaft Creek Diversion alignment adjacent to the existing DCM mining area;
- ongoing surface monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The general arrangement of the DCM, showing modifications, is provided in Figure 2.





1.2 PURPOSE AND SCOPE

This Groundwater Management Plan (GWMP) has been prepared by DCPL in accordance with Condition 29(c), Schedule 3 of Project Approval (08_0203).

This revision of the GWMP has been prepared by DCPL to:

- consider the outcomes of the 2013 and 2014 Annual Reviews for the DCM (submitted October 2013 and August 2014, respectively);
- consider the recommendations from the Department of Planning & Environment (DP&E) Compliance Audit completed on 6 December 2013 and
- incorporate changes associated with the Duralie Open Pit Modification.

No significant changes have been made to this GWMP as a result of the 2013 or 2014 Annual Reviews or DP&E Compliance Audit.

1.3 SUITABLY QUALIFIED AND EXPERIENCED PERSONS

The DP&E as delegate for the Director-General, approved the appointment of Dr Noel Merrick (Heritage Computing Pty Ltd [now HydroSimulations Pty Ltd]) as a suitably qualified and experienced person for the preparation of the WAMP on 18 February 2011.

The GWMP was previously prepared/reviewed by Dr Noel Merrick.

The Interface Investigation Program – Waste Emplacement and Alluvium (Attachment F) was also prepared by Dr Noel Merrick.

1.4 STRUCTURE OF THE GWMP

The remainder of the GWMP is structured as follows:

- | | |
|-------------|--|
| Section 2: | Outlines the statutory requirements applicable to the GWMP. |
| Section 3: | Describes the existing groundwater conditions, including groundwater use. |
| Section 4: | Provides detailed baseline data. |
| Section 5: | Provides summary of predicted groundwater impacts and provides processes to validate the DCM groundwater model and further calibrate the model to site specific conditions. |
| Section 6: | Describes the monitoring programs. |
| Section 7: | Details the measures and indicators that will be used to assess the performance of the Duralie Extension Project (incorporating the Open Pit Modification) in relation to groundwater. |
| Section 8: | Describes the groundwater contingency plan. |
| Section 9: | Describes the review and improvement of the environmental performance process. |
| Section 10: | Describes the management and reporting of incidents, complaints and non-compliances. |
| Section 11: | Lists the references cited. |

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

- (i) the conditions of the NSW Project Approval (08_0203);
- (ii) the conditions of the Commonwealth Approval (2010/5396);
- (iii) relevant licences and permits, including conditions attached to mining leases; and
- (iv) other relevant legislation.

These are described below.

2.1 EP&A ACT APPROVAL

Groundwater Management Plan

This GWMP has been prepared in accordance with Condition 29(c), Schedule 3 of the NSW Project Approval (08_0203). Table 1 indicates where each component of Condition 29 is addressed within this GWMP.

Table 1
Groundwater Management Plan Requirements

NSW Project Approval (08_0203) Condition	GWMP Section
<p>Condition 29, Schedule 3</p> <p>29. The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Director-General. This plan must be prepared in consultation with OEH and NOW by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval.</p> <p>In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:</p> <p>...</p> <p>c) a Groundwater Management Plan, which includes:</p> <ul style="list-style-type: none"> • groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts; • a program to monitor: <ul style="list-style-type: none"> – groundwater inflows to the open cut mining operations; – the impact of the project on: <ul style="list-style-type: none"> ○ the alluvial aquifers including investigating the potential for direct interface between mine spoil and alluvium and assessment of any consequential impact on alluvial and surface water; ○ base flows to Mammy Johnsons River; ○ any groundwater bores on privately-owned land; and – the seepage/leachate from water storages or backfilled voids on site; and • a program to validate the groundwater model for the project, and calibrate it to site specific conditions; and • a plan to respond to any exceedences of the performance criteria, including, <ul style="list-style-type: none"> – if a direct interface between mine spoil and alluvium is identified, development of a trigger action response plan (TARP) for potential salinity impacts on alluvial and surface water sources; and – a plan to offset the loss of any base flow to Mammy Johnsons River caused by the project. 	<p>Section 7</p> <p>Section 6</p> <p>Section 6.1</p> <p>Section 6.2</p> <p>Section 6.3</p> <p>Section 6.4</p> <p>Section 6.5</p> <p>Section 5.2</p> <p>Sections 7 and 8</p>

In accordance with Condition 29, Schedule 3 of the NSW Project Approval (08_0203), this GWMP is included as part of the WAMP for the DCM (i.e. Appendix 3 of the WAMP).

Of relevance to this GWMP, Condition 26, Schedule 3 of the NSW Project Approval (08_0203) requires:

26. *The Proponent shall offset the loss of any base flow to Mammy Johnsons River. This condition does not apply if the Secretary determines this loss to be negligible.*

Condition 27, Schedule 3 of the NSW Project Approval (08_0203) requires:

27. *The Proponent shall provide compensatory water supply to any landowner of privately-owned land whose water licence entitlements are impacted (other than an impact that is negligible) as a result of the project, in consultation with NOW, and to the satisfaction of the Secretary.*

The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent to the loss attributed to the project. Equivalent water supply must be provided (at least on an interim basis) within 24 hours of the loss being identified.

If the Proponent and the landowner cannot agree on the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Secretary for resolution.

If the Proponent is unable to provide an alternative long-term supply of water, then the Proponent shall provide alternative compensation to the satisfaction of the Secretary.

Sections 7 and 8 provide response plans to offset the loss of any baseflows to Mammy Johnsons River and provide compensatory water supply to any landowner of privately-owned land whose water licence entitlements are impacted (other than an impact that is negligible) as a result of the Duralie Extension Project (incorporating the Open Pit Modification).

Management Plan Requirements

In addition, Condition 2, Schedule 5 of the NSW Project Approval (08_0203), outlines the requirements that are applicable to the preparation of the management plans. The WAMP indicates where each component of the conditions is addressed within the plans under the WAMP (including this GWMP). Table 2 indicates where each relevant component is addressed within this GWMP.

Table 2
Management Plan Requirements

NSW Project Approval (08_0203) Condition	GWMP Section
Condition 2, Schedule 5 2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include: <ul style="list-style-type: none"> a) detailed baseline data; b) a description of: <ul style="list-style-type: none"> • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures; 	Sections 3 and 4 Section 2 Section 7 Section 7

Table 2 (Continued)
Management Plan Requirements

NSW Project Approval (08_0203) Condition	GWMP Section
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 5, 6, 7 and 8
d) a program to monitor and report on the: <ul style="list-style-type: none"> impacts and environmental performance of the project; effectiveness of any management measures (see c above); 	Sections 6, 9 and 10
e) a contingency plan to manage any unpredicted impacts and their consequences;	Sections 7, 8 and Appendix A
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 5, 9 and 10
g) a protocol for managing and reporting any; <ul style="list-style-type: none"> incidents; complaints; non-compliances with statutory requirements; and exceedances of the impact assessment criteria and/or performance criteria; and 	Refer to Section 10 and the PIRMP Refer to Section 10 and EMS Refer to Section 10 and EMS Section 7 and 8
h) a protocol for periodic review of the plan.	Section 9

2.2 EPBC ACT APPROVAL

Condition 11 of the Commonwealth Approval (2010/5396) requires:

Mitigation Measures

11. *In order to minimise the impacts of the project on listed threatened species, the person taking the action must implement all measures in the following plans/documents or their subsequent revisions as approved by the Minister:*
- (a) *The DCM Vegetation Clearance Protocol (DCPL, 2002);*
 - (b) *The DCM Irrigation Management Plan (DCPL, 2008);*
 - (c) *The DCM Site Water Management Plan (DCPL, 2008); and*
 - (d) *The DCM Rehabilitation Management Plan (DCPL, 2007).*

In accordance with Conditions 3 and 11 of the Commonwealth Approval (2010/5396), the WAMP (including this GWMP) will be submitted for approval by the Commonwealth Minister for the Environment (or delegate) in consultation with DP&E, the NSW Office of Environment and Heritage (OEH) and the NSW Office of Water (NOW).

2.3 GROUNDWATER LICENCE

Consistent with Condition 4 of Groundwater Licence – Duralie Coal Open Cut (20BL168404) issued under Part 5 of the NSW *Water Act, 1912* by the Department of Land and Water Conservation (now NOW) in September 2002 (renewed September 2012), DCPL have developed a Groundwater Monitoring and Contingency Plan using the template provided by NOW (Attachment A).

2.4 LICENCES, PERMITS AND LEASES

In addition to the NSW Project Approval (08_0203), and Commonwealth Approval (2010/5396), all activities at DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

A summary of the key licences, permits and leases pertaining to the DCM is provided in Section 2.3 of the WAMP. The WAMP is available on the Duralie Coal website (www.duraliecoal.com.au).

2.5 OTHER LEGISLATION

DCPL will operate the DCM consistent with the NSW Project Approval (08_0203), the Commonwealth Approval (2010/5396) and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

A summary of other NSW legislation that may be applicable to the conduct of the DCM is provided in Section 2.4 of the WAMP.

3 EXISTING GROUNDWATER CONDITIONS

The various sedimentary rocks in the DCM area have low permeability due to their fine grained nature, the predominance of cemented lithic sandstones and the common occurrence of a clayey matrix in the sandstones and conglomerates (HydroSimulations, 2014). The permeability of the aquifer system is therefore related to the spacing of fissures, the degree of opening of individual fissures and the permeabilities of the coal seams. Permeability of the aquifer generally decreases with depth as the fissures tighten and become less frequent, however, relatively higher permeabilities are encountered in the coal seams (HydroSimulations, 2014).

A conceptual model of the hydrogeological regime was developed by HydroSimulations (2014) based on review of the available hydrogeological data. The data supports two groundwater systems including (HydroSimulations, 2014):

- shallow groundwater system – associated with alluvium and regolith; and
- deeper groundwater system, including:
 - the Weismantel and Clareval coal seams; and
 - low permeability/disconnected fractured rock/coal measures of the Mammy Johnsons, Weismantels and Durallie Road Formations (Figure 3).

Alluvial deposits are associated with Mammy Johnsons River to the east of the DCM area (Figure 3). The alluvium consists of silty sands and silts with lenses of gravelly sands and sandy, coarse gravel with an average thickness of approximately 9 m (HydroSimulations, 2014).

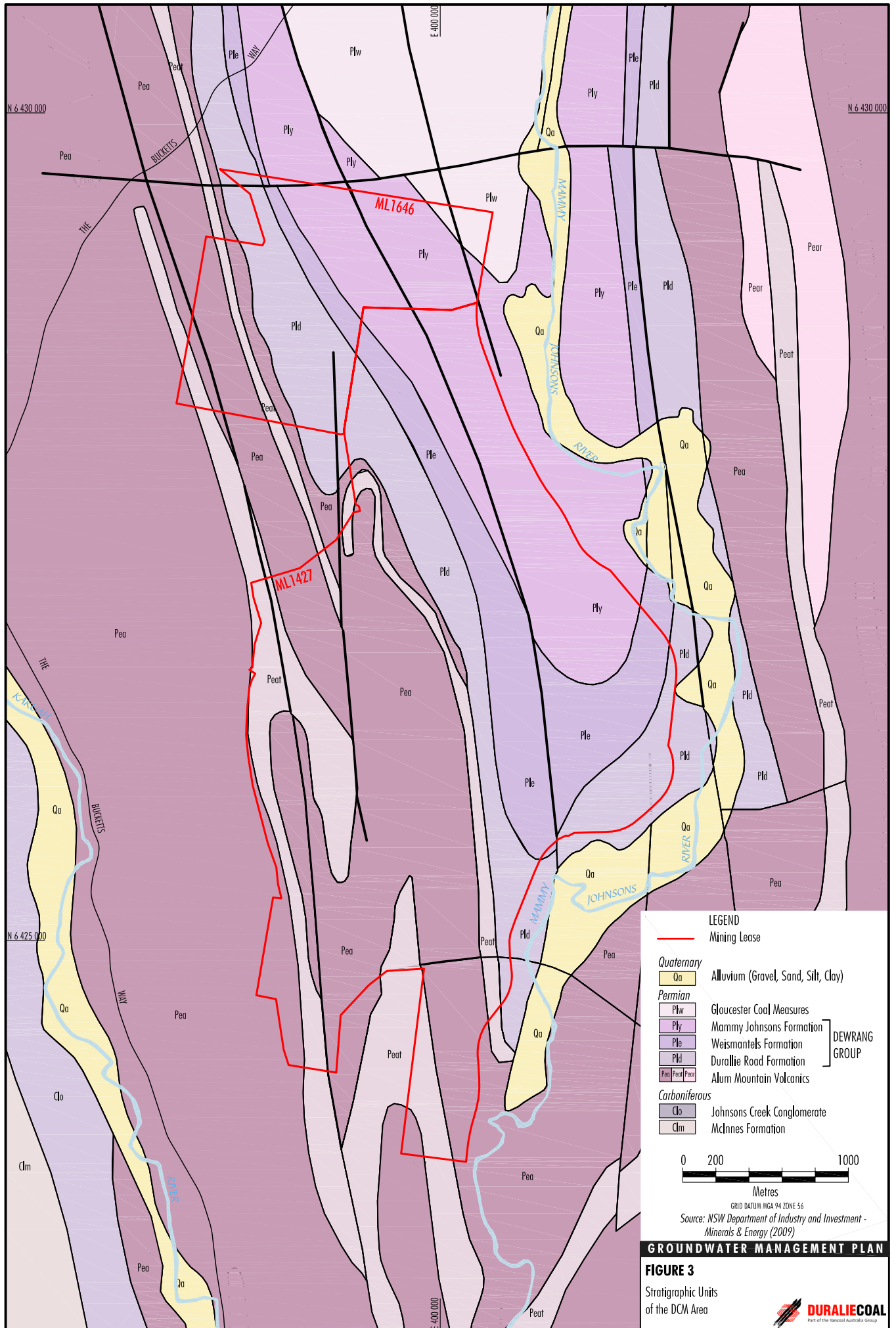
Recharge to the groundwater system is from rainfall and from lateral groundwater flow at the boundaries of the study area. Although groundwater levels are sustained by rainfall infiltration, they are controlled by topography, geology and surface water levels. Local groundwater mounds develop beneath hills and ridgelines. Groundwater moves from these higher elevations toward incised creeks and waterbodies. Groundwater is also lost to evapotranspiration through outcropping sandstone/shales and vegetation where the watertable is within a few metres of the ground surface (HydroSimulations, 2014).

During short events of high surface flow, streams can lose water to the aquifers that host the streams (i.e. leakage), but during recession, the aquifer would discharge water slowly back into the stream from bank storage and slow drainage from the surrounding rock strata (i.e. baseflow) (HydroSimulations, 2014). Baseflow is caused by slow drainage of groundwater from the surrounding rock strata or alluvium. In places where mining has occurred, groundwater discharge is expected to occur to the mined pit in proportion to local permeabilities (HydroSimulations, 2014).

Groundwater recharge is focused into the coal seams where the seams subcrop or outcrop (HydroSimulations, 2014). The deeper groundwater system is of low to very low permeability. The Weismantel and Clareval coal seams are the more permeable layers of the deeper groundwater system.

3.1 GROUNDWATER USE

Groundwater use in the DCM area is predominantly related to mine dewatering at the DCM. The number of privately held bores in the DCM area and surrounds is low due to the high rainfall and subsequent high rates of runoff and widespread use of surface water storages.



LEGEND

— Mining Lease

Quaternary

Qa Alluvium (Gravel, Sand, Silt, Clay)

Permian

Plw Gloucester Coal Measures

Ply Mammy Johnsons Formation

Ple Weismantels Formation

Pld Durrallie Road Formation

Pea Alum Mountain Volcanics

Carboniferous

Clc Johnsons Creek Conglomerate

Clm McInnes Formation

DEWRANG GROUP

0 200 1000

Metres

GRID DATUM: NGA 94 ZONE 56

Source: NSW Department of Industry and Investment - Minerals & Energy (2009)

GROUNDWATER MANAGEMENT PLAN

FIGURE 3

Stratigraphic Units of the DCM Area

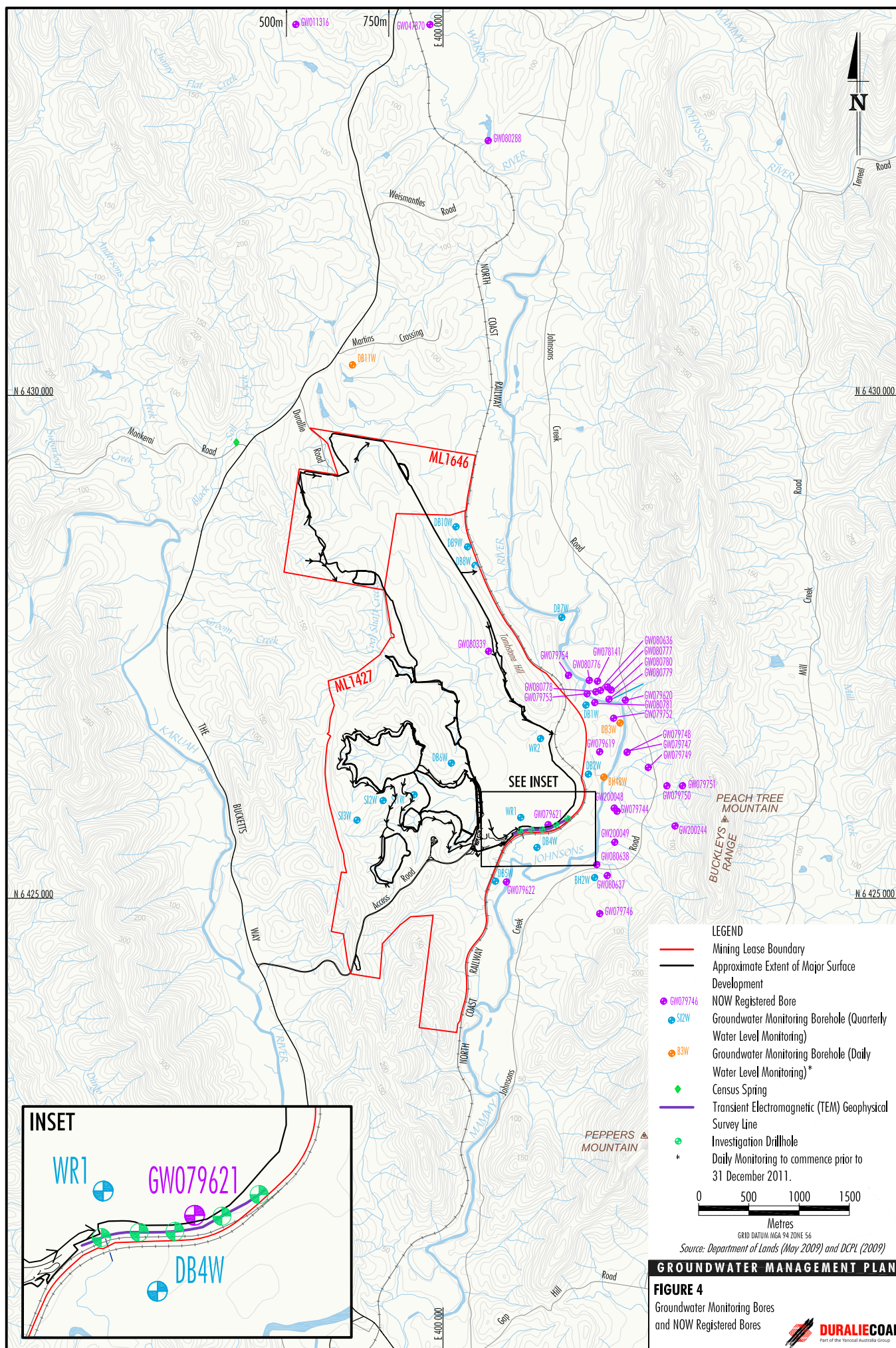
DURALIECOAL
Part of the Yancoal Australia Group

According to the NSW Pinnena bore database (2013), there are 37 registered bores in the within 5 km of the DCM, three of which are registered production bores (GW080288, GW047870, GW011316) located on privately owned land located at least approximately 3 km to the north of the DCM (Figure 4) (i.e. the remainder of the bores are on GCL-owned land). The licensed use of these bores is stock watering, irrigation and industrial applications.

Bore details for registered bores in the vicinity of the DCM are provided in Attachment B.

A supplementary bore census was undertaken by DCPL in October 2009 to locate any unregistered bores that may also be located on adjacent private properties and obtain additional data on the depth and use of local bores.

No unregistered bores were identified by the bore census, however one spring was recorded on privately owned land in the vicinity of the DCM in a drainage line in or near Black Soil Creek (Figure 4). The spring is located west of the groundwater divide described by Woodward-Clyde (1996), which lies to the west of the ridgeline that effectively screens the DCM from The Bucketts Way (Figure 4).



4 BASELINE DATA

4.1 HYDROGEOLOGICAL DATA

A detailed description of baseline hydrogeological data is provided in the *Duralie Extension Project Groundwater Assessment* (Heritage Computing, 2009) and *Duralie Coal Mine Extension Project Modification Groundwater Assessment* (HydroSimulations, 2014) which is available on the Duralie Coal website (www.duraliecoal.com.au).

4.2 GROUNDWATER QUALITY MONITORING DATA

A detailed description of baseline groundwater quality is provided in the *Duralie Extension Project Groundwater Assessment* (Heritage Computing, 2009) and *Duralie Coal Mine Extension Project Modification Groundwater Assessment* (HydroSimulations, 2014) which is available on the Duralie Coal website (www.duraliecoal.com.au).

4.3 METEOROLOGICAL MONITORING DATA

A summary of relevant meteorological information in the DCM area is provided in *Duralie Extension Project Groundwater Assessment* (Heritage Computing, 2009) and *Duralie Coal Mine Extension Project Modification Groundwater Assessment* (HydroSimulations, 2014) which is available on the Duralie Coal website (www.duraliecoal.com.au).

5 GROUNDWATER PREDICTIONS AND VALIDATION PROCESS

5.1 GROUNDWATER MODEL PREDICTIONS

A numerical groundwater model developed by HydroSimulations (2014) was used to simulate the potential impacts of the Duralie Extension Project (incorporating the Open Pit Modification) on the local aquifer systems and to estimate the potential quantity of groundwater inflow to the open pits. A summary of the potential impacts on local groundwater aquifers, surface water resources (i.e. Mammy Johnsons River) and on existing groundwater users is presented below.

Shallow (Alluvial) Groundwater System

The analysis of the conceptual groundwater system and modelling results supports the assessment that the shallow alluvial groundwater system in which the Mammy Johnsons River sits, is hydraulically disconnected from the deeper groundwater system. Dewatering of the deeper groundwater system by mining is predicted not to affect the shallow alluvial groundwater system (HydroSimulations, 2014).

Predicted changes in baseflow and natural river leakage as a result of the Duralie Extension Project (incorporating the Open Pit Modification) were modelled by HydroSimulations (2014) for the Mammy Johnsons River. River-aquifer exchanges were compared for transient simulations with and without mining.

The numerical modelling demonstrated that negligible impact on stream baseflow and natural river leakage from the Mammy Johnsons River to the deeper groundwater system is predicted to occur due to drawdown in the deeper system caused by the Duralie Extension Project (incorporating the Open Pit Modification) (HydroSimulations, 2014). The modelling results show that the maximum predicted reduction in groundwater baseflow and river leakage is 0.00005 megalitres per day per square kilometre (ML/day/km², equivalent to mm/day) in the Mammy Johnsons River when the size of the catchment is taken into consideration.

This loss of water is anticipated to be immeasurable and ‘negligible’ as defined in the NSW Project Approval (08_0203), that is *small and unimportant, such as to be not worth considering*.

Deeper Groundwater System

The deeper groundwater system would be partially dewatered/depressurised by the Duralie Extension Project (incorporating the Open Pit Modification). The results of the numerical groundwater model indicate that groundwater flow would move toward the open pit as mining progresses. The numerical model shows substantial reduction in potentiometric head in the aquifers of the deeper groundwater system to the east and north of the DCM area (HydroSimulations, 2014). The numerical model also shows negligible impacts on surface stream baseflows (HydroSimulations, 2014).

The numerical model indicates inflows to the open pits would range from approximately 204 megalitres per annum (ML/annum) to 252 ML/annum over the five years of mining and final pit inflows would equilibrate in the order of 0.1 ML/day at the completion of mining (HydroSimulations, 2014).

Numerical modelling of the post-mining groundwater levels shows slow but complete recovery of the groundwater system over many decades and that the Clareval void, once filled with water, would act as a sink, while the Weismantel void lake would act as a flow-through lake system. To the east of the mine, groundwater flow is expected to be restored to a dominant easterly direction. At the mine itself, the spoil infill would encourage preferential flow in south-southeast direction (HydroSimulations, 2014).

Because the Clareval void will act as a hydraulic sink, any changes in water quality within that will not result in noticeable changes to water quality in surrounding areas. However the Weismantel void lake will act as a flow through system, with the predominant groundwater flow toward the south and south-east, and so there may be an increase in the salinity within the fractured rock and coal measures in this direction (HydroSimulations, 2014).

Surface Water Resources

HydroSimulations (2014) concluded that the coal seams and the alluvium of the Mammy Johnsons River are hydraulically disconnected. Numerical modelling indicates that there would be negligible effect on water levels in the alluvials of the Mammy Johnsons River, on river leakage or on groundwater contribution to baseflow as a result of the Duralie Extension Project (incorporating the Open Pit Modification) (HydroSimulations, 2014).

The spring identified during the bore census is located west of the groundwater divide, which lies to the west of the ridgeline that effectively screens the DCM from The Bucketts Way (HydroSimulations, 2014). HydroSimulations (2014) concluded that the spring is unlikely to be affected by the Duralie Extension Project (incorporating the Open Pit Modification).

Given the localised disturbance of open pit mining, and the negligible effects on river leakage, baseflow and groundwater quality, inconsequential effects on the Mammy Johnsons River are anticipated (HydroSimulations, 2014).

Registered Production Bores

Depressurisation in the deeper groundwater system as a result of the development of the open pits would be naturally limited to the east, west and south by outcropping volcanics (HydroSimulations, 2014). Depressurisation in the aquifers of the deeper groundwater system is therefore expected to propagate only to the north (HydroSimulations, 2014). Attachment C shows the drawdown magnitude and pattern for the Weismantel Seam and Clareval Seam.

Three relatively shallow (<60 m depth) private production bores are located to the north of the DCM area. The maximum predicted drawdown in the Weismantel coal seam varies from 4 to 7 m at the three bores, but the potentiometric level would remain close to ground level (HydroSimulations, 2014). Therefore, the predicted drawdown in the water level in each bore is expected to be negligible (HydroSimulations, 2014).

5.2 GROUNDWATER MODEL VERIFICATION AND REFINEMENT

The numerical model developed by HydroSimulations (2014) as part of the groundwater assessment for the Duralie Open Pit Modification would be used as a management tool for the review and calibration of the prediction of groundwater impacts throughout the DCM life.

The results of the groundwater monitoring program (Section 6) would inform progressive refinement of the numerical model. Revised outputs from the numerical model would be reported periodically over the life of the Duralie Coal Mine and used to inform the site water balance review as described in the Surface Water Management Plan (SWMP) (Appendix 2 of the WAMP).

In addition, core sampling and testing will be conducted during appropriate DCPL drilling within the DCM area, where practicable, to determine aquifer properties within the natural rock strata (e.g. porosity and permeability). DCPL will create a database of testing data throughout the DCM area, which will be used to guide potential future groundwater assessments.

The results of the groundwater model verification and any model refinements will be reported in the Annual Review (Section 9.1).

In the event that actual groundwater drawdown levels exceed the predicted groundwater drawdown levels over the life of the DCM, the groundwater model will be further refined using any new data available to characterise the aquifer systems (Section 7). The groundwater model refinement process (if necessary) will be conducted in consultation with the NOW.

6 MONITORING PROGRAM

The following groundwater monitoring program has been developed in accordance with Condition 29 (c), Schedule 3 of the NSW Project Approval (08_0203). Table 3 provides a summary of the DCM groundwater monitoring program.

Table 3
Groundwater Monitoring Program

Monitoring Locations ¹		Frequency	Parameters
Open Cut Operations	• Open pit sump(s).	During pumping	• Volume of water extracted.
		Weekly	• Water level ² , pH, EC and Turbidity.
		Monthly	• Total Acidity, Total Alkalinity, Total Suspended Solids (TSS), Chloride, Sulphate (SO ₄), Calcium, Magnesium, Aluminium, Iron, Manganese, Zinc.
Mammy Johnsons River	• DB3W, BH4BW (Alluvium).	Daily	• Water level.
		Quarterly	• pH, EC, dissolved oxygen, Total Dissolved Solids (TDS), Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.
	• DB1W, DB2W, DB4W, DB5W, DB7W, DB9W, DB10W (Deeper Groundwater).	Quarterly	• Water level, pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.
	• DB8W (Deeper Groundwater)	Quarterly	• Water level.
	• DB11W (Deeper Groundwater).	Daily	• Water level.
		Quarterly	• pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.
Coal Shaft Creek	• DB6W, SI1W, SI2W, SI3W (Deeper Groundwater).	Quarterly	• Water level, pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.
In-pit Waste Rock Emplacement	• WR1, WR2.	Daily	• Water level.
		Quarterly	• pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.

¹ Monitoring locations are shown on Figure 4.

² Visual observation of sump level. Sumps are generally kept at a minimum for operations.

Monitoring bores have and will continue to be constructed in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (Land and Water Biodiversity Committee, 2003) by an appropriately qualified water bore driller. Bore licences have been and will continue to be obtained from the NOW prior to installation of any new monitoring bores.

A summary of the characteristics of the existing groundwater monitoring bores is provided in Table 4.

Table 4
Groundwater Monitoring Bore Characteristics

Bore	RL (mAHD) (Collar)	RL (mAHD) (Ground)	Date Drilled	Depth (m)	Screen (m)	Formation
DB1W	62.8	62.3	11/2002	36.5	17.5-36.5	Upper Durallie Road Formation
DB2W	63.8	63.3	11/2002	60	40-60	Upper Durallie Road Formation
DB3W	53.5	52.9	01/2003	5.8	4.0-5.5	Alluvium
DB4W	54.1	53.6	11/2002	40	25-40	Upper Durallie Road Formation
DB5W	56.0	55.5	11/2002	40	30-40	Upper Durallie Road Formation
DB6W	93.9	93.5	11/2002	40	25-40	Upper Durallie Road Formation
DB7W	70.5	70	11/2007	15.5	12.5-15.5	Mammy Johnsons Formation
DB8W	-	78	10/2008	51	-	Mammy Johnsons Formation
DB9W	-	75	10/2008	50	44-50	Mammy Johnsons Formation
DB10W	-	75	10/2008	34	28-34	Mammy Johnsons Formation
BH4BW	53.7	53.1	01/2003	5.8	4.3-5.8	Alluvium
SI1W	83.4	82.5	01/2004	16.4	13.4-16.4	Lower Durallie Road Formation
SI2W	108.6	107.7	02/2004	35.7	32.7-35.7	Lower Durallie Road Formation
SI3W	124.2	123.3	01/2004	28.2	25.2-28.2	Lower Durallie Road Formation
WR1	- [#]	- [#]	03/09/2013	77	71-77	Waste Emplacement
WR2	- [#]	- [#]	03/09/2013	20	14-20	Waste Emplacement
DB11W	- [#]	- [#]	03/09/2013	50	38-50	Waukivory Creek Formation

[#] Elevation to be included in next revision of the GWMP once survey has been completed.

Groundwater monitoring, water level measurements and sample collection, storage and transportation are undertaken in accordance with the procedures outlined in the *Murray Darling Basin Groundwater Quality Sampling Guidelines* (Murray Darling Basin Commission, 1997). A copy of the guidelines is provided in Attachment D.

Analysis is undertaken by a laboratory which has been accredited by the National Association of Testing Authorities, Australia (NATA) to undertake testing for the parameters being determined. Field testing is undertaken using field equipment that is well maintained and calibrated in accordance with the manufacturer's recommendations.

Data collected by the GWMP will: enable verification and refinement (where necessary) of the groundwater modelling results presented in HydroSimulations (2014); be used in the continued development of groundwater impact assessment criteria and investigation triggers (Section 7); and provide input to annual reviews of groundwater monitoring data (Section 9).

The independent environmental audit (Trevor Brown & Associates, 2011) concluded that the monitoring program (including groundwater) was '*considered adequate to provide data for assessment of the Duralie operations in relation to the MCoA [Minister's Conditions of Approval] and EPL requirements and to assess consistency with the predictions in the EIS, Environmental Assessments and Statements of Environmental Effects.*'

6.1 GROUNDWATER INFLOWS TO OPEN CUT MINING OPERATIONS

Groundwater seepage and surface water runoff will collect in pit sumps. Water level¹, pH, EC and turbidity of the collected water will be monitored on a weekly basis², with more comprehensive water quality analysis undertaken on a monthly basis. The volumes of water extracted from the pit sumps will also be recorded. Maintenance of the device used to measure the volume of water extracted from the pit sumps will continue to be undertaken in a manner which is acceptable to NOW.

A site water balance review will be undertaken on an annual basis to monitor the status of inflows (including groundwater inflows to open pits), storage and consumption. The site water balance review will be used to optimise water management performance and will enable corrective actions to be implemented, if required (as described in the SWMP [Appendix 2 of the WAMP]). The results of the water balance reviews will be reported in the Annual Review (Section 9.1).

6.2 ALLUVIAL AQUIFERS

Two alluvium bores will be monitored in the vicinity of Mammy Johnsons River (i.e. DB3W and BH4BW) (Figure 4). Alluvium bores are equipped to measure water level daily. Field pH, field EC, and field dissolved oxygen will be monitored on a quarterly basis. Laboratory analyses for TDS, total acidity, total alkalinity, chloride, sulphate, calcium, magnesium, sodium, aluminium, iron, manganese and zinc, will also be undertaken quarterly.

To address the requirements of Condition 29(c), Schedule 3 of the Project Approval (08_0203) which requires a program to investigate the potential for direct interface between mine spoil and alluvium and an assessment of any consequential impact on alluvial and surface water, DCPL commissioned Dr Noel Merrick (HydroSimulations) to prepare the Interface Investigation Program – Waste Emplacement and Alluvium (Attachment F),

In accordance with the recommendations of this report, DCPL will conduct an investigation program which will include three stages (Attachment F):

- investigation;
- monitoring; and
- analysis.

These phases are discussed further below.

Investigation

The investigation phase of the program will include (Attachment F):

- Transient Electromagnetic (TEM) geophysical survey along one transect along or near the southern boundary of ML 1427 (Figure 4).
- Drilling and logging of up to five holes at regular (100 to 150 m) intervals along the TEM transect (selected based on the results of TEM and drilling results).
- Installation of up to two shallow monitoring bores at the most appropriate drillhole sites (selected based on the results of TEM and drilling results).

¹ Visual observation of sump level. Sumps are generally kept at a minimum for operations.

² Subject to safe access to the pit sumps.

Monitoring

The monitoring program for the additional monitoring bore(s) is outlined in Table 5.

Table 5
Additional Monitoring Program

Location	Frequency	Parameter
Additional monitoring bore(s)	Continuously*	Water level
	Quarterly	pH, EC, DO, temperature
	Quarterly	pH, reduction potential (Eh), EC, major cations, major anions and metals

* Continuous monitoring would be undertaken for a period of two years (i.e. up to July 2017) and quarterly thereafter.

Analysis

The following information will be analysed to inform the potential of any interface between mine spoil and alluvium (Attachment F):

- degree of saturation of any alluvium or unconsolidated deposits;
- direction of any discernible shallow groundwater gradient, based on:
 - water levels in new monitoring bores;
 - local surveyed Mammy Johnsons River bed level and High Noon Gauging Station records; and
 - groundwater levels in existing monitoring bores BH4W, WR1 and DB4W.
- groundwater chemistry changes suggesting potential groundwater movement from the overburden emplacement toward Mammy Johnsons River; and
- comparison of monitored water levels near the Coal Shaft Creek confluence with modelled results to verify the model.

6.3 CONNECTIVITY AND BASEFLOWS TO MAMMY JOHNSONS RIVER

The potential for any increase in connectivity between the Mammy Johnsons River and deeper groundwater systems will be monitored through monitoring of groundwater inflows to open pits (Section 6.1) and water levels in alluvium bores (Section 6.2). Flow monitoring will be undertaken as described in the SWMP (Appendix 2 of the WAMP).

In the unlikely event that groundwater inflows to open pits and water levels in alluvium bores indicate an increase in connectivity between the Mammy Johnsons River and deeper groundwater systems, DCPL monitoring at High Noon may be used in conjunction with data from the DCM automatic weather station (AWS) and NOW gauging station GS209002 (on the Mammy Johnsons River) to determine any potential impact on stream baseflow and/or natural river leakage from the Mammy Johnsons River to the deeper groundwater system (Section 7).

6.4 LANDHOLDER BORES AND DCPL MONITORING BORES

As described in Section 5.1, predicted drawdown as a result of the Duralie Extension Project (incorporating the Open Pit Modification) in the water levels in known privately-owned bores are expected to be negligible.

Groundwater monitoring will be undertaken at existing bores surrounding the DCM area at the request of relevant landholders. DCPL has contacted relevant landholders to inform them that their bores could be monitored if requested.

In addition, monitoring of DCPL bores (Table 3 and Figure 4) will be conducted on a regular basis (Table 2) to monitor groundwater levels and quality compared to groundwater model predictions.

6.5 WATER STORAGES AND BACKFILLED VOIDS – GROUNDWATER SEEPAGE

Monitoring bores WR1 and WR2 (Figure 4) monitor groundwater levels and quality within the waste rock emplacement to provide information on the recharge rates and spoil permeabilities and to validate modelling assumptions and predictions (Table 3). In addition, groundwater inflows to the open pits will be monitored as described in Section 6.1.

In addition, as described in the SWMP (Appendix 2 of the WAMP), water quality monitoring will be conducted in water storages, Coal Shaft Creek and Mammy Johnsons River to detect any anomalous changes in water quality that may be attributed to groundwater seepage.

7 ASSESSMENT OF PERFORMANCE INDICATORS AND MEASURES

In accordance with Condition 29 (c), Schedule 3 of NSW Project Approval (08_0203), DCPL has developed:

- performance measures (groundwater assessment criteria), including performance indicators (trigger levels) for investigating any potentially adverse groundwater impacts; and
- a plan to respond to any exceedances of the performance criteria, including:
 - development of a trigger action response plan (TARP) for potential salinity impacts on alluvial and surface water sources, in the event a direct interface between mine spoil and alluvium is identified; and
 - a plan to offset the loss of any base flow to Mammy Johnsons River caused by the Duralie Extension Project (incorporating the Open Pit Modification).

7.1 PERFORMANCE MEASURES

DCPL will assess the Duralie Extension Project (incorporating the Open Pit Modification) against the groundwater performance indicators and measures outlined in Table 6.

Table 6
Summary of Groundwater Performance Indicators and Measures

Performance Measure	Performance Indicator(s)
No more than negligible ¹ impact on stream baseflow and/or natural river leakage of Mammy Johnsons River to the deeper groundwater system as a result of the Duralie Extension Project (incorporating the Open Pit Modification).	Groundwater inflows to open pits are consistent with Duralie Open Pit Modification Environmental Assessment (EA) predictions (refer Section 5.1 and Table 7).
	Groundwater levels in alluvium bores are consistent with Duralie Open Pit Modification EA predictions (accounting for temporal changes in rainfall recharge ²) (refer Section 5.1 and Table 7).
No more than negligible ¹ impact on water levels in groundwater production bores on privately-owned land as a result of the Duralie Extension Project (incorporating the Open Pit Modification).	No groundwater related complaints received (refer Table 7).

¹ Consistent with the NSW Project Approval (08_0203), the term 'negligible' is defined as "*small and unimportant, such as to be not worth considering*".

² Refer to Section 4.1.

Section 6 describes the monitoring that will be conducted to inform the assessment of the DCM against the performance indicators and measures for groundwater. The monitoring program includes the monitoring of:

- groundwater inflows to open cut mining operations (Section 6.1);
- water levels and quality of alluvial aquifers (Section 6.2);
- water levels and quality of alluvial aquifer investigation bores (Section 6.2)
- water levels and quality of DCPL monitoring bores (Section 6.4); and
- indicators of potential groundwater seepage from water storages and backfilled voids (Section 6.5).

The monitoring results will be used to assess the DCM against the performance indicators and performance measures as detailed in Table 7. If data analysis indicates a performance indicator has been exceeded or is likely to be exceeded, an assessment will be made against the performance measure. If a performance measure is considered to have been exceeded, the Contingency Plan will be implemented (Section 8). DCPL will implement suitable contingency measures (Section 8) and continue to monitor (Section 6). If data analysis indicates that the performance measure has not been exceeded, DCPL will continue to monitor.

7.2 TRIGGER ACTION RESPONSE PLAN (TARP)

In the event the investigation into alluvial connectivity outlined in Section 6.2 identifies a direct interface between mine spoil and alluvium, DCPL will develop a TARP to avoid potential salinity impacts on alluvial and surface water sources in accordance with Condition 29(c), Schedule 3 of Project Approval (08_0203). The TARP will be based on the conceptual TARP outlined in Table 7.

The TARP will be based on results of ongoing water quality sampling for pH and EC levels at the shallow monitoring bore(s) (developed as part of the investigation into alluvial connectivity [Section 6.2]), DCPL will develop three water quality trigger levels for these bore(s) in consultation with the NOW and DP&E. The proposed actions corresponding to each proposed trigger are outlined in Table 7.

Table 7
Conceptual Trigger Action Response Plan

Trigger		Action/Response
Level 1	pH and EC levels above Trigger Level 1	<ul style="list-style-type: none"> Detailed analysis of water quality sampling data to assess the likely source of such a result.
Level 2	pH and EC levels above Trigger Level 2	<ul style="list-style-type: none"> Detailed analysis of water quality sampling data to assess the likely source of such a result. Notification of NOW. Immediate sampling and laboratory analysis of pH, EC, Eh, cations, anions, and metals.
Level 3	pH and EC levels above Trigger Level 3	<ul style="list-style-type: none"> Notification of NOW. Consideration of actions to prevent further migration of plume with relative poor water quality (i.e. installation of new bore or pumping from existing bore to capture any plume).

Table 7
Monitoring Against Performance Indicators and Measures

Performance Measure	Monitoring of Environmental Consequences			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Assessment of Performance Indicator(s)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No more than negligible impact on stream baseflow and/or natural river leakage of the Mammy Johnsons River to the deeper groundwater system as a result of the Duralie Extension Project (incorporating the Open Pit Modification).	<ul style="list-style-type: none"> Open pit sump(s) Meteorological Station High Noon 	<ul style="list-style-type: none"> Volume of water extracted Rainfall Streamflow 	<ul style="list-style-type: none"> During pumping Daily Monthly/Event 	<ul style="list-style-type: none"> Analysis of water collected in pit sumps to calculate approximate groundwater inflows (i.e. by taking account of rainfall/runoff to the pit sumps) on an annual basis and comparison to predictions in the Duralie Open Pit Modification EA. 	<ul style="list-style-type: none"> Groundwater inflows to open pits are consistent with Duralie Open Pit Modification EA predictions. 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates that groundwater inflows to the open pits are greater than the predictions in the Duralie Open Pit Modification EA (i.e. outside the bounds of the sensitivity analysis, refer to Attachment E). If data analysis indicates the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a greater than negligible change in the stream baseflow and/or natural river leakage of Mammy Johnsons River caused by the Duralie Extension Project (incorporating the Open Pit Modification). 	<p>The performance measure is exceeded if:</p> <ul style="list-style-type: none"> Analysis of the monitoring and modelling results confirms that the Duralie Extension Project (incorporating the Open Pit Modification) has resulted in a greater than negligible change in the stream baseflow and/or natural river leakage of Mammy Johnsons River. The above analysis will include consideration of streamflow gaugings at High Noon and NOW gauging stations. The above analysis will also consider groundwater EC results from the groundwater monitoring program (Table 5). The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E and NOW. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 8). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Offsets – retirement of water entitlements.
	<ul style="list-style-type: none"> DB3W, BH4BW High Noon 	<ul style="list-style-type: none"> Water Level Streamflow 	<ul style="list-style-type: none"> Daily Monthly/Event 	<ul style="list-style-type: none"> Analysis of groundwater levels in alluvial bores on an annual basis. 	<ul style="list-style-type: none"> Groundwater levels in alluvium bores are consistent with Duralie Open Pit Modification EA predictions (accounting for temporal changes in rainfall recharge). 	<ul style="list-style-type: none"> The performance indicator will be considered to have been exceeded if data analysis indicates there has been a statistically significant reduction in groundwater levels in alluvial bores, specifically: <ul style="list-style-type: none"> if the sliding 7-day averages in water levels fall more than 2 standard deviations below the long-term (at least one year) average. If data analysis indicates the performance indicator has been exceeded, the performance measure will be assessed to determine if there has been a greater than negligible change in the stream baseflow and/or natural river leakage of Mammy Johnsons River caused by the Duralie Extension Project (incorporating the Open Pit Modification). 		
No more than negligible impact on water levels in groundwater production bores on privately-owned land as a result of the Duralie Extension Project (incorporating the Open Pit Modification).	<ul style="list-style-type: none"> N/A DB11W 	<ul style="list-style-type: none"> Complaints Water Level 	<ul style="list-style-type: none"> When received Daily 	<ul style="list-style-type: none"> Review of complaints register. 	<ul style="list-style-type: none"> No groundwater related complaints received. 	<ul style="list-style-type: none"> If a complaint is received, the performance measure will be assessed to determine if the Duralie Extension Project (incorporating the Open Pit Modification) has resulted in a greater than negligible change in water levels in groundwater production bores on privately-owned land 	<p>The performance measure is exceeded if:</p> <ul style="list-style-type: none"> Analysis of the monitoring and modelling results confirms that the Duralie Extension Project (incorporating the Open Pit Modification) has resulted in a greater than negligible change in water levels in groundwater production bores on privately-owned land. The above analysis will include consideration of monitoring results at DB11W. The above analysis will be peer reviewed by a specialist approved by the DP&E. The results will be reported to DP&E and NOW. If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 8). 	<ul style="list-style-type: none"> Additional monitoring (e.g. increase in monitoring frequency or additional sampling). Provision of equivalent water supply or compensation.

8 CONTINGENCY PLAN

In the event a performance measure detailed in Section 7 is considered to have been exceeded, DCPL will implement the following Contingency Plan:

- The Environmental Coordinator will immediately report the likely exceedance to the General Manager within 24 hours of assessment completion.
- DCPL will report the exceedance of the performance measure to the DP&E and NOW as soon as practicable after DCPL becomes aware of the exceedance.
- DCPL will identify an appropriate course of action (e.g. potential contingency measures described below) with respect to the identified impact(s), in consultation with specialists and DP&E and/or NOW, as necessary.
- DCPL will, on request, submit the proposed course of action to the DP&E for approval.
- DCPL will implement the approved course of action to the satisfaction of the DP&E.

DCPL holds two surface water licences on the Mammy Johnsons River, which have a total extraction allowance equivalent to 19 megalitres per annum. In the unlikely event that more than negligible losses are recorded, DCPL would use these licences as a contingency to account for any losses from the Mammy Johnsons River, and would retire adequate water entitlements to account for the loss calculated as attributable to the Duralie Extension Project (incorporating the Open Pit Modification).

Privately-owned Landholder Bores

If the performance measure is exceeded such that there is a more than negligible impact on water levels in groundwater production bores on privately-owned land as a result of the Duralie Extension Project (incorporating the Open Pit Modification), DCPL will investigate appropriate remedial measures which may include:

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

The exact nature of remedial measures will be determined in consultation with the affected landholder. Equivalent water supply will be provided (at least on an interim basis) within 24 hours of the loss being identified.

If an alternative water supply source is to be provided, it will be DCPL's responsibility to obtain a licence and pay for this source, in consultation with the relevant landholder(s). The nature of the source will depend on the location of the affected landholder and the availability of nearby sources.

If an alternative long-term water supply source is unable to be provided, DCPL may provide alternative compensation in consultation with the relevant landholder(s) and to the satisfaction of the Secretary of DP&E.

The nature of the measures implemented will be reported to NOW and DP&E. Where agreement cannot be reached on the measures to be implemented, DCPL may refer the matter to DP&E for resolution.

9 REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

9.1 ANNUAL REVIEW

In accordance with Condition 3, Schedule 5 of the NSW Project Approval (08_0203), DCPL conducted an Annual Review of the environmental performance of the DCM prior to the end of December 2011, and will annually thereafter. These will be made publicly available from the Duralie Coal website, in accordance with Condition 10, Schedule 5 of the NSW Project Approval (08_0203).

The Annual Review will specifically address the following aspects of Condition 3, Schedule 5 that are directly relevant to water management:

- include a summary of any new bores or pits constructed over the past year;
- include a comprehensive review of the monitoring results and complaints records for the DCM over the past year, including a comparison of these results against the:
 - relevant statutory requirements, limits or performance measures/criteria;
 - monitoring results of previous years; and
 - relevant predictions in the Duralie Open Pit Modification EA;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the DCM;
- identify any discrepancies between the predicted and actual impacts of the DCM, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the DCM.

This GWMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, as described in Section 9.2.

9.2 GWMP REVIEW

In accordance with Condition 4, Schedule 5 of the NSW Project Approval (08_0203), this GWMP will be reviewed and if necessary revised to the satisfaction of the Director-General of the DP&E, within three months of the submission of:

- an Annual Review, in accordance with Condition 3, Schedule 5;
- an Incident Report, in accordance with Condition 6, Schedule 5;
- an audit, in accordance with Condition 9, Schedule 5;
- any modification to the conditions of consent; or
- prior to the commencement of clearing in accordance with the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014).

This GWMP will also be reviewed and if necessary revised, if results of the groundwater monitoring programme indicate that refinement of the numerical groundwater model is required (Section 5.2).

This GWMP will be made publicly available on the Duralie Coal website in accordance with NSW Project Approval (08_0203). A hard copy of the GWMP will also be kept at the DCM.

9.3 INDEPENDENT WATER AUDIT

In accordance with Condition 7 of the Groundwater Licence – Duralie Coal Open Cut (20BL168404) issued under Part 5 of the NSW *Water Act, 1912*, DCPL will conduct an independent water audit prior to the end of DCPL's 5-year licence period (i.e. September 2017) and submitted to NOW as a comprehensive report. The audit will:

- be carried out in accordance with guidelines and general principles for environmental auditing and procedures for environment auditing approved by NOW;
- assess compliance with the requirements of Groundwater Licence 20BL168404, including the groundwater monitoring and contingency plan;
- review actual impacts of groundwater extractions on any aquifers, groundwater dependant ecosystems and any streams in the area;
- make comparisons between actual and predicted impacts (modelled results);
- provide recommendations as to works that ought to be performed or additional obligations that ought to be imposed in order to rectify any impacts on groundwater;
- be conducted by an independent certified auditor, nominated by DCPL and approved in advance by NOW; and
- be carried out at DCPL's expense.

10 REPORTING SYSTEMS

In accordance with Condition 2(g), Schedule 5 of the NSW Project Approval (08_0203), DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints; and
- non-compliances with statutory requirements.

The management of incidents is described in the Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the Environmental Management Strategy. Management and reporting of exceedances of impact assessment criteria and/or performance criteria are described in Sections 7 and 8.

11 REFERENCES

- Heritage Computing (2009) *Duralie Extension Project Groundwater Assessment*. Appendix B of Duralie Coal Pty Ltd (2010) *Duralie Extension Project Environmental Assessment*.
- HydroSimulations (2014) *Duralie Coal Mine Extension Project Modification – Groundwater Assessment*. Appendix C of Yancoal (2014) *Duralie Open Pit Modification Environmental Assessment*.
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ATTACHMENT A

GROUNDWATER MONITORING AND CONTINGENCY PLAN

Groundwater Monitoring and Contingency Plan																					
Water Level and Quality																					
Alluvial Groundwater Monitoring - (Shallow Bores)																					
Bore Description	Licence Number	Type of bore (e.g. monitoring or production)	Location Description	Property Id Lot/DP	Coordinates (GPS)		Monitoring Target/s	Monitoring Effect of - e.g. Natural and any Pumping-Induced Water Level Changes.	Height (mAHD)	Depth (m)	Monitoring Depth/s	Sampling Frequency, e.g. Dedicated water level loggers, measurements at hourly intervals. Field EC, pH, DO weekly for first month then review whether monthly to be adopted. Bore marked * have telemetry facilities rather than data loggers	Sampling Parameters, e.g. SWL, field testing EC, pH, DO. Laboratory analysis of TDS and major anions and cations.	Frequency of Data Download, e.g. Weekly with field chemistry for the first month then review whether monthly frequency may be adopted. Retain weekly until reviewed.	Trigger Value or level indicating potential impact, Gradual reduction in water level or dramatic decline. Relevance or otherwise to be determined by monitoring prior to pumping after a rain fall event to assess if a water level is ever present.			Action Required Assess data, establish trends and relate to pumping regimes and climatic data. Also report in Contingency worksheet.	Any follow up actions Progressive assessment of trends with prediction of any potential impacts. Determine whether the changes due to impacts from pumping, if so modify the pumping schedule so that impact is removed.	Additional reporting to Office of Water, If agreed trigger parameters exceed , further reporting on parameters @ month 1, 2, 3 & 6	
					Easting	Northing									Level*	pH	EC				
DB3W	20BL168404	Monitoring	See Figure 1	Lot 125 DP 95694	401762	6426743	Water Quality and Drawdown Gradient	Natural and pumping-induced water level changes and groundwater quality	53.5	5.8	4.0-5.5	Daily	Water Level	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends	Progressive assessment of trends to determine causes and predict potential impacts	Quarterly reporting of Trigger Level Exceedances to NOW	
												Quarterly	pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO4, Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly							
BH4BW	20BL168404	Monitoring	See Figure 1	Lot 126 DP 95695	401600	6426205	Water Quality and Drawdown Gradient	Natural and pumping-induced water level changes and groundwater quality	53.7	5.8	4.3-5.8	Daily	Water Level	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends	Progressive assessment of trends to determine causes and predict potential impacts	Quarterly reporting of Trigger Level Exceedances to NOW	
												Quarterly	pH, EC, dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO4, Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly							

Groundwater Monitoring and Contingency Plan

Metered pumps

Mine Pits - water quantity and quality														
Pit	Licence Number	Location Description	Property Id Lot/DP	Coordinates (GPS)	Monitoring Target/s, e.g. water quantity	Monitoring Effect of, e.g. Natural and any Pumping-Induced Water Level Changes.	Monitoring Points	Measuring Device Meter	Annual set water budget, Volume in KL	Frequency of Data Download, e.g. Weekly with field chemistry, including parameters pH, etc	Trigger Value or level indicating potential impact, Gradual reduction in water level or dramatic decline. Relevance or otherwise to be determined by monitoring prior to pumping after a rain fall event to assess if a water level is ever present.	Action Required. Calculate volume of groundwater extraction, variation in water quality. Also report in Contingency worksheet.	Any follow up actions, Monitor the volume against the annual set water budget volume	Additional reporting to Office of Water, If agreed, trigger parameters exceed, further reporting on parameters on quarterly (3-months) basis
Weismantel	20BL168404	Weismantel Pit	Lot 22 DP 95765	N/A	Water Quantity	Pumping-Induced Water Level Changes	Discharge End	Dopler Electromagnetic Flow Meter	300000	Real-time	300 ML	Calculate level of Groundwater Extraction	Monitor volume against Annual Set Water Budget	Quarterly reporting of Budget Exceedances to NOW
Clareval	20BL168404	Clareval Pit	Lot 1 DP 595876	N/A	Water Quantity	Pumping-Induced Water Level Changes	Pump	Pump rates	N/A	Weekly	N/A	Calculate level of Groundwater Extraction	Monitor volume against Annual Set Water Budget	Quarterly reporting of Budget Exceedances to NOW

Hard Rock Groundwater Monitoring (Monitoring/Dewatering/ Production Bores)

Bore Description (see note)	Licence Number	Location Description	Property Id Lot/DP	Coordinates (GPS)		Monitoring Target/s, e.g. Water Quality plus Drawdown gradient	Monitoring Effect of, e.g. Pumping at Design Flow Rates and investigate a number of pumping arrangements to determine sensitivities	Height (mAHD)	Depth (m)	Monitoring Depth/s	Sampling Frequency, e.g. Telemetry Used to record water level - Baseline then weekly water quality sampling individual bore and testing for first month then monthly thereafter on a composite basis. *Bore 9 has chemical testing only - not equipped for water level data collection	Sampling Parameters, e.g. Field testing EC, pH, DO, Laboratory analysis of TDS and major anions and cations for each bore, Monitor for Hydrocarbons at No.11	Frequency of Data Download, e.g. Monthly with field chemistry for the first month then review whether quarterly frequency may be adopted. Retain monthly until reviewed.	Trigger Value or level indicating potential impact, e.g. Excessive level of contamination, isolate bore ASAP, increase sampling frequency			Action Required Assess data, establish trends and relate to pumping regimes and climatic data. Also report in Contingency worksheet.	Any follow up actions - Progressive assessment of trends with prediction of any potential impacts. Determine whether the changes due to impacts from pumping, if so modify the pumping schedule so that impact is removed. Increased frequency on monitoring as required	Additional reporting to Office of Water, If agreed trigger parameters exceed, further reporting on parameters on quarterly (3- months) basis
				Easting	Northing									Water Level	pH	EC			
DB1W	20BL168404	See Figure 1	Lot 125 DP 95694	401423	6426922	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	62.8	36.5	17.5-36.5	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB2W	20BL168404	See Figure 1	Lot 126 DP 95695	401447	6426235	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	63.8	5.8	4.0-5.5	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB4W	20BL168404	See Figure 1	Lot 130 DP 95768	400936	6425505	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	54.1	40	25-40	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB5W	20BL168404	See Figure 1	Lot C DP 160430	400522	6425170	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	56	40	30-40	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB6W	20BL168404	See Figure 1	Lot 6 DP 876013	400083	6426345	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	93.9	40	25-40	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB7W	20BL168404	See Figure 1	Lot 636 DP 95742	401183	6427793	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	70.5	15.5	12.5-15.5	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB8W	20BL168404	See Figure 1	Lot 30 DP 95765	400245	6428495	Drawdown	Natural and pumping-induced water level changes	78	51	Equal to Water Level	Quarterly	Water Level	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	N/A	N/A	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB9W	20BL168404	See Figure 1	Lot 30 DP 95765	400321	6428310	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	75	50	44-50	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB10W	20BL168404	See Figure 1	Lot 30 DP 95765	400130	6428694	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	75	34	28-34	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
DB11W	20BL168404	See Indicative Location onFigure 1	Lot 9 DP 804536	399176.0441 (Indicative)	6430350.1351 (Indicative)	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	To be confirmed once drilled.			Daily	Water Level	Quarterly	TBC	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Assess data and establish trends.	Assess data and establish trends.
SI1W	20BL168404	See Figure 1	Lot C DP 160430	399713	6426029	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	83.4	16.4	13.4-16.4	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
SI2W	20BL168404	See Figure 1	Lot C DP 160430	399404	6425971	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	108.6	35.7	32.7-35.7	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
SI3W	20BL168404	See Figure 1	Lot C DP 160430	399145	6425777	Water Quality and Drawdown	Natural and pumping-induced water level changes and groundwater quality	124.2	28.2	25.2-28.2	Quarterly	Water Level, pH, EC, Dissolved oxygen, TDS, Total Acidity, Total Alkalinity, Chloride, SO ₄ , Calcium, Magnesium, Sodium, Aluminium, Iron, Manganese, Zinc.	Quarterly	Consistent with Duralie Extension Project EA Predictions. No groundwater complaints.	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Progressive assessment of trends to determine causes and predict potential impacts.	Quarterly reporting of Trigger Level Exceedances to NOW.
WR1	20BL168404	See Indicative Location onFigure 1	Lot 131 DP 95773	400851 (Indicative)	6425891 (Indicative)	Water Quality and Groundwater Recovery	Natural and pumping-induced water level changes and groundwater quality	To be confirmed once drilled.			Daily	Water Level	Quarterly	TBC	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Assess data and establish trends.	Assess data and establish trends.
WR2	20BL168404	See Indicative Location onFigure 1	Lot 6 DP 876013	400973 (Indicative)	6426588 (Indicative)	Water Quality and Groundwater Recovery	Natural and pumping-induced water level changes and groundwater quality	To be confirmed once drilled.			Daily	Water Level	Quarterly	TBC	Min: 6.0 Max 8.0	Min: 100 Max: 7600	Assess data and establish trends.	Assess data and establish trends.	Assess data and establish trends.

Surface Water Monitoring

Surface Water Monitoring Location	Coordinates (GPS)		Monitoring Target	Monitoring Effect of, e.g. Pumping at Design Flow Rates and investigate a number of pumping arrangements to determine sensitivities	Sampling Frequency	Sampling Parameters, e.g. Field testing EC, pH, DO. Laboratory analysis of TDS and major anions and cations for each bore, Monitor for Hydrocarbons at No.11	Action Required Assess data, establish trends and relate to pumping regimes and climatic data. Also report in Contingency worksheet.	Trigger Level	Any follow up actions - Progressive assessment of trends with prediction of any potential impacts. Determine whether the changes due to impacts from pumping, if so modify the pumping schedule so that impact is removed. Increased frequency on monitoring as required
	Easting	Northing							
High Noon Gauging Station	400571	6423925	Flow in Mammy Johnsons River	Loss of Baseflow to Mammy Johnsons River	At least monthly (on an event basis).	Flow (Vus)	Assess data to develop an accurate rating relationship.	N/A	N/A

Groundwater Monitoring Plan And Contingency Plan

Contingency measures

[illegible]

Groundwater Monitoring and Contingency Plan

Bores

[illegible]

ATTACHMENT B

KNOWN REGISTERED BORES IN THE VICINITY OF THE DURALIE COAL MINE (HYDROSIMULATIONS, 2014)

Table B-1
Known Registered Bores in the Vicinity of the DCM

Bore ID (Work No)	DCM bore ID	Work Licence	Type	Owner	Easting (zone 56)	Northing (zone 56)	Depth	Year Completed	Property	Groundwater Management Area	Salinity	Bore yield l/s	Standing water level (mBG)	Ground elevation or TOC (mAHD)	Distance to DCM mine workings (m)
GW022488			Bore	Private	402721	6414346	25.3	1955		Gloucester Basin	(Unknown)				11400
GW052650		20BL117175	Bore open t	Private	391794	6424674	36.6	1981		New England Fold Belt	(Unknown)				8000
GW054253		20BL114844	Bore	Private	403228	6413304	25	1980		Gloucester Basin	Good				12600
GW047870			Bore open t	Private	399805	6434366	30	1981		Gloucester Basin	(Unknown)				4800
GW051643		20BL112285	Bore open t	Private	403021	6415765	23	1980		Gloucester Basin	Good				10100
GW032846		20BL025489	Bore	Other Govt	399499	6420443	15.2	1970		Gloucester Basin	(Unknown)				5200
GW011316		20BL004470	Well	Private	398447	6434075	18.3	1955		Gloucester Basin	Good Stock				4500
GW011988		20BL005309	Bore	Private	402003	6415663	20.1	1956		Gloucester Basin	(Unknown)				10000
GW078141	DB1W	20BL166741	Bore	Mines	401423	6426930	36.5	1997		Gloucester Basin		0.8	14.09	62.246	500
GW078171			Bore	Mines	401122	6444326	0			Gloucester Basin				133	14900
GW078219		20BL167122	Bore		401700	6418851	31.5	1999	20PT910681	Gloucester Basin		0.526	3		6800
GW079610		20BL167416	Bore	Mines	401228	6444142	0			Gloucester Basin					14700
GW079612		20BL167416	Bore	Mines	401280	6444204	0			Gloucester Basin					14800
GW079614		20BL167416	Bore	Mines	401332	6444235	0			Gloucester Basin					14800
GW079615		20BL167416	Bore	Mines	401366	6444296	0			Gloucester Basin					14900
GW079619	DB2W	20BL166741	Bore	Mines	401444	6426228	60			Gloucester Basin				63.37	100
GW079620		20BL166741	Bore	Mines	401700	6426741	60	1997		Gloucester Basin		5	14.78	55.112	600
GW079621	DB4W	20BL166741	Bore	Mines	400932	6425503	40	1997		Gloucester Basin		1.81	7.26	53.6	200
GW079742		20BL167297	Bore		400597	6420147	30	1999		Gloucester Basin			4		5400
GW200048		20BL166741	Bore	Mines	401589	6425668	6	1996		Karuah Alluvium			5.72		400
GW079746		20BL166741	Bore	Mines	401445	6424619	11	1997		Gloucester Basin					1100
GW079744		20BL166741	Bore	Mines	401618	6425637	9.5	1996		Karuah Alluvium					400
GW079747		20BL166741	Bore	Mines	401717	6426224	7	1996		Gloucester Basin					400
GW079748		20BL166741	Bore	Mines	401717	6426224	10	1996		Gloucester Basin					400
GW079749		20BL166741	Bore	Mines	401928	6426072	10	1996		Gloucester Basin					600
GW079751		20BL166741	Bore	Mines	402269	6425890	9.5	1996		Gloucester Basin					1000
GW079752		20BL166741	Bore	Mines	401583	6426561	9.5	1996		Karuah Alluvium					500

Duralie Coal Mine – Groundwater Management Plan

Bore ID (Work No)	DCM bore ID	Work Licence	Type	Owner	Easting (zone 56)	Northing (zone 56)	Depth	Year Completed	Property	Groundwater Management Area	Salinity	Bore yield l/s	Standing water level (mBG)	Ground elevation or TOC (mAHD)	Distance to DCM mine workings (m)
GW079753		20BL166741	Bore	Mines	401319	6426805	7.5	1996		Gloucester Basin					300
GW079761			Well	Private	399996	6443251	13.39	1994		Gloucester Basin			13.39		13700
GW079758			Bore	Private	401497	6440788	0			Gloucester Basin					11500
GW079759			Bore	Private	401176	6438783	0			Gloucester Basin					9400
GW079618			Bore	Mines	401175	6444265	0			Gloucester Basin				130	14800
GW078349			Bore		398789	6416340	22	1996		New England Fold Belt					9400
GW078759		20BL166869	Bore		400610	6419041	22	1998		Gloucester Basin			1.5		6500
GW079049		20BL167416	Bore	Private	401944	6443867	0			Gloucester Basin				124	14600
GW078585		20BL167242	Bore	Private	402432	6417275	19	1999		Gloucester Basin	Good	9.3	3		8500
GW078586		20BL167454	Bore	Private	402152	6413376	33.5	1999		Gloucester Basin		0	9		12300
GW080578		20BL168966	Bore		403063	6414614	33	2004		Gloucester Basin		1	7		11200
GW080508		20BL168893	Bore	Local Govt	404720	6413293	0	2003		New England Fold Belt					12900
GW080509		20BL168893	Bore	Local Govt	404801	6413159	0	2003		New England Fold Belt					13100
GW080288		20BL166921	Bore		400436	6432706	0	2002	20PT910726	Karuah Alluvium					3300
GW064028		20BL135976	Bore	Private	387111	6427087	25.9	1987		New England Fold Belt	1001-3000 ppm				11700
GW066016			Excavation	Private	390494	6428726	2	1991		New England Fold Belt			2		8100
GW067275			(Unknown)	(Unknown)	387366	6425365	10	1991		New England Fold Belt			10	115.8	11800
GW079613		20BL167416	Bore	Mines	401306	6444235	0			Gloucester Basin					14800
GW079617		20BL167416	Bore	Mines	401207	6444274	0			Gloucester Basin					14900
GW079622		20BL166741	Bore	Mines	400517	6425167	40	1997		Gloucester Basin		0.6		55.97	400
GW079750		20BL166741	Bore	Mines	402113	6425889	10.5	1996		Gloucester Basin					800
GW079754		20BL166741	Bore	Mines	401134	6426988	12	1996		Gloucester Basin					300
GW079048		20BL167416	Bore	Mines	401532	6444000	5.97			Gloucester Basin				125	14600
GW050402		20BL111604	Bore	Private	403134	6420263	26	1980		Gloucester Basin	Good				5800
GW080571		20BL169147	Bore	Private	403129	6414366	0	2004		Gloucester Basin					11500
GW080778		20BL168404	Bore		401407	6426825	36.5	2002	20PT910957	Gloucester Basin		0.75	18		400
GW080776		20BL168404	Bore		401342	6426938	40	2002	20PT910957	Gloucester Basin		0.25	9		400
GW080777		20BL168404	Bore		401522	6426872	40	2002	20PT910957	Gloucester Basin		1	22		500
GW080779		20BL168404	Bore		401537	6426751	60	2002	20PT910957	Gloucester Basin		4	40		500

Bore ID (Work No)	DCM bore ID	Work Licence	Type	Owner	Easting (zone 56)	Northing (zone 56)	Depth	Year Completed	Property	Groundwater Management Area	Salinity	Bore yield l/s	Standing water level (mBG)	Ground elevation or TOC (mAHD)	Distance to DCM mine workings (m)
GW080780		20BL168404	Bore		401599	6426842	40	2002	20PT910957	Gloucester Basin		0.3	22		600
GW080781		20BL168404	Bore		401396	6426717	58	2002	20PT910957	Gloucester Basin		0.35	25		300
GW080636		20BL168404	Bore		401453	6426839	35.7	2004	20PT910957	Gloucester Basin		0.25	33.7		400
GW080637		20BL168539	Bore		401520	6424997	16.4	2004		Gloucester Basin			14		800
GW080638		20BL168539	Bore		401416	6425106	28.2	2004		Gloucester Basin					700
GW079050		20BL167416	Bore	Mines	401701	6443473	8.28			Gloucester Basin				125	14100
GW079611		20BL167416	Bore	Mines	401254	6444173	0			Gloucester Basin					14800
GW200049		20BL166741	Bore	Mines	401595	6425329	7	1996		Gloucester Basin					600
GW080484		20BL168934	Bore		402734	6414554	39	2004		Gloucester Basin		2	8.5		11200
GW200244		20BL168404	Bore		402195	6425490	40	2002	20PT910957	Gloucester Basin		0.25	9		1000
GW200431		20BL169316	Bore		403353	6435280	60	2004		New England Fold Belt		0.25	8		7000
GW200432		20BL169271	Bore		398903	6434728	60	2004		Gloucester Basin					5100

ATTACHMENT C

GROUNDWATER PREDICTIONS AT THE END OF MINING
(FROM HYDROSIMULATIONS, 2014)

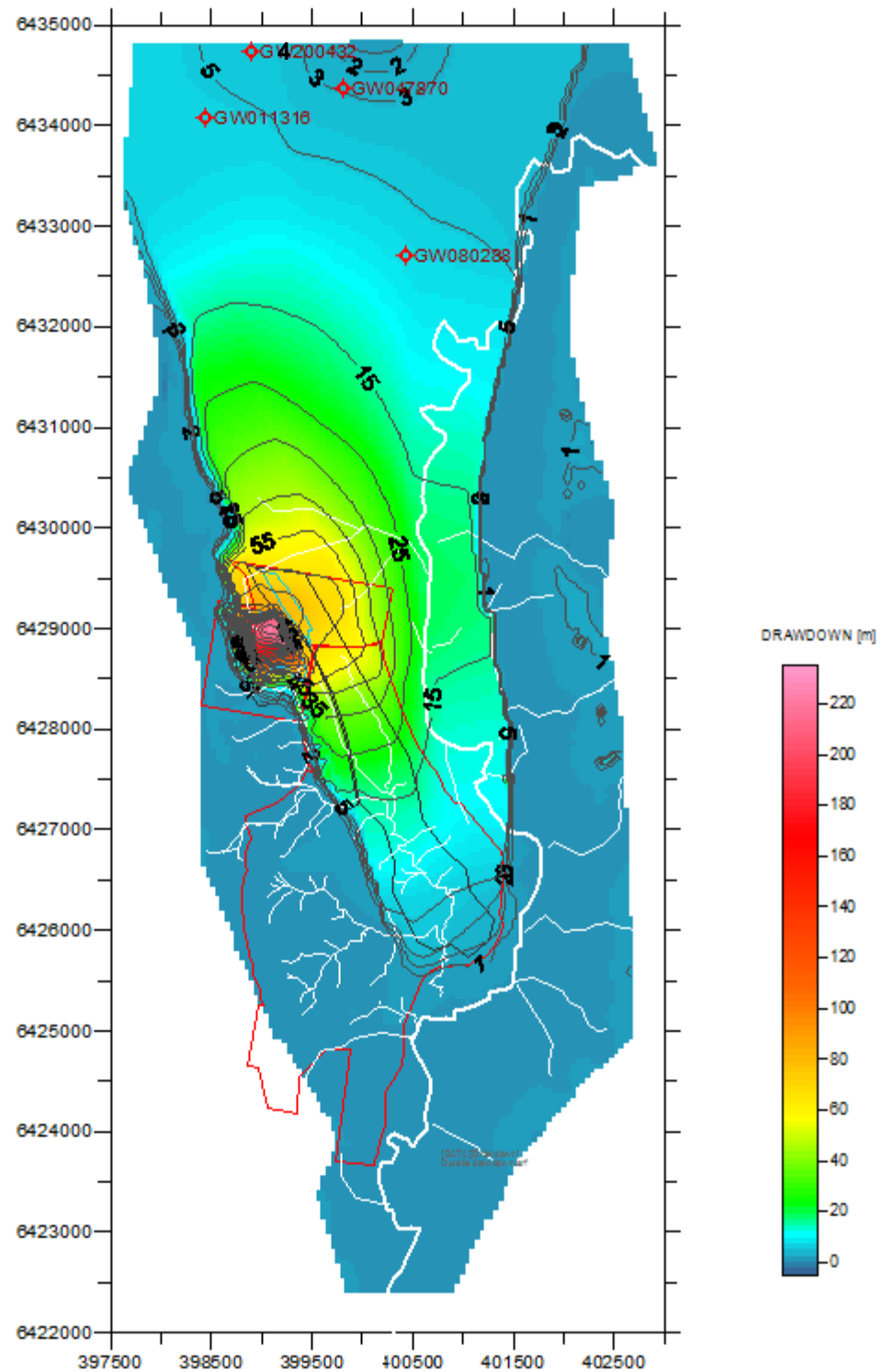


Figure C-1 Simulated Drawdown in Groundwater Levels at the End of Mining in Model Layer 3 (Weismantel Coal Seam)

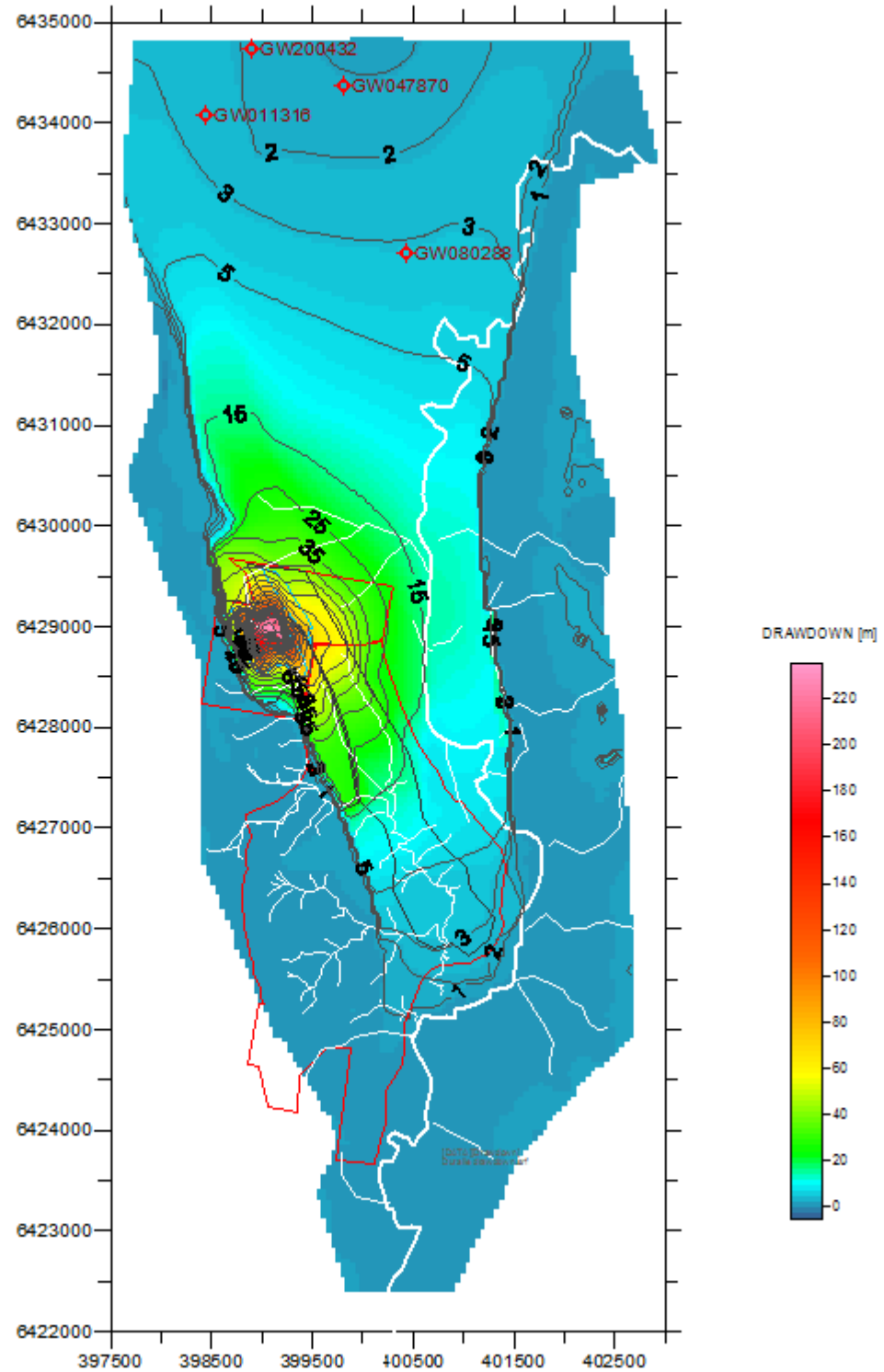


Figure C-2 Simulated Drawdown in Groundwater Levels at the End of Mining in Model Layer 5 (Clareval Coal Seam)

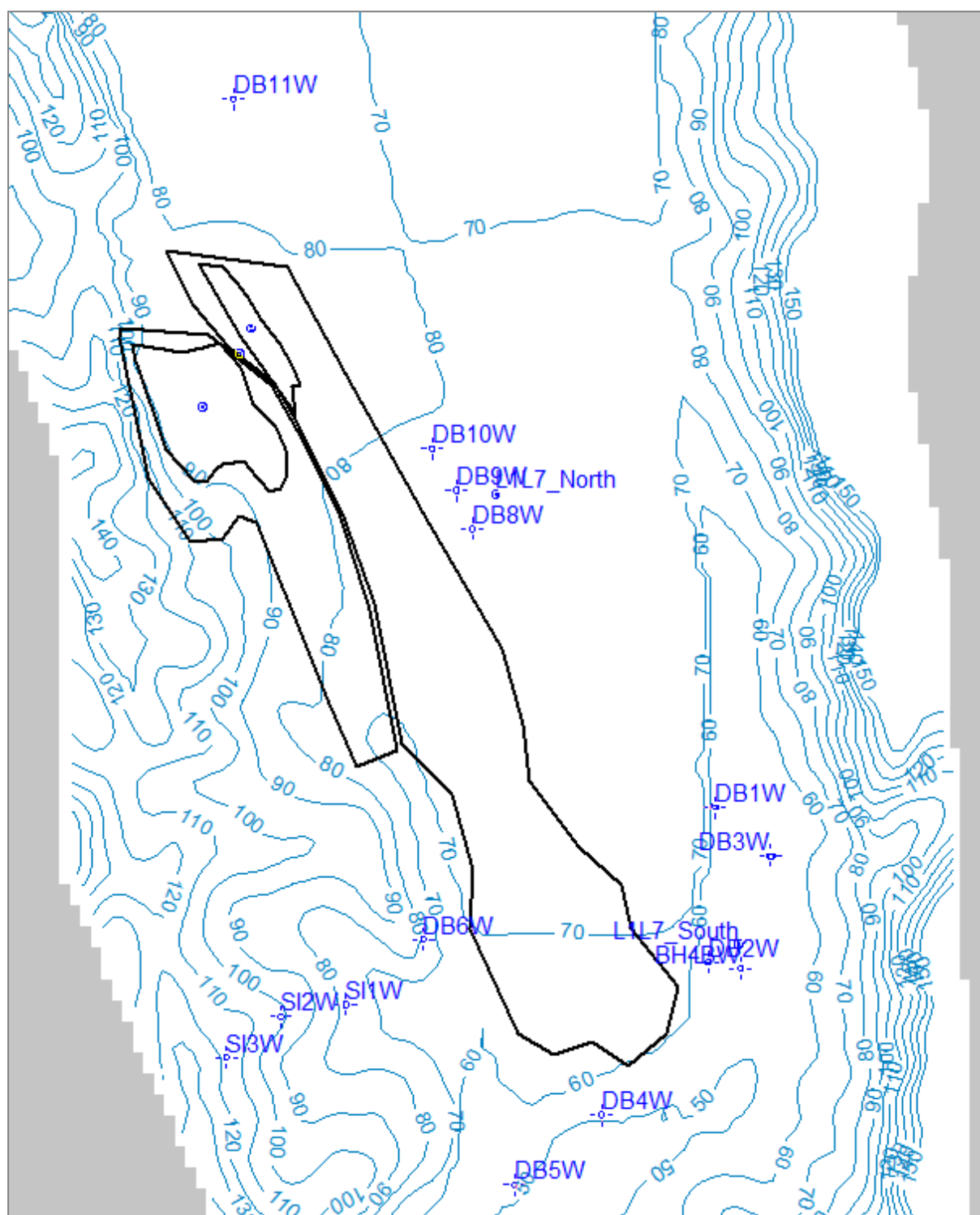


Figure C-3 Simulated Post-mining Equilibrium Groundwater Levels in Model Layer 2 [mAHD]

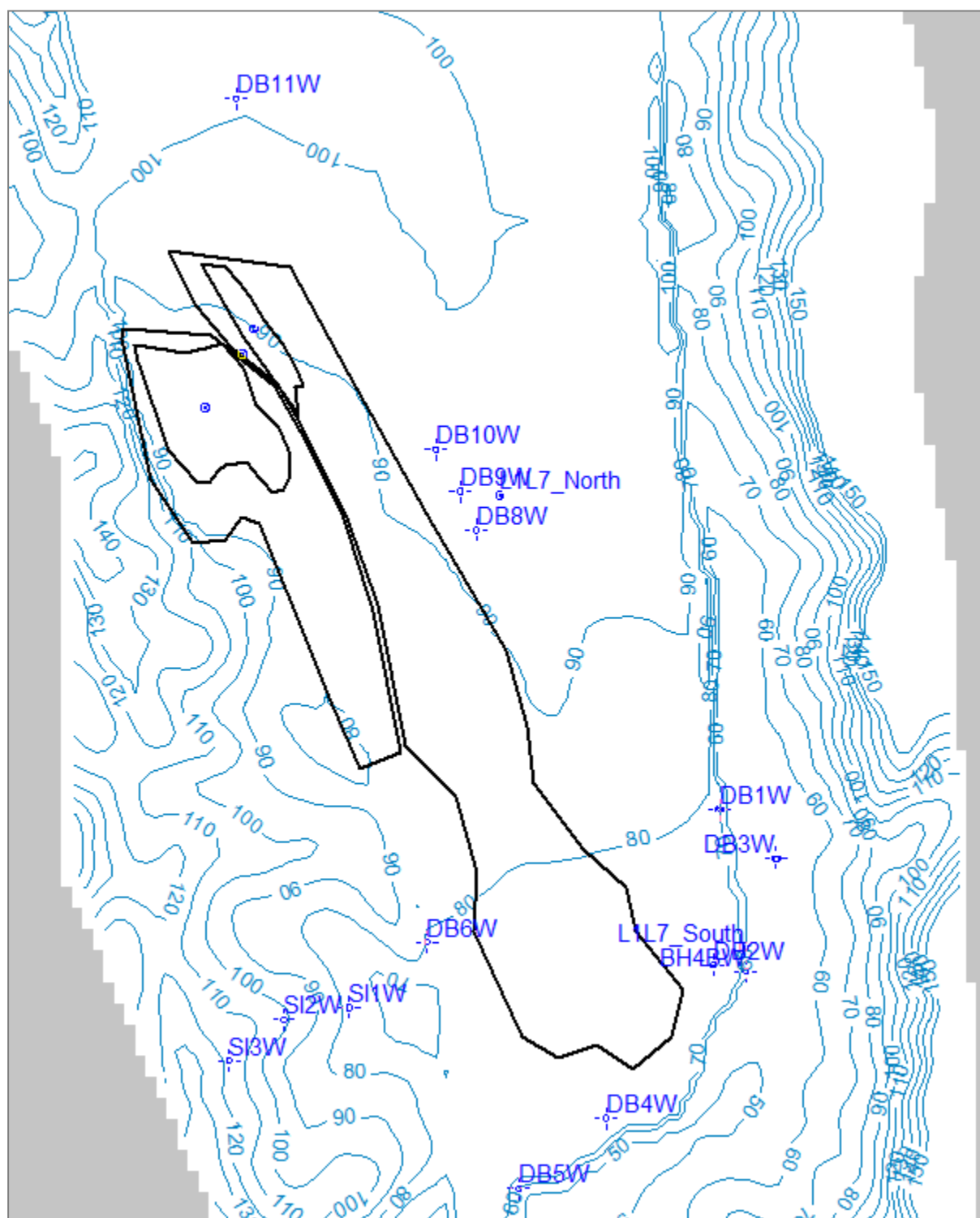


Figure C-4 Simulated Post-mining Equilibrium Groundwater Levels in Model Layer 5 [mAHD]

ATTACHMENT D

MURRAY DARLING BASIN GROUNDWATER QUALITY
SAMPLING GUIDELINES

Murray-Darling Basin Groundwater Quality Sampling Guidelines

Technical Report No 3
Groundwater Working Group

INTRODUCTION

This document aims at providing a set of guidelines for groundwater quality sampling with an emphasis on regional monitoring networks. These protocols were developed as part of the Groundwater Quality in the Murray-Darling Basin Project. This is a Murray-Darling Basin Commission - Natural Resources Management Strategy funded project involving the four States within the Basin and the Commonwealth. The objective of this project is to determine the basic design, key parameters and research requirements for the establishment of a groundwater quality monitoring program for the Murray-Darling Basin and to ensure its implementation.

Surface water quality sampling procedures have been developed over the past 50 years and are very well documented. Groundwater quality monitoring assessment requirements and goals are often quite different to those of surface water and there has been less emphasis in the past to define a set of standards applicable to groundwater. The objective of groundwater sampling is to obtain a sample with minimum disturbance to the geochemical and hydrogeological conditions.

There exist some recent publications by the State agencies on sampling (ie Jiwan & Gates, 1992, Rayment & Poplawski, 1992) and a document on sampling for contaminated sites (AWRC, 1991). Although these documents are very relevant to the issues they address there is need to provide a set of sampling guidelines that can act as a standard across state boundaries. The purpose of this report is to outline a set of groundwater sampling protocols that focuses on regional monitoring and sources of contamination throughout the Murray-Darling Basin. A uniform, accurate and reliable set of sampling procedures will ensure that comparable data of a known standard is collected throughout the basin. Ultimately, this allows for greater confidence in the interpretation of any basin-wide data.

This document provides a general overview for practical purposes and covers the elements of effective groundwater sampling and the basic capabilities for routine applications. It outlines the procedures for sampling from the bore site to delivery at the laboratory. It does not include bore construction and development or laboratory analyses. It is a general field manual including sampling for physical parameters, major ions, metals, nutrients, pesticides and microbiology. It is not aimed for use by researchers requiring specialised sampling methods for specific studies. There has been an emphasis on trying to include explanations for the various procedures.

The main issues and procedures of groundwater sampling covered in this document include:

- 1) Planning and the selection of appropriate indicators, locations and frequency;
- 2) Selection of the various sampling devices available;
- 3) Decontamination and bore purging procedures;

- 4) Field measurements and filtration of samples;
- 5) Determination of container, preservation methods and holding time, including transport to a laboratory;
- 6) The significance of and steps involved in Chain of Custody documentation;
- 7) The elements of a QA/QC program;
- 8) A summary of the standard sampling protocol and some commonly encountered problems.

This set of protocols is very much a compilation of existing groundwater sampling documents. Appendix 2 and 3 summarise the various reports that contributed to this one. These documents may provide additional information and discussion on procedures given in this report. The core of this document has been based on A Practical Guide to Groundwater Sampling - 1st Edition (Jiwan & Gates, 1992).

1. GROUNDWATER SAMPLING OBJECTIVES AND PRINCIPLES

There are many different reasons for sampling groundwater. These include meeting regulatory requirements, industrial or municipal waste disposal site monitoring, ambient ground-water quality monitoring, research, and general bacteriological and chemical quality monitoring. Each of these different objectives can result in a different set of protocols for sampling. This document is mainly focussed on ambient and regional monitoring.

The ultimate objective of any groundwater sampling program is to obtain a representative sample of groundwater and to try to maintain the sample integrity from field to laboratory. This means that the relative proportions of all components must be the same in the sample as in the material being sampled and that there must be a minimum of disturbance to the sample during the sampling process.

The time and resources allocated for the construction of bores for groundwater monitoring, combined with a sampling program, can involve quite large sums of money. Because of this it is very important that proper sampling procedures are followed and resources are not wasted.

When utilising any set of sampling protocols it is important to remember that they must be tailored to the actual site conditions, the information needs of the program and the time/cost limitations imposed on the program.

Groundwater, and therefore groundwater sampling, is unusual by its nature. Some of its unique features include:

- The necessity of having a bore or similar structure to obtain a sample. This is a major part of the cost of any monitoring system and can have the effect of disturbing the chemistry of the sample.
- The quality of groundwater can be variable over quite short distances. This can be ambient water quality variability or it can be affected by anthropogenic factors (ie. pesticide contamination, septic tank leakage). An understanding of the hydrogeology and flow dynamics of the system is important before any water quality sampling is undertaken.
- Groundwater suffers from the 'out of sight - out of mind' syndrome. Water quality problems in groundwater are unseen and therefore easily ignored

With the developing scarcity of good quality water resources, it is becoming increasingly important that the quality as well as the quantity of groundwater supplies are managed properly.

2. PLANNING AND PREPARATION

(adapted from P. Garrett, 1988)

Careful planning and preparation of a groundwater sampling trip is very important and can save time and reduce the number of minor and major difficulties that commonly occur with fieldwork. The following are suggestions of things to consider before going on a groundwater sampling field trip. These elements can be set out in a Work Plan for routine sampling and will ensure more efficient use of time with future work. A suggested checklist of equipment to take into the field can be found in Appendix 1. The objectives of the trip will determine what equipment is necessary but the list is useful as a reminder.

Depending on the nature of the suspected contamination, there may be Occupational Health and Safety (OH&S) issues to be addressed in the collection, handling and transport of groundwater samples and by-products. Personal OH&S issues should be addressed in a Work Plan and include details of the level of protective clothing required and procedures to be used. Such plans may require input from qualified OH&S professionals to ensure all aspects are covered..

- 1) Check with your **client**, especially if off-site wells are to be sampled. Be aware of liabilities that your actions may incur in the name of your client or your own agency/firm.
- 2) Call **home well-owners** to inform them of what you are doing and to arrange access and a time for sampling. This could include providing them with a summary sheet of the project for their information and results from their bore.
- 3) Coordinate with the **laboratory**. They will need to schedule in your sample set. Discuss any problems you foresee with procedures, containers, etc. and collect all necessary sample bottles, trip blanks and spike solutions as required.
- 4) Plan how and when you will get the **samples back to the laboratory**, cool and as quickly as possible. This is especially relevant for bacterial samples.
- 5) Organise and review **maps and diagrams** for the area to be sampled. Include bore details and coordinates.
- 6) Be sure you know the **diameter** of the wells you want to sample: your sampling gear must be the right size.
- 7) Choose the **order of sampling**. Try to keep cross-contamination to a minimum, ie. sample from the suspected least contaminated bore to the most contaminated.
- 8) **Test** all equipment for the trip by performing a 'test run' on a local bore.
- 9) Fill out as much **paperwork** as possible before you leave. That includes chain of custody and shipping forms - if appropriate.

10) Call the **local council or police station** if you are sampling where people may be suspicious of your motives. Carry a few business cards.

3. INDICATOR SELECTION

There are three basic criteria used in selecting appropriate indicators for groundwater studies:

- relevance to the issues identified
- acceptable precision
- cost (collection, preservation and analysis)

Some indicators will be selected for immediate management decisions. For example identification and definition of a pollution plume will need very specific water quality measurements at many locations and at closely spaced time intervals. Once however the source and processes of contaminant flow are established, then key indicators at regular intervals (say 3 monthly) would be sufficient monitoring. Guidelines on safe levels for drinking water are documented in Australian Drinking Water Guidelines (NH&MRC, 1995) and guidelines for other water uses can be found in Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 1992).

Table 1 shows recommended key indicators for important groundwater issues while Table 2 shows key indicators for different groundwater uses.

Table 1

Recommended Key Indicators for Groundwater Issues

ISSUE	INDICATOR(S)
Salinity	Electrical conductivity, pH, major anions/cations (when necessary)
Iron Bacteria	Gallionella Crenothrix and Leptothrix. iron (soluble), iron (total)
Regional Resource Evaluation and Management	Electrical conductivity, pH, major anions/cations (including nitrate, silica)
Organic Pollution	Hydrocarbons (as appropriate)
Inorganic Pollution	Heavy metals, nitrate, phosphate, others as appropriate
Pesticides	As appropriate
Biological Contamination	E. coli, faecal streptococci, bacteria, viruses, nitrate, nitrogen and ammonia
Bore Corrosion	pH, dissolved gases (CO ₂ , O ₂ , H ₂ S), electrical conductivity, iron (soluble), iron (total), anions/cations

Note: Major anions include - CO₃, HCO₃, SO₄, Cl, NO₃. Major cations include - Ca, Mg, Na, K

Table 2

Recommended Key Indicators for Groundwater Uses

USE	KEY INDICATORS
Potable Water Supply	Bacteria, total coliforms, faecal coliforms, cyanobacteria, DO, BOD, pH, turbidity, odour, colour, taste, hardness, major anions/cations, nutrients, metals, organics, radioactivity, aesthetic chemicals, filtrable residue.
Agricultural Water Supply (including stock)	Bacteria, E. coli, faecal coliforms, pH, salinity, major anions/cations, nutrients, DO, BOD, organics.
Irrigation	pH, salinity, major anions/cations, nutrients, photo toxic trace elements, bacteria, algae, SAR.
Industrial Water Supply	Varies according to particular industry but usually includes pH, colour, turbidity, taste, hardness, major anions/cations, dissolved solids, total iron.
Recreation	Bacteria, algae, faecal coliforms, pH, odour, colour, salinity, nutrients, biostimulants, toxicants. Varies.
Edible fish and crustacea and protection of ecosystems and water associated wildlife.	pH, DO, salinity, suspended solids, turbidity, colour, nutrients, biostimulants, toxicants.

When selecting what indicators are to be included in a groundwater study it is important to confer with the analysing laboratory on the detection limits for each indicator. All analytical results should be interpreted with respect to the detection limit.

4. LOCATION AND FREQUENCY

Location

The selection of optimal sampling location will depend on the purpose of the program and the aquifer characteristics. For the purpose of this document there are two main categories of monitoring/sampling.

1) Ambient/Regional Monitoring

This type of monitoring aims at understanding the characteristic regional water quality variations and changes over time. It is usually accomplished through routine sampling of bores - either in a dedicated monitoring network or production bores, where no network is available. Generally, rigorous well construction and sampling procedures are not required for these projects and the objective of sampling is to detect gross changes in water quality on a regional basis.

When monitoring to identify extensive diffuse pollution of aquifers it may be worthwhile constructing some purpose-drilled boreholes. This could include shallow observation bores screened over different depth intervals in the aquifer. The distribution should be spread over the area of interest and sited according to the different hydrogeological and land-use conditions. Depending on the size of the project, one or more bores should be placed to determine natural groundwater quality outside the area of suspect contamination.

2) Point-Source Monitoring

This type of monitoring is conducted at a potential pollution source, ie waste disposal sites and feedlots. The objective of point-source monitoring is to detect and quantify the extent and the migration of the pollution plume. Sampling will be necessary both upgradient, to determine natural groundwater conditions, and downgradient of the source, to determine changes in water quality due to land use.

Sampling Bores

The use of existing **production bores** for sampling is the cheapest method available. High yielding bores can provide good representative samples. Care should be taken to ensure that aeration of the sample has not occurred due to pumping.

If there are **existing monitoring bores** in the area then these can also be used for samples.

Depending on funds available for the program, a range of **new monitoring bores** can be constructed. The use of specialist knowledge will ensure the proper design in terms of construction materials used and their effect on the quality of groundwater. PVC, stainless steel or Teflon are different materials that can be used for casing depending on what is required in terms of sample parameters and detection limits.

In all cases it is imperative to have bore information on these sites in the form of driller's logs, lithological logs and/or construction details. Information on bore yield

and water quality, from previous bore performance or sampling work, will assist in determining issues such as purge volume and rate.

Frequency

The frequency of water quality measurement is dependent on the issue being examined and the variation in quality of the groundwater in both a temporal and spatial sense, although quality changes in groundwater are usually much more gradual than those in surface waters. In some aquifers there are factors producing seasonal variations in quality and in other cases - particularly where groundwater pollution is occurring - there are short-term variations of between several hours and a few days. These variations should be recognised before a long-term sampling programme is defined.

For quality surveillance of potable supplies, the temporal variation is a very significant factor. For most determinands a monthly, or less frequent sampling, is normally adequate. In bores where microbiological contamination is a potential problem, more frequent sampling is advisable.

Continuous monitoring of pH, temperature and electrical conductivity at a few key sites is useful for identifying the rate of quality change. This information can then be used in the project area to determine the optimum sampling frequency. Continuous monitoring results from pumped bores can be used to indicate when quality variations of the pumped water are not occurring and a representative sample can be taken. With high pump rates extra care should be taken to avoid aeration of the sample.

Statistical techniques can help determine the value of individual sites within a network or alternatively if more sites are necessary. For resource inventory monitoring, such as statewide and regional water quality networks, managers should regularly review the sampling networks to determine if appropriate locations are being measured to address the issues at hand.

5. SAMPLING DEVICES

There are a variety of devices which can be used for sampling. An important consideration when selecting a sampling device is the change in water quality that may occur during the process of sampling. For example degassing can occur during pumping. Analytical error introduced during sampling becomes important in environmental studies because, even though very low analytical limits are achievable in the laboratory, detectable levels are sometimes limited practically by sampling device performance or by errors introduced by cross-contamination.

Table 3 lists a range of sampling devices and gives their advantages and disadvantages. This information should be considered when planning a sampling program. For sampling of shallow, low yield bores bailers may be the most appropriate sampler. For routine monitoring of deeper bores a submersible pump is the preferred device. If this is not available then a bailed sample should be taken after the appropriate purging of the bore.

Table 4 provides information on the preferred material for use in groundwater sampling devices. The material selected will depend on the accuracy and precision of the information required, including equipment handling and decontamination, as well as cost. For routine monitoring of a regional network, materials from order 2 to 7 would be suitable in both rigid and flexible materials.

PVC is rigid and non-porous. It has good general chemical resistance except for low-molecular weight ketones, aldehydes and chlorinated solvents. PVC is fine for inorganic analyses but may introduce a bias with some organic compounds.

Polyethylene materials are not recommended because they tend to adsorb trace metals.

Teflon is the most commonly used material for specialist sampling devices, however it is primarily limited by cost. Teflon exhibits inertness to chemical attack, has poor sorptive properties and a very low leaching potential. Monitoring bores and sampling devices used for the detection of very low concentrations of pollutants are sometimes made of Teflon. Other non-metal devices may be suitable in place of Teflon if the device is single use, ie. disposable bailers.

Stainless steel is another expensive material used for high quality monitoring programs. The usual choice is 316 quality stainless steel. However, stainless steel bailers are readily available in a range of sizes and, with the appropriate cleaning and handling, can be re-used indefinitely. They are the most commonly used sampling device for general groundwater monitoring.

When utilising production bores for sampling it is important to be aware that pumping equipment may affect chemical analysis, ie. some oil from oil lubricated pumps can contaminate the water sample.

Table 3

Sampling Devices: Their Advantages and Disadvantages

(after Jiwan & Gates, 1992)

Sampling Equipment	Advantages	Disadvantages
1. Bailer	<ul style="list-style-type: none"> Can be constructed from variety of material compatible with parameter of interest Can be different diameter and length to suit the sampling point No external power source required Easy to clean or disposable Inexpensive and readily available Lower surface area to volume ratio reduces outgassing of volatile organics 	<ul style="list-style-type: none"> Time consuming, non-continuous flow The person sampling the bore is susceptible to exposure to any contaminants in the sample It may be difficult to determine the point within the water column that the sample represents Can be impractical to remove casing storage (stagnant) water in a deep bore with a bailer Aeration may result during transfer of sample from bailer to sample bottle When used in deep installations, more prolonged sample handling may effect air-sensitive chemical constituents Bailer check valves may fail to function properly Swabbing effect of bailers that fit tightly into a bore casing may include fines from the formation to enter the bore
2. Syringe Devices	<ul style="list-style-type: none"> Neither aeration nor outgassing of the sample occurs as it does not come in contact with atmosphere Can be made of inert or any material Inexpensive, highly portable and simple to operate Can be used in small diameter wells Sample can be collected at various intervals Can be used as sample container 	<ul style="list-style-type: none"> Inefficient for collecting large samples Syringes can not be used for evacuating stagnant water Syringes are relatively new in this application and may not be as readily available as other sampling devices Sample contamination by components of "home-made" syringe sampling devices is possible unless fabrication materials are carefully selected The use of syringes is limited to water with a low suspended solids content Some leakage may occur around the plunger when syringes are used to sample water containing high level of suspended solids
3. Air-lift sampler	<ul style="list-style-type: none"> Relatively portable Readily available Inexpensive Some are suitable for well development - depends on yield rate of device 	<ul style="list-style-type: none"> Causes changes in carbon dioxide concentration and thus not suitable for sampling for pH-sensitive parameters Because of degassing effect on sample it is not appropriate method of sampling for detailed chemical analyses Oxygenation is impossible to avoid unless elaborate precautions are taken
4. Suction-lift pumps	<ul style="list-style-type: none"> Highly portable Easily available Flow rate can easily be controlled Inexpensive Can be constructed in small diameter 	<ul style="list-style-type: none"> Limited sampling depth (6-8m) Loss of dissolved gases and volatiles due to vacuum effect Potential of hydrocarbon contamination of samples due to use of petrol or diesel for running the pump Use of centrifugal pumps results in aeration and turbulence.
5. Gas-operated pump	<ul style="list-style-type: none"> Can be constructed in small diameter from a wide range of materials Portable Reasonable range of pumping rates Use of inert driving gas minimises chemical alteration 	<ul style="list-style-type: none"> If air or oxygen is used as the driving gas, then oxidation may occur causing the precipitation of metals Gas-stripping of volatiles may occur CO₂ may be driven from the sample causing a pH shift
6. Bladder pump	<ul style="list-style-type: none"> Portable, small diameter Non-contact, gas driven pump that uses compressed air to expand and contract flexible bladder Minimal effect on water chemistry because of non-contact 	<ul style="list-style-type: none"> Non-continuous flow Low flow rate Time consuming to purge bore
7. Submersible pump	<ul style="list-style-type: none"> Constructed from various materials Wide range of diameter Readily available High pumping rates are possible for evacuation of large volumes Provides a continuous sample over extended periods of time 	<ul style="list-style-type: none"> Conventional units are unable to pump sediment laden water without incurring damage to pump Smallest diameter pump is relatively expensive Most of submersible pumps are too large for 50mm diameter pumps Must be able to pump at a low rate for sampling and a high rate for purging
8. Inertial pump	<ul style="list-style-type: none"> Simple construction, inexpensive Manual, gas or electric motor driven Good for sediment clogged bores If dedicated, it avoids cross-contamination 	<ul style="list-style-type: none"> For use primarily in small diameter bores as large bores increase the possibility of tubing sway Works optimally with deep installation of tubing. This may result in the bore non being properly purged. Low flow capacity

Table 4

Preferred Materials for Use in Groundwater Sampling Devices

(Adopted from Canter et al, 1988)

A. Rigid Material

Order of Preference	Material
1	Teflon
2	Stainless steel
3	Polyvinyl Chloride (PVC)
4,2	Low-carbon steel
5	Galvanised steel
6	Carbon steel
7	Copper

B. Flexible Materials

Order of Preference	Material
1	Teflon
2	Polypropylene
3	Flexible PVC/Linear Polyethylene
4	Viton
5	Conventional Polyethylene
6	Tygon
7	Silicone/Neoprene

6. DECONTAMINATION

Decontamination of sampling equipment is recommended for all sampling work and considered essential when sampling for microbiological parameters, organics and low concentration constituents, ie. pesticides. It is not routine for major ion analyses. The purpose of decontamination is to ensure the sampling equipment is clean and contains no trace of the previously sampled groundwater that can cause erroneous analytical results (cross-contamination). Decontamination of equipment should be completed before each bore sampling.

Equipment

Plastic sheets

Clean sterile gloves

Concentrated sodium hypochlorite bleach (12-20%) or biodegradable P-free detergent for non-microbiological sampling

CAUTION: Operator should be familiar with the safety aspects of sodium hypochlorite

Large tank distilled water

Contaminant-free water, e.g. from town supply. (Do not use farm or tank water as it may be contaminated)

Solution of 70% ethanol and 30% water

Hand spray pumps

2 large containers that will hold the bailer or pump hose and pump

Procedure

- Decontaminate pump away from sampling site
- Place plastic sheets around sample site to prevent contamination from ground material.
- It is advisable to wear clean, sterile gloves and protective clothing when performing the decontamination process.
- Prepare bleach or detergent solution in large container 4 hours prior to use to allow it to kill any bacteria.
 - 20 L contaminant-free water
 - 100 ml concentrated sodium hypochlorite bleach
- Place pump into container and pump until the pump hose is full of bleach solution. If using bailer, run several litres of bleach/detergent solution through equipment.
- For microbiological samples, trap bleach solution with foil or Glad-Wrap at the ends. The hose doesn't need to be totally full as the gas from the solution does the work.

- The pump and pump hose can then sit in the remaining solution in the container so that the outer hose is decontaminated as well. If a bailer is being used, scrub the outside with the solution.
- Wait 15 minutes minimum for microbiological samples.
- Pump approximately 20 L of distilled water through the pump and line and rinse the external hose. Similarly, rinse bailer. If distilled water is not available, then contaminant-free water may be used as a second choice.
- Take a Before Blank sample and End of Line Blank sample - ie a sample of contaminant-free water before it is pumped through the system and a sample after it has been pumped through the system. This should be done at the beginning and end of each sampling event. This is part of the QA/QC procedure to check on the effectiveness of the decontamination process (see Section 12).
- After allowing the equipment to air-dry the equipment is now ready for sampling.
- If the hose gets dirty/dusty spray with the solution of 70% ethanol plus 30% water in hand pumps. If solution is not available, use distilled water.

If contamination is suspected, the wastewater resulting from the decontamination process may require containment and disposal to a treatment facility. If this is the case, DO NOT dispose to groundwater or local drainage.

7. BORE PURGING

The principle of bore purging is to evacuate the stagnant water in the well casing prior to sampling so as to provide a representative sample of in-situ groundwater.

The number of bore volumes to be pumped before collection of water samples depends upon bore depth, hydraulic properties, sampling methodology and program requirements. There is no set number of volumes to be pumped that fits all situations. The aim is to obtain water from the geologic materials being monitored with minimum disturbance of the regional flow system and the collected sample.

It is generally agreed that a minimum of 3 casing volumes of water should be evacuated as well as attaining the stabilisation of pH, temperature and electrical conductivity of the discharging water. This results from this procedure should be documented - pumping rate, volumes pumped, chemical parameter measurements.

The following examples illustrate the method for calculating bore volumes.

$$\text{Volume} = \Pi r^2 h$$

Given:

15m deep, 50mm diameter piezometer (approx. 2 inch)
Static level about 4.5m below ground surface

Calculation:

$$\begin{aligned}\text{One bore volume} &= (15 - 4.5) \times 25^2 \times 3.14 \times 10^{-6} \\ &= 20.6 \text{ litres}\end{aligned}$$

Record the static water level (SWL) prior to pumping. If possible, the groundwater level should also be recorded during purging to monitor bore performance to determine possible maintenance requirements, especially with deep bores.

The pump should be located several metres above the screen and the pump rate should be set to maintain constant drawdown a few metres above the pump if possible. If the pump is too close to the screen, high entrance velocities and turbulence may result in a change of chemistry. Once a constant flow rate has been achieved the pump can be manually lifted to near the top of the water column and the bore “vacuumed” ie: the stagnant water which has been sitting in the casing well above the slotted level is directly pumped out. When using a bailer, purge from the screened interval. Use a calibrated bucket/container to record the volume of water being discharged.

The chemical stability of the discharge water is indicated when three successive measurements of pH, temperature and EC, taken at intervals of 5 minutes or more, differ by less than the following amount:

pH	0.1 unit
temperature	0.2 degrees Celsius
EC	5 percent

If the chemical stability has not been attained after four casing volumes of water have been removed, it is advised that sampling can commence if notes are made clearly describing the stabilisation problem. Continuously operated production wells need to be pumped only to chemical stability.

Periods of long pumping may lead to sampling water which is not in-situ or is at some depth other than that at which the bore is screened. Overpumping may also introduce groundwater from a distance source that may dilute or concentrate certain components and result in erratic or misleading data.

Low-yield bores (bores that are incapable of yielding three casing volumes) present a difficult situation. The following procedure is recommended: The operator should evacuate bores to dryness once. As soon as the bore recovers sufficiently, the first sample can be tested for pH, temperature and electrical conductivity. If full recovery exceeds two hours the sample should be extracted as soon as sufficient volume is available for a sample for each parameter.

It is important to note that some pumps cause volatilisation and produce high pressure differentials and thus may cause variability in the analysis of pH, EC, metals and volatile organic samples. They are, however, acceptable for purging the bores if sufficient time is allowed to let the water stabilise prior to sampling. Where possible sample should be taken with pump set at lowest rate.

When purging equipment must be reused, it should be decontaminated using the same procedures required for the sampling equipment. (See Section 6 for Decontamination.)

There may be an issue with the disposal of potentially contaminated water extracted from the bore during purging. Some containment may be required where disposal to ground will create a risk to the environment.

8. FIELD MEASUREMENTS

The optimal situation for chemical analysis of all parameters would be to determine them on site. Unfortunately there is a limited number of suitable, portable instruments for this purpose. The standard procedure is to take pH, temperature and electrical conductivity readings (include dissolved oxygen and redox potential if required) on site. All field instruments should be calibrated and verified prior to field use and then calibrated again when in the field.

The purpose of these readings are:

- to ensure purging has removed a sufficient quantity of water (see Section 7).
- to provide valid on site measurements of pH, temperature, electrical conductivity (Eh and redox potential if required)
- to compare with laboratory measurements to check for chemical changes due to holding time and transport. Temperature and pressure changes during the sampling process have the effect of altering these parameters.

The basic procedure follows:

- It is recommended that a flow-through cell with probes is used for this procedure. This allows for continuous measurement and prevents contact between the sample and atmosphere. If a flow-through cell is not available, measure in a container with the discharge pipe placed at the base of the container. This will reduce contact with the atmosphere.
- Calibrate the probes at the beginning and end of each working day (minimum) and when accuracy of equipment is suspect. Be aware that the value of the standards for calibration change as the temperature changes. Note calibration in log book.
- Rinse the probes with distilled water. The probes should be used in accordance with the operation manual supplied by the manufacturer. Make sure to keep a copy with the probes.
- Record initial chemistry readings and then take at least one set of readings per volume pumped. Also record flow rate.

The two forms (pages 18 and 19) are examples of the data that can be recorded in the field.

Form 1. WATER QUALITY PURGING INFORMATION

Site ID

Bore No

Date

Datum =
Altitude =
N =
E =

Measured W.L. (m) =	
Measured Total .Depth. (m) =	
Casing Height (m) =	
Radius of bore (cm) =	
Casing Material	
Slots/Screen (m)	
Pump Depth (m)	
Average Flow Rate (L/min)	
Pumping Time (min)	

Reduced W.L. (m) =		Measured W.L. - Casing height
Reduced T. D. (m) =		Measured T.D. - Casing height
Water column (cm)		Reduced T.D. - Reduced W.L. x 100
Approx casing volume (L)		$3.1415 \times \text{radius}^2 \times \text{water column} \times 10^{-3}$
Approx volume removed (L)		Pumping time x average flow rate

Results During Pumping

Time	Flow Rate L/min	pH	Temp Deg C	D.O. mg/lt	Redox mV	EC scale=	Salinity ‰ Refract

Comments

Form 2. SAMPLE SUMMARY SHEET

Page ____ of ____

REGION/UNIT PROJECT MANAGER:

URGENCY: 0-1 Week []
 1-2 Weeks []
 >2 Weeks []

Please forward a copy of this sheet with samples and post or fax another copy to:

PROJECT NAME: ACCOUNT CODE:
 SAMPLED BY: SAMPLE METHOD:

FIELD MEASUREMENTS

Sample Number	Sample Date	Site Name	Bore Lic. Number	Sample Depth	Appearance	pH	EC (μS/cm)	T (°C)	Preservative Y/N	Other Info

LAB USE ONLY: Checked and logged by:
 Received in good order: yes/no
 Work Order Number:
 Date Received:

9. FILTRATION

On-site filtration is a necessary step in the process of groundwater quality sampling if determination is required of the 'dissolved' fraction. If the 'total' constituents are required then you do not filter. Also, filtering is not undertaken for microbiological constituents.

Reasons for filtering include:

- Removal of particulate matter
- The adsorption-desorption equilibrium between water, sediments and particles occurs within 72 hours.
- Bacterial growth can cause the redistribution of metal ions between solution and particulate phases.

The common standard pore size of filter used in groundwater quality sampling is 0.45 µm. This size filter does not remove all particulates from water. It removes phytoplankton and most bacteria but fails to remove the colloidal fraction (0.1 - 0.001 µm) of biological and non-biological origin. The pore size of the filter will vary downwards as the mass of material on the filter accumulates. If the filter is not changed when an excessive build-up of material occurs, it may result in total clogging of the filter.

A wide range of filtration media exist. These include cellulose nitrate, cellulose acetate and glass fibre filters. Cellulose nitrate filters are commonly used for major ions, and metals. One of the advantages is that they are relatively inexpensive. The more expensive cellulose acetate membrane filters are used for nutrients to prevent contamination. They are relatively inert and have well defined pore sizes. Glass fibre filters block less regularly but do not have a well-defined pore size. They are used for ³⁶Chlorine samples.

Filtration should be performed on-site as soon as possible after collection. Clean the filter in the same way as the container used for holding the sample (see Section 10). Filter papers should be handled using forceps. It is useful to have at least two filter systems to provide a separate one for trace metals.

The mechanism for filtration can be either with a vacuum or under pressure. In either case, only low pressures (<30 kPA) must be used to avoid rupture of living cells and release of organics/metals into the soluble phase.

It is recommended that this procedure is documented and the results be reported as 'filterable' species, quoting the appropriate pore size of the filter.

10. CONTAINERS, PRESERVATION, HOLDING TIME AND TRANSPORT

The purpose of using particular handling, container and preservation techniques is to try to maintain the sample integrity as much as possible between the point of sampling and the place of analysis. It is important that the decisions concerning these procedures are made at the planning phase of any water quality sampling program.

The sampling containers and preservation techniques to be used for various parameters are detailed in Table 5. Further information can be obtained from the Australian Standard AS 2031-1986 “Selection of Containers and Preservation of Water Samples for Chemical and Microbiological Analyses”. The laboratory doing the analysis should always be consulted when a choice of techniques exists. The samples need to be carefully tracked/documentated before entering the laboratory so that all stages of their transport can be checked.

Containers

The selection and preparation of the containers is important because of the effect it can have on the water sample. Plastics, unless pre-treated can release heavy metals or organics into the sample and act as ion exchange resins. Glass can release or exchange elements of interest into the water sample.

The most common form of pre-treatment for containers is acid washing followed by thorough rinsing with high purity water. The acid leaches heavy metals adhering to the container wall and reduces the ion exchange properties of the container. Bacteriological sample bottles must be sterile and remain so during transport. Pesticide sample bottles should be initially cleaned with detergent and pesticide-free water then rinsed with pesticide-free water and, finally, cleaned with methanol.

Preservation

The preservation methods are based on the retardation of biological, chemical and physical changes and vary greatly in their effectiveness. They should be employed only when the sample cannot be analysed immediately (or within a few hours of collection). If preservation is necessary then it should be done as soon as possible after the sample has been collected. It is important to be aware that preservation will affect the sample in some way. For example, preservation for trace metal analysis samples by acidification will alter the speciation of the metals.

CAUTION: It is recommended that staff familiarise themselves with the safety aspects of using preservatives.

The main preservation methods are:

- 1) Temperature Control

The most common and simplest change of temperature procedure is to keep the samples in storage at 4°C. This minimises microbial activity.

For some parameters, such as some nutrients, freezing is used as a method of preservation. In this case, samples are best frozen in small aliquots. Sealable polyethylene bags (150 mL capacity) are useful containers for this purpose. If using polyethylene bottles, make sure they are stored upright and contain sufficient air space to allow for expansion. Quick freezing with dry ice is recommended as the most satisfactory approach. **CAUTION:** Dry ice can result in frostbite, suffocation if used in confined spaces and pH shifts due to absorption.

Samples must be allowed to reach ambient temperature and be thoroughly mixed before analysis.

2) Acidification

Acidification to below pH 2 has become standard practice for the preservation of samples for trace metal analysis. The function of this step is to prevent adsorption of metals onto the container walls by minimising ion exchange effects. Acidification prior to filtration will result in the release of metals bound to particulates and this will contribute to the results upon analysis. If the requirement is for dissolved metals only then acidification should occur AFTER filtration.

In other cases, the pH adjustment can be to a different level to hold the analyte in a more stable form. Change of pH can also be used to reduce biological activity.

Select an acid that will not interfere with the analysis. For example, do not use nitric acid when analysing for nitrates.

3) Prevention of Redox Changes

Loss of certain substances occurs through redox reactions. A number of oxidants can be used to prevent this process. For example, a draft Australian Standard for mercury determination uses nascent bromine.

4) Solvent Extraction

This method is used to separate the analytes from the matrix and is a recommended procedure for trace organics (ie pesticides). Although it is recommended that this procedure be carried out in the field, it is usually done in the laboratory because it is an unwieldy procedure. The samples are usually stored at 4°C in the interim.

Preservation of samples is difficult because almost all methods interfere to some degree with the analytical tests. Chemical preservatives should only be used when they do not interfere with the examination being made and should be selected accordingly.

Holding and Transport

It is necessary to maintain a dialogue with the analyst particularly with respect to holding time. The holding time is the period between collection of the sample and commencement of analysis - NOT delivery to the laboratory. Therefore, the samples should be delivered to the laboratory without any delay so that the requested analyses can be performed within the specified allowable holding time.

During transportation the following precautions must be taken:

- Bottle caps are secured tightly
- Samples are protected from the effects of light and excessive heat
- Glass bottles are cushioned
- Sample labels do not become lost or damaged
- Samples requiring preservation are transported after preservation.

Table 5

SAMPLING CONTAINERS, PRESERVATION AND HOLDING TIMES

Measurement/ Parameter	Recommended Container	Volume Required (min) mL	Preservation/Treatment	Maximum Holding Period
PHYSICAL PROPERTIES				
General	P	250	Completely fill bottle and store at 4° C	Various - see below
Colour	GB, G, P	100	Store in dark, cool 4°C	24 hours
Dissolved Oxygen	G only	300		Field determination preferred
Electrical Conductivity	P,G,T	100	If field determination not taken, completely fill bottle and store at 4°C	Field determination preferred (24 hours)
Hardness	P,G	200	Fill bottle completely. Add HNO ₃ to pH<2 or store at 4°C	7 days
Odour	G	200	Cool 4°C	Field determination preferred (24 hours)
pH	P,GB,T	100		Field determination preferred
Residue filterable non-filterable total Settleable matter	P,G	100 100 100 1000	Cool 4°C	7 days
Temperature	P,G			Field determination preferred
Turbidity	P,G	100	Cool 4°C	Field determination preferred (24 hours)
MAJOR IONS/ INORGANIC/NON- METALLIC				
General	P,G	1000	Filter, Store at 4°C	6 months
Alkalinity	P,G	200	Cool 4°C	24 hours
Bromide	P,G	500	Cool 4°C	28 days
Chloride	P,G	100	None required	6 months
Chlorine	P,G	200	Field determination	No holding time
Cyanides	P,G	500	Cool 4°C, Add NaOH to pH 12	24 hours
Fluoride	P,G	500	None required	28 days
Iodide	P,G	500	Cool 4°C, Store in dark	7 days
Silica	P only	200	Store at 4°C if not analysed within 24 hours	24 hours
Sulphate	P,G	200	Cool 4°C	7 days
Sulphide (Total)	P	500	Add 2ml Zinc acetate solution, Cool 4°C	7 days
Sulphite	P,G	50	Field determination	No holding time
METALS				
Total Dissolved Metals	P,G	1000	Filter on site. Add HNO ₃ to pH<2	6 months
Suspended (Filterable) Metals	P,G	1000	Filter on site.	6 months
Total Metals	P,G	1000	Add HNO ₃ to pH<2 For Ag use dark bottles	6 months
Mercury (Dissolved)	GB	500	Filter on site. Add HNO ₃ to pH<1, add potassium dichromate to 0.05% m/V	3 days
Mercury (Total)	GB	500	As for dissolved analysis but do not filter	3 days
NUTRIENTS				
Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen	P,G	500	Cool 4°C or freeze.	6 hours if cool/7 days if frozen
Phosphorus (all forms)	P,G	300	Cool 4°C or freeze	6 hours if cool/28 days if frozen
Phosphorus (soluble)	P,G	300	Filter on site. Cool 4°C	24 hours
PESTICIDES				
General	Prepared glass or teflon. Use Aluminium or PTFE lined bottle caps	1000	Immediately after collection store at 4°C. Samples should arrive refrigerated to the lab within 48 hours of sampling.	2 weeks
BACTERIA				
General	Sterile GB	40	Store at 4°C	24 hours

Adapted from M.R. Scaif et al, 1981, Manual of Ground-Water Quality Sampling Procedures

Where P = Plastic
G = Glass
T = Teflon
GB = Borosilicate Glass

For parameters not listed here please consult the Laboratory Manager or the following document:
AS2031-1986 Selection of Container and Preservation of Samples for Chemical and Microbiological Analysis

.Sampling for Specific Purposes

Below are some more specific instructions for sampling different parameter groups.

Major Ions

- Filter sample if required.
- Rinse sample bottle at least 3 times (use filtrate if sample has been filtered).
- If not filtering, take sample, fill bottle to overflowing, preferably by placing a small delivery tube at the bottom of the bottle and expelling the entrapped air in the bottle.
- Preserve (if necessary), seal and store at the appropriate temperature.

Metals

- Pre-prepare bottles by rinsing with 5% HNO₃ then with deionised water.
- Filter sample as required (See Section 9).
- Pour in sample, seal and store.

Nutrients

- Sample 500mL in a bottle. For environmental monitoring, these bottles should be prepared (sterilised) and supplied by a laboratory.
- Preserve and store sample on ice or freeze

Stable Isotopes

- Check with laboratory for specific instructions

Pesticides

- Preparation of bottles should include cleaning with detergent and pesticide-free water, rinsing with pesticide-free water and, finally, cleaning with methanol.
- If glass bottles are to be used, bake at 450°C for 2 hours after cleaning.
- The bottle tops should have a Teflon or aluminium liner to prevent contact of lid with water. It is advisable to obtain these prepared bottles from a laboratory.

Bacteria

- Undertake the decontamination procedure of the pumping equipment after each sampling event.
- Use only prepared sterile containers, preferably Borosilicate glass. Do NOT rinse micro sample bottles.
- Use clean, sterile equipment. Do not remove lid from container until you are ready to take the sample. It is suggested that, as part of the decontamination process, you spray the end of the discharge hose with 70% ethanol or sodium hypochlorite and allow to evaporate.
- When taking sample, take care not to touch bottle tip or stopper with delivery pipe or fingers.
- Seal and store.
- Samples can also be taken by lowering bottle down the bore, but care must be taken not to touch the side of the bore with the sample bottle.
- It is advisable to take replicate samples as it is often found that bacteria are not detected in every sample from a bore.
- Sample should be stored on ice and delivered to the laboratory in the same day. Do not freeze. Temperature should not exceed 10°C nor fall below 4°C,

11. CHAIN OF CUSTODY RECORDS

The collection and analysis of groundwater samples usually requires a substantial investment of resources in terms of equipment, facilities and staff. If inadequate information is recorded, regarding the circumstances of collection and subsequent disposition of the sample, then the resulting data could be rendered useless. If sampling programs are related to legal action then proper documentation is crucial.

Documentation of the sample history is referred to as chain of custody records. The field recording practices should be of a level that the sampling event can be reconstructed. There are four main components of chain of custody documentation:

- the Chain of Custody record
- sample labels
- field logbook/sample record
- sample analysis request record

Chain of Custody Records

To establish the documentation necessary to trace sample possession from the time of collection, a chain of custody record must be filled out and should accompany every sample or group of individually identified samples. This practice is especially important in the advent of litigation. Copies of this document should be made available to the laboratory, the requesting agency and one for the field book. They can contain the following information:

- Sample Identification Number
- Project title
- Date and time of sample collection
- Signature and name of sample collector
- Number of containers and their type
- Method of transport
- Condition of samples when received by the laboratory
- Specific comments and remarks
- Date and time of each change of custody
- Signatures of people in the Chain of Custody sample handover

Prior to signature the number of samples, label details and sample condition should be checked against the Chain of Custody.

Sample Labels

Sample labels are necessary to prevent misidentification of samples. Paper labels or tags should be used and should include at least the following information:

- Bore number or licence number including a unique sample code that distinguishes field samples, duplicates, spikes or blanks. The laboratory should not be cognisant of the code.
- Project name or number
- Signature or initials of sample collector
- Sampling interval or depth (m)
- Date and time of sample collection
- Location of sample collection
- Type of preservation used

Labels should be affixed to the sample container prior to or at the time of sampling. The labels should be filled out at the time of sample collection. The exact sample location and type of sample must be recorded in the field logbook.

Labelling of any boxes used for archiving or sample storage should include:

- Job Number
- Location
- Site
- Depth Interval
- Date
- Disposition

Field Logbook/Sample Record

Information pertinent to the sampling effort must be recorded in a field sampling log. All entries should be made in indelible ink and all corrections should follow error correction protocol of one line through the error and initial and date of correction. Field personnel should also record all information on the appropriate sampling forms

The following list suggests some of the main items that could be recorded in a logbook or sampling workplan, depending on the individual situation:

- Project title
- Purpose of sampling
- Location, description and photographs of sampling point
- Details of sampling site (elevation of casing, casing diameter and depth, integrity of casing, casing type, screen depth, interval sampled, condition of bore)
- Name and address of field contact
- Reference to procedures for preparation of reagents or supplies which become an integral part of the sample (eg, filters and absorbing reagents)
- Identification of sampling crew members
- Number and volume of sample taken
- Sample method
- Sample preservation including storage method
- Date and time of collection
- Collector's sample identification number
- Sample distribution and transportation method (eg, laboratory name and cartage agent)
- References such as maps of the sampling site
- Field observations
- Field measurements
- Signature and date by the personnel responsible for observations
- Decontamination procedures
- Specific comments and remarks

The logbook should be kept under strict chain of custody and stored in a location so as to make it accessible to the project manager and associated project staff. Some of the information can be gathered and prepared prior to sampling as a workplan.

Sample Analysis Request Form

The Sample Analysis Request Form is a document outlining what is required from the laboratory in terms of analysis. It should include the variables to be analysed and the total number and type of samples being sent to the lab.

An example of a Chain of Custody/Sample Analysis Request Form is on pages 29 and 30.

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST FORM

General Information:

PROJECT NAME:

Name of Organisation:

Address of Organisation:

Name of Person Requesting Analysis:

Account Code:

Telephone Number: Fax Number:

Sample Data:

Bore No.: Licence No.:

Map No.: Map Reference:

Weather Conditions:

Sample Depth: Sample Device:

Decontamination: Bore Volumes Purged:

Samplers (names and signatures):

.....

Chain of Custody:

Relinquished By (name and sign.)	Received By (name and signature)	Date and Time

Form 3 (page 2)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST FORM

Bore No.	Date	Time	Sample Method	No. Of Containers	Volume	Filter	Preservative	Storage	Laboratory Analyses To Be Conducted	Remarks

12. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance is a set of operating principles that when carefully followed during sample collection and analysis will produce data of known, consistent and defensible quality. Most analysts use a level of quality control techniques to obtain credible results, but a comprehensive quality assurance/quality control (QA/QC) programme requires systematic use of QA/QC measures throughout the sampling and analytical process.

In a broad sense, the elements of undertaking such a QA/QC procedure are:

- establishment of the information needs and the rationale for their implementation
- documentation of statistical and other accompanying investigations to validate the statistical design
- documentation of the sampling sites and procedures
- use of qualified personnel for sample collection and field analysis
- use of a certified/accredited laboratory (ie NATA registered) for analysing the samples in the field and/or in the laboratory
- use of a certified database and adoption of standard procedures for data handling (NWQMS, 1996, draft)

The use of such a program establishes the correct use of procedures and methods during the sampling program. In terms of field sampling procedure and laboratory analysis, the QA/QC process is used to check accuracy and precision with the use of duplicates, spikes and blanks.

Accuracy is the ability of the laboratory to report what is in the sample and can be measured by the use of spiked samples. Precision is the ability of the laboratory to reproduce results and is determined by submitting duplicate samples from the same source. Discussions of whether significant changes have occurred in groundwater quality must be tempered by the accuracy and precision performance for specific chemical constituents.

Sensitivity and completeness are further measures of sampling performances. Sensitivity relates to the limit of detection and the method detection limit for a particular chemical constituent. The method detection limit is the lowest concentration of a particular chemical constituent which can be measured reliably in a sample. Completeness is a measure of the amount of data meeting the data evaluation criteria obtained from a measurement system compared to the amount that was expected to be obtained.

It is not necessary to analyse for every parameter for QA/QC purposes. Choose the more sensitive parameters or ones of primary interest.

Blanks

A blank is a portion of deionised water that is carried through all or part of the sampling and analytical process and is designed to provide an indication of contamination. It is important that the volume used for blanks be the same as the samples. The various types of blanks include:

Method blanks: A sample of deionised water is carried through the entire sampling and analytical process.

Trip blanks: These blanks are used to monitor potential contamination during shipping and storage. These blanks are sent from the laboratory with empty bottles and remain with other samples throughout the sampling trip but are not opened in the field.

Field and equipment blanks: These blanks are taken under field conditions and include filtration and addition of preservatives, as appropriate.

Decontamination/pump blanks (a subset of field/equipment blanks): The purpose of these blanks is to check on the decontamination process of the pump system. Two blanks are taken - one BEFORE decontamination water is pumped through pump system and one AFTER decontamination water is pumped through the system. They should be collected, treated and stored as per normal. These blanks should be taken at the beginning and end of each trip and anytime that pumping equipment is changed.

Duplicates

These are duplicate water samples that should preferably be the split of one sample or they can be two samples bottled in immediate succession and put through similar filtering, preservation, holding and analysis. Their purpose is to test for precision. Depending on the nature of the sampling project, duplicates can be taken anywhere in the range from every tenth sample to every twentieth sample. Duplicate results can be compared as relative percent difference (RPD).

$$\begin{array}{l} \text{Relative} \\ \text{Percent} \\ \text{Difference} \end{array} = \frac{\text{Sample A} - \text{Sample B}}{\text{Average Sample A} + \text{B}} \times 100$$

Spikes

A spike is a sample in which a known amount of a compound being analysed is added (or spiked) into the sample. It tests the accuracy of the analytical system and any degradation or chemical alteration of the sample from the point of collection to analysis. The spike is used to determine if you can get back as much as you put in and

the results are expressed in terms of the percent recovery with regard to the amount added. The spike solutions are transported to the field and added during the sampling process. It is recommended that they be taken whenever a duplicate is taken and that each laboratory involved in the analysis program receive a spiked sample.

$$\% \text{ Recovery} = \frac{\text{Spike Result} - \text{Unspiked Sample Result}}{\text{Concentration Added}} \times 100$$

The distribution of the type and number of quality-assurance samples will not be equal among the different types of analyses because some of the types of samples require more comprehensive quality assurance than others (ie pesticides and microbiology) and different types of samples may be affected by different conditions.

Some additional recommendations in conducting field quality assurance are:

- Select wells ahead of time for quality-assurance sampling to help assure good coverage of different field conditions. However, if field conditions indicate the potential for sampling differences, the duplicate program can be restructured. Changes and reasons for changes should be documented.
- Intensify quality assurance when there are significant changes in sample collection procedures, including equipment changes.
- Conduct the different types of quality-assurance for a particular constituent class at the same sampling sites to help in interpretation of the results.

A QA/QC program will enable quantitative corrections for systematic errors (bias) during the sampling and analytical process. The QA/QC program should be made in consultation with the laboratory and will depend on the nature of the sampling project. It is especially important that these procedures are performed for the most sensitive chemical constituents. It is important that the laboratory does not know which are the QA/QC samples as all analyses should be treated equally.

A fully valid set of groundwater analytical data should include analytical performance data (eg. method, accuracy, precision, detection and quantitation limits) reported along with each set of results

13. PROBLEMS COMMONLY ENCOUNTERED WITH GROUNDWATER SAMPLING

(adapted from Jiwan & Gates, 1992)

The following list highlights some of the problems associated with groundwater sampling that can result in a chemical analysis being unrepresentative of the groundwater. Techniques to overcome the problems are also described.

- Stagnant waters are subject to evaporation and may contain animal and plant life which is not representative of natural groundwaters. If the bore has not been pumped recently, it will be necessary to purge the bore (See Section 7).
- Contamination of a water sample by entrained sediment is a common problem when the bore has not been developed properly or low aquifer yields have not allowed for proper development. In this situation the sample should be filtered at the bore head and both the liquid and solid samples sent for analysis. This process can take a while when the sediment load is heavy.
- Release of carbon dioxide during pumping may cause an increase in pH which in turn may cause many metallic ions to come out of solution. Sample at a very slow pump rate (1 to 5 litres per minute) or bail.
- The chemistry of the sample can alter as a result of oxidation. This can occur either in the pump or can be caused by water cascading into a bore installed in tight formations or by purging, such that the water level falls to the screen interval and allows the aquifer to be exposed to the air. Groundwater usually exists in a reduced state, therefore some of the common chemical changes that occur include:

- oxidation of organics
 - oxidation of sulphide to sulphate
 - oxidation of ferrous iron and precipitation of ferric hydroxide
 - oxidation of ammonium to nitrate
 - oxidation of manganese and precipitation of manganese dioxide or similar hydrous oxide.

Problems with oxidation can largely be avoided by monitoring the oxidation state of the bore during pumping (Eh meter) and taking a sample only after the water has stabilised.

- Cross-contamination of water samples due to chemical residue in the pump or sampling equipment can cause erroneous results. This includes the improper handling of sampling equipment on the ground where it can become contaminated. Decontamination of all sampling equipment is important between samplings when high precision of results is necessary.
- The time lag between collection of a sample and analysis together with the correct preservation of the sample are two important aspects of sampling which are often

misunderstood. Table 5 shows the preferred methods of preservation and the maximum time a sample can be held in storage.

- Poor sampling logs/records have in the past resulted in a mix-up of samples. Section 11 reviews the documentation that should accompany a sample. It should be filled out at the time of sample collection with a copy for the project manager. Where appropriate, Chain of Custody forms should also be filled out.
- To date there have either been poorly designed or no quality assurance/quality control programs to ensure that the analytical results accurately express the actual concentrations of solutes in the water as they exist in the field situation. A QA/QC program should be built into all new work programs.
- The selection of equipment for sample collection can also present problems. Many of these “tools” have not been proven reliable in specific hydrogeological situations. Table 3 sets out the advantages and disadvantages for a variety of sampling equipment.

As a result of the unique nature of groundwater there is a need to be diligent with sampling procedure. A few of the problems that occur repeatedly with sampling programs include:

- When using existing bores, there are often only poor bore construction records available or none at all.
- Untrained personnel are used for sampling programs. There are many steps to sampling and each one needs to be understood in order to carry them out properly and to be able to make decisions on them in the field.
- It is difficult to do more than the minimum of determinations on-site.

14. SUMMARY OF GROUNDWATER SAMPLING PROTOCOL

The following Table outlines in step form the requirements for a generalised sampling protocol for situations like a regional groundwater quality investigation.

Table 6

Groundwater Sampling Protocol Summary

Step	Goal	Recommendation
Preparation	To integrate sampling and analysis functions	Confer with laboratory personnel about the objectives of the program and the choice of best techniques for collection, preservation and testing.
Set-up	To prevent ground contamination and have everything ready for the sampling process	Prepare field record sheets and record data in logbooks. Place plastic sheeting around well area to prevent direct contact with ground and lay out equipment. Calibrate probes, preferably everyday or when accuracy is in doubt during the sampling program.
De-contamination	To clean sampling equipment and prevent cross-contamination.	Use bleach or detergent solution. Clean system internally and externally. Consider disposal of decontamination solution.
Hydrologic Measurements	Establish non-pumping water level	Measure depth to water, total depth of well and height of casing to +1mm.
Bore Purging	To remove stagnant water	Pump a minimum of 3 bore volumes until pH, temperature, EC and Eh have stabilised. Record volume, rate, duration and time of purge.
Pumping /Bailing to Obtain Sample	To collect samples with minimal disturbance of sample chemistry	Collect samples using appropriate pump device/bailer. Use low pump rate for gas-sensitive parameters. Higher rates can be used for inorganic parameters.
Field Measurements	To avoid bias in determination of parameters/constituents which do not store well, eg gases, pH, alkalinity.	Analysis for determinations of gases, alkalinity, temperature, pH, EC, DO, and Eh should be carried out in the field. The best system is a flow-through chamber fitted with probes. Record results.
Sample Collection	To collect samples with minimal disturbance of sample chemistry	Use containers as recommended in Table 5. Ideally run a plastic hose from the bore head outlet to the bottom of the sampling bottle (Do not use plastic with organics).
Filtration	To determine 'soluble' constituents and preserve sample. To be carried out in the field as soon as possible after collection	Standard filter is 0.45 µm. Use with vacuum or pressure pump. Filter trace metals, inorganics, anions/cations, alkalinity. Do not filter for microbiology, some stable isotopes and organic compounds.
Rinse and Fill	To collect samples with minimal disturbance of sample chemistry	Rinse the sample container and cap 3 to 4 times taking care of disposing the water away from the sampling site. If sample requires filtering then use filtered water for rinsing. Fill to overflow and expel completely any air trapped in the sample bottle. If sample is to be frozen, leave air space for expansion. If container has pre-prepared preserving material in it do not rinse and allow to overflow. Cap container as soon as possible.

Sample Preservation/Storage and Transport	To minimise chemical alteration of samples prior to analysis by temperature control and/or addition of preservative.	Follow preservation method and maximum sample holding period as recommended in Table 5. Document preservation method and holding time and make sure bottles are properly labelled. Store securely and at appropriate temperature for transport.
QA/QC	To ensure analytical results accurately represent water in the field and to permit any correction of analytical result for changes which may occur after sample collection.	Collect blank, duplicate and spiked samples. There should be a minimum of 5% samples submitted as blind duplicates to a laboratory.
Chain of Custody Documentation	To be able to follow the sample history of each sample.	Ensure that each sample procedure is properly documented on the appropriate form and that there are sufficient copies for filing.

Adapted from Jiwan & Gates, 1992

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ATTACHMENT E

SIMULATED PIT INFLOWS
(HYDROSIMULATIONS, 2014)

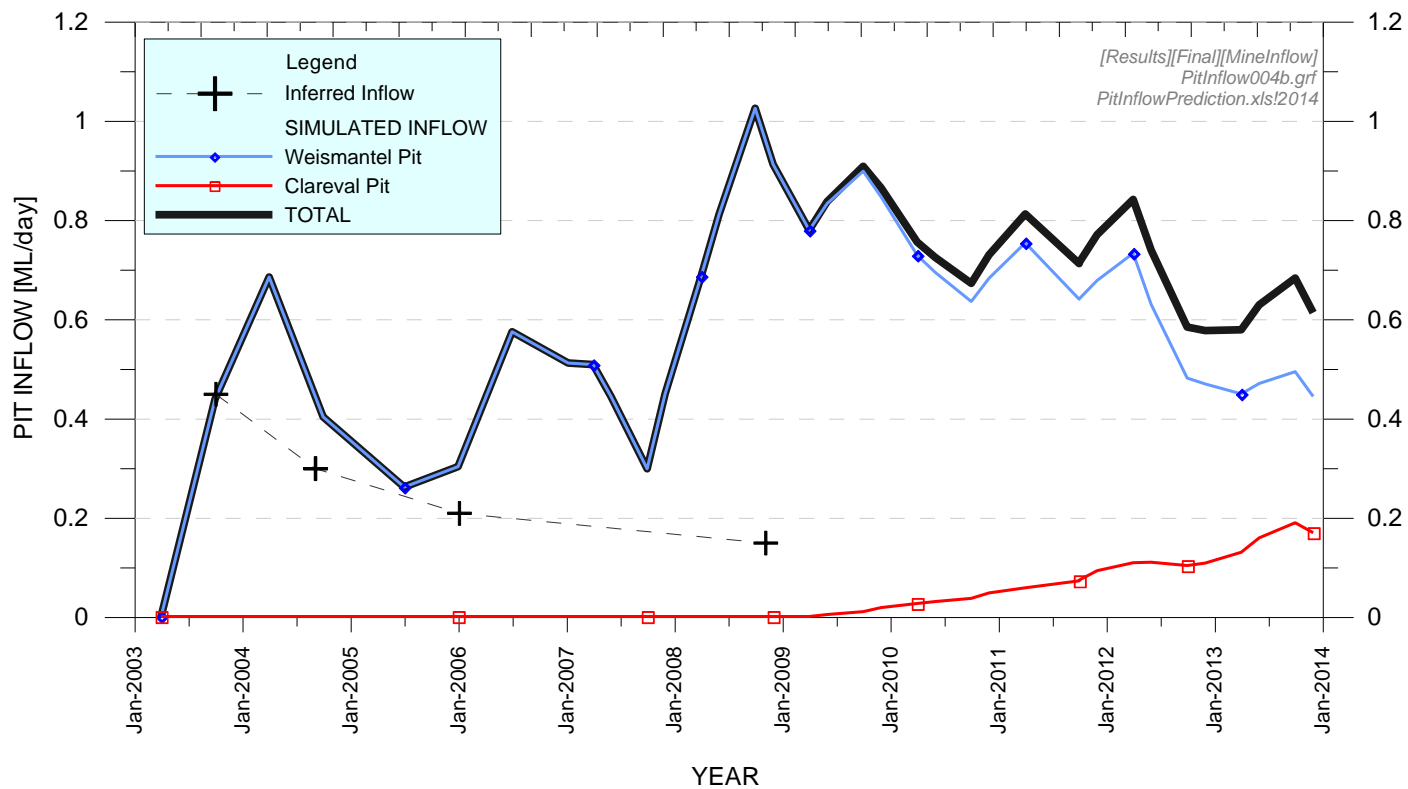


Figure E-1 Simulated Pit Inflows [ML/day]

ATTACHMENT F

INTERFACE INVESTIGATION PROGRAM – WASTE EMPLACEMENT AND
ALLUVIUM
(HYDROSIMULATIONS, 2015)



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DATE:	10 August 2015
TO:	Scott Mitchell Environmental Manager Duralie Coal Pty Ltd
	Duralie Coal (Yancoal) PO Box 168, Gloucester NSW 2422
FROM:	Will Minchin and Dr Noel Merrick
RE:	Interface Investigation Program – Waste Emplacement and Alluvium
OUR REF:	YAN004– HC2015/11c

1. INTRODUCTION

The Duralie Coal Mine (DCM) is an existing coal mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (**Figure 1**). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM. The NSW Minister for Urban Affairs and Planning granted Development Consent for the DCM in August 1997 and coal production commenced in 2003.

The Duralie Extension Project involves the extension and continuation of mine operations at the DCM. DCPL was granted approval for the Duralie Extension Project under section 75J of the NSW *Environmental Planning and Assessment Act, 1979* on 26 November 2010 (NSW Project Approval [08_0203]) and under sections 130 and 133 of the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* on 22 December 2010 (Commonwealth Approval [EPBC 2010/5396]). On 10 November 2011, the NSW Project Approval (08_0203) was amended by Order of The Land and Environment Court of NSW. On 1 November 2012, the NSW Project Approval (08_0203) was modified as a result of the Duralie Rail Hours Modification. On 5 December 2014, the NSW Project Approval (08_0203) was modified as a result of the Duralie Open Pit Modification. A copy of the consolidated NSW Project Approval (08_0203) and the Commonwealth Approval (EPBC 2010/5396) is available on the Duralie Coal website (<http://www.duralie.coal.com.au>).

Condition 29, Schedule 3 of the NSW Project Approval (08_0203), requires the preparation of a Water Management Plan for the DCM.



Figure 1 Location of Duralie Coal Mine

This report has been prepared by HydroSimulations to provide assistance in addressing the following components of the Water Management Plan, required by Condition 29(c), Schedule 3 of the NSW Project Approval (08_0203), specifically:

29. The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Secretary. This plan must be prepared in consultation with EPA¹ and NOW² by suitably qualified and experienced persons whose appointment has been approved by the Secretary, and submitted to the Secretary within 3 months of the date of this approval. In addition to the standard requirements for management plans (see Condition 2 of Schedule 5), this plan must include:

...

(c) a Groundwater Management Plan, which includes:

...

- *a program to monitor:*

...

- *the impact of the project on:*
 - *the alluvial aquifers including investigating the potential for direct interface between mine spoil and alluvium and assessment of any consequential impact on alluvial and surface water;*

...

- *a plan to respond to any exceedances of the assessment criteria, including,*
 - *if a direct interface between mine spoil and alluvium is identified, development of a trigger action response plan (TARP) for potential salinity impacts on alluvial and surface water sources; and*
 - *a plan to offset the loss of any base flow to Mammy Johnsons River caused by the project.*

2. OVERVIEW OF REGIONAL AND LOCAL HYDROGEOLOGY

The following overview is sourced primarily from HydroSimulations (2014a), with additional local detail regarding the extent of alluvium sourced from HydroSimulations (2014b).

2.1 Regional Setting

The DCM coal resource is located within the Permian-aged Gloucester Basin in NSW. To the west of the DCM, the Karuah River flows south (**Figures 1 and 2**). To the east of the DCM the Mammy Johnsons River flows south and then west just outside the DCM Mining Lease (ML) 1427 before flowing south again before joining the Karuah River (**Figure 2**). A small tributary of the Mammy Johnsons River, Coal Shaft Creek, used to flow south through the middle of the DCM mine lease, exiting at the southern edge of the lease. This is now diverted around the DCM, and still discharges to the Mammy Johnsons River (**Figure 2**).

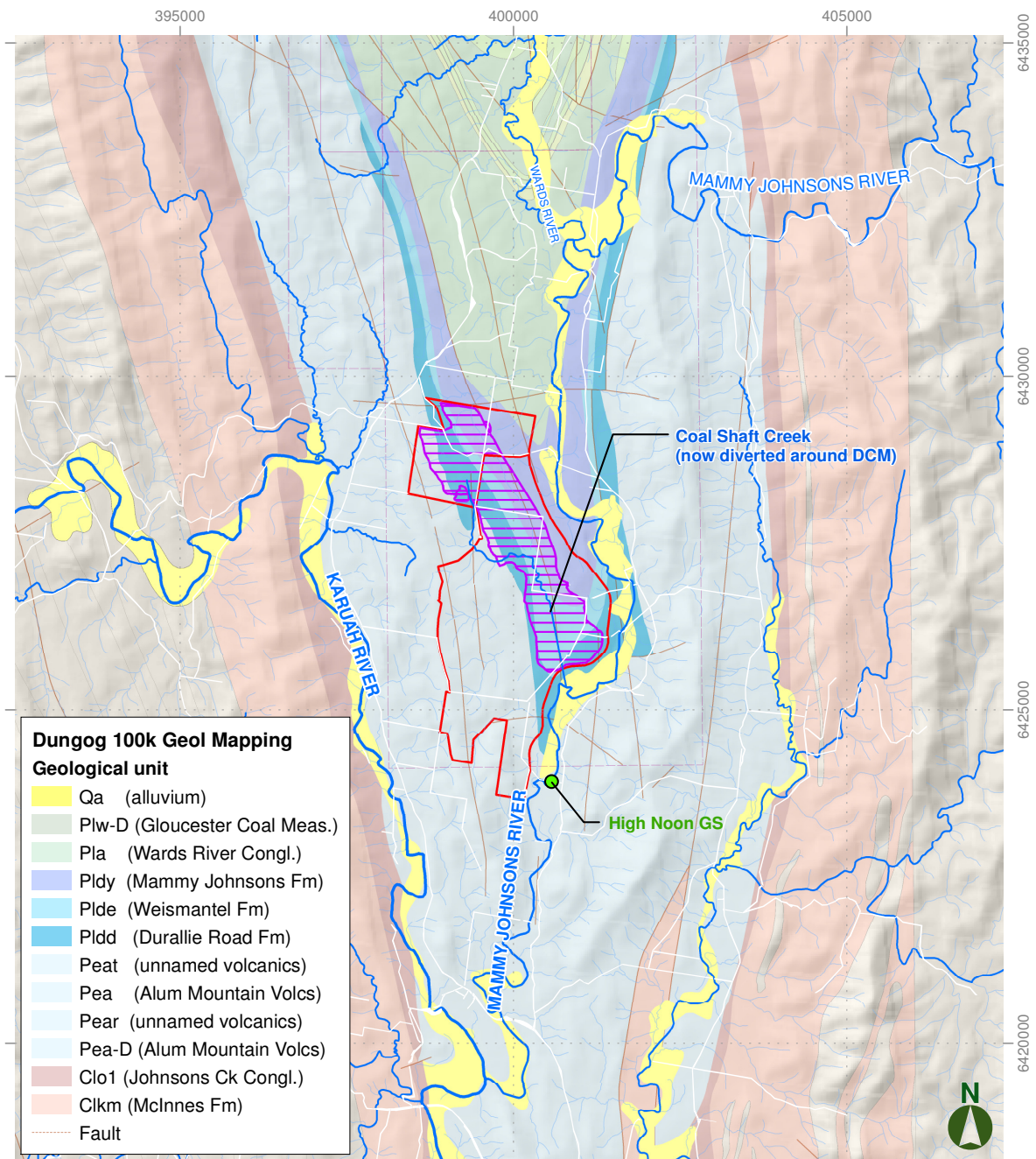
The DCM is located in the southern closure of the main synclinal structure of the Gloucester Basin and is associated with the coal bearing strata of the Dewrang Group. The Dewrang Group comprises three main stratigraphic units, namely:

- Mammy Johnsons Formation;
- Weismantels Formation; and
- Durallie Road Formation.

The outcrop mapping on **Figure 2** is the 1:100k Dungog map-sheet (Roberts *et al*, 1991).

¹ EPA: Environment Protection Authority

² NOW: NSW (Department of Primary Industries) Office of Water



- Duralie Coal Mine - full extent of Open Pit
- Coal Title (Duralie Coal)
- NSW coal title
- Watercourse
- Road
- Fault

Scale: 80,000 at A4
GDA 1994 MGA Zone 56

0 0.5 1 2 3 4 kilometres

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Figure 2 Outcrop Geology and Watercourses around DCM

2.1.1 Alluvium and Regolith

At land surface in this area there is typically either a weathered profile (regolith) which developed across the Permian or other hard-rock strata, or there is alluvium, deposited along current or prior drainage lines.

Based on the 1:100k scale mapping in **Figure 2**, a thin, narrow and discontinuous deposit of Quaternary to recent alluvial deposits occurs along the river flats of Mammy Johnsons River. The alluvium consists of silty sands and silts with lenses of gravelly sands and sandy, coarse gravel, particularly towards the base of the alluvium. The gravel lenses correspond to former channel deposits of the river and are evident in the present bed and banks of the river. Monitoring bores in the alluvium are drilled to depths of 5.8 to 10.1 m; other evidence from exploration holes suggests an average thickness of about 9 m for the alluvium, but the maximum thickness is unknown.

In recent months, a series of new datasets have become available, and of these the relevant depth of regolith (essentially depth to unweathered rock) data set (CSIRO, 2014) suggests that the maximum depth of alluvium in this area is 10-13 m. This is in good agreement with the earlier description from HydroSimulations (2014a).

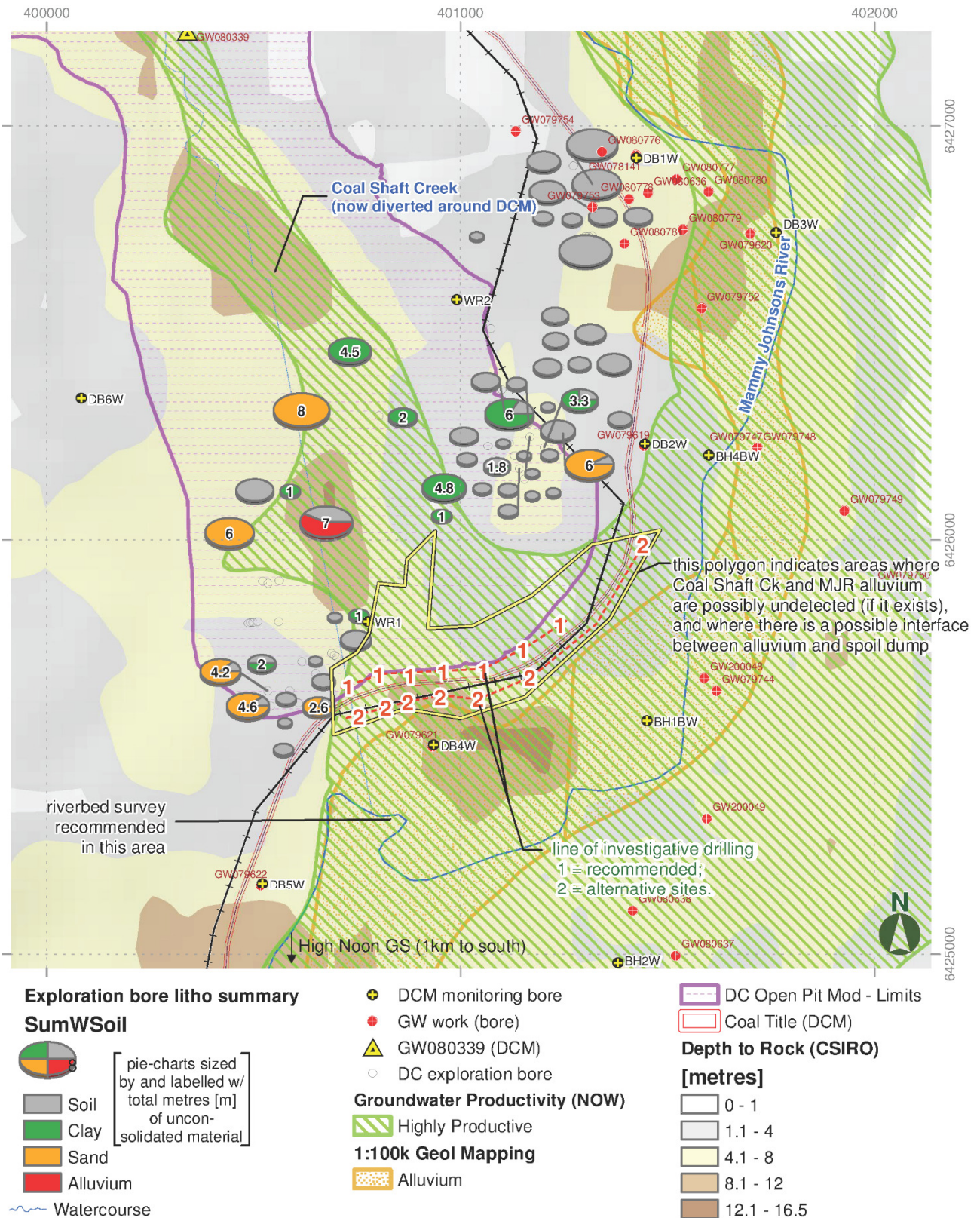
2.2 Local Hydrogeology

During the preparation of the *Duralie Coal Mine Extension Project Modification Groundwater Assessment* (HydroSimulations, 2014a), NOW indicated that their mapping of 'Highly Productive' alluvium (**Figure 3**) extends to the toe of the existing DCM waste rock emplacement (i.e. the southern extent of the waste rock emplacement), whereas the conceptualisation in the Groundwater Assessments carried out for DCPL (including the *Duralie Coal Mine Extension Project Modification Groundwater Assessment* [HydroSimulations, 2014a]) have not included this northward 'tongue' of alluvium, and nor did they have alluvium extending into the waste rock emplacement area on the southern and eastern edge of the DCM.

HydroSimulations understand that the NOW mapping is based on NSW 'Soil Landscape' mapping, which indicates that Highly Productive alluvium is present in the southern part of the DCM disturbance area (an area that was mined in the early 2000s). HydroSimulations (2014b) showed that the Soil Landscape mapping, and therefore the mapping for Highly Productive alluvium, was different to the alluvium mapped in any of the available geological maps (1:500k, 1:250k, and 1:100k).

Subsequent analysis of bore locations and bore logs (HydroSimulations, 2014b) showed that there are a number of bores in the area, although perhaps not in the area mapped as Highly Productive alluvium between the Mammy Johnsons River and the waste rock emplacement. The 15 bores present showed varied depths of unconsolidated material (up to 8 m), with most showing a thin unconsolidated horizon or only clay-dominant material above rock. Only three showed coarse grained material that is consistent with the concept of potentially Highly Productive alluvium (subject to salinity and yield criteria) and capable of providing a preferential flow path to connect the waste rock emplacement to the Mammy Johnsons River.

However the recently released 'depth to rock' mapping (CSIRO, 2014) is also presented on **Figure 3**. This shows a channel-like feature, more or less congruent with the NOW's Highly Productive alluvium. This, along with the current bore distribution, guides the recommended investigation and monitoring program outlined in **Section 3**.



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3 RECOMMENDED MONITORING PROGRAM

As described in **Section 1**, the DCM Groundwater Management Plan is required to include a program to monitor the potential impacts of the DCM on the alluvial aquifers including investigating the potential for direct interface between mine spoil (waste rock emplacement) and alluvium and assessment of any consequential impact on alluvial and surface water.

This section outlines a recommended monitoring program to address this requirement.

3.1 Field Investigations

To obtain additional information regarding the extent of alluvium in the vicinity of the southern extent of the DCM waste rock emplacement, HydroSimulations recommend the following field investigations:

- Transient Electromagnetic (TEM) geophysical survey - one transect along or near the southern boundary of ML 1427 (alternative transect lines are marked “1” and 2” on **Figure 3**). Advice will need to be taken from the TEM operator regarding the transect or survey area. The results of this survey will guide
- Drilling and logging of up to five drillholes at regular intervals (approximately 100-150 m spacing) near the southern boundary of ML 1427 along either transects suggested in **Figure 3** (but guided by the results of the TEM survey); followed by
- Installation on one, possibly two, shallow monitoring bores at the most appropriate drillhole sites, selected on the basis of TEM and drilling results. With respect to potential baseflow capture in the case of more alluvium being encountered in the previous investigations, one of these bores might need to be located within about 50 m of the river, (i.e. beyond ML 1427, just south of the [original] Coal Shaft Creek confluence).

These recommendations are based on the existing hydrogeological information described in **Section 2**.

Further details of those three recommended field investigations are as follows.

It is recommended that the TEM survey and any bores be located inside ML 1427, but as close to the boundary as possible to avoid investigating ground previously disturbed by mining. However space and access may be constrained in the field, and so may mean that the TEM survey and bore drilling cannot be conducted within ML 1427, in which case further approvals may be required. However, the recommendation is to investigate within 100 m of the ML 1427 boundary or the railway line, and the preference is as close as possible to the DCM footprint. TEM surveys are not usually affected by the presence of a rail line beyond about 10 m.

The TEM survey should be conducted first. After initial interpretation, sites for the drillholes can be selected considering the data displayed in **Figure 3**. Drilling should continue at least a couple of metres into ‘fresh’ rock (i.e. to the base of any alluvium and weathered profile) and can then be discontinued at that hole.

Once drilling has been completed and logs completed, the TEM interpretation can be finalised.

Finally, it is recommended that one, but possibly two depending on the lithology encountered, of the drillholes be completed as monitoring bores and the ground level and top of casing surveyed. It is possible that further investigative drilling may be recommended based on the finding of this initial round of investigative drilling. The preference for choosing a site is the location with the thickest horizon of coarse materials, however sites aligned with the channel features in the Highly Productive alluvium and CSIRO (2014) mapping are *probably* also favoured. The second of these could be located to further assess gaining and losing conditions to the south of the Coal Shaft Creek confluence (which is currently assessed using DB3W vs BH4BW, which are located over 1 km upstream).

3.2 Monitoring

Once the field investigations are completed, the following monitoring at the new monitoring bores should be undertaken:

- Water levels: use of water level data loggers is recommended for the first two years, mainly to investigate the response of water levels to high rainfall events as well to as high river level events. After that, water levels can be dipped in the regular round of water level monitoring;
- Field parameters (pH, EC, DO, temperature): every 3 months for the first year, then done with the usual monitoring rounds after that;
- Water chemistry: sampling for water chemistry analysis should be carried out. Monitoring is to be for pH, Eh, EC, major cations, major anions, and metals. This is to be done 3-monthly for the first year, then as per the TARP (below).

The Groundwater Management Plan should be updated to incorporate this additional monitoring.

3.3 Analysis

Following the installation of monitoring bores (one or more) along the southern edge of ML 1427 (near the former Coal Shaft Creek confluence with Mammy Johnsons River) and monitoring data becomes available, analysis of the following should be conducted:

- Degree of saturation of any alluvium or unconsolidated deposits.
- Direction of any discernible shallow groundwater gradient, comparing water levels from new monitoring bore(s), local surveyed Mammy Johnsons River river bed level and High Noon stage records, and groundwater levels from existing monitoring bores BH4W, WR1, DB4W.
- Assessment of local groundwater chemistry changes suggesting potential groundwater movement from waste rock emplacements toward the Mammy Johnsons River.
- Comparison of any monitored water levels near the Coal Shaft Creek confluence with modelled results to verify the numerical model. This may need to include findings from the investigation of alluvium described above. Discrepancy between modelled and observed groundwater levels may then indicate more or less baseflow capture than predicted in HydroSimulations (2014a).

The information collected from the recommended monitoring program should allow DCPL to confirm if there is any direct interface between mine spoil (the waste rock emplacement) and alluvium. An assessment of any consequential impact on alluvial and surface water should also be able to be conducted at this stage.

4 TRIGGER ACTION RESPONSE PLAN (TARP) AND BASEFLOW OFFSET PLAN

As outlined in Section 1, Condition 29(c), Schedule 3 includes the requirement for:

a plan to respond to any exceedances of the assessment criteria including,

- *if a direct interface between mine spoil and alluvium is identified, development of a trigger action response plan (TARP) for potential salinity impacts on alluvial and surface water sources; and*
- *a plan to offset the loss of any base flow to Mammy Johnsons River caused by the project.*

These requirements are discussed in the following sections.

4.1 Trigger Action Response Plan

In accordance with Condition 29(c), Schedule 3 of the NSW Project Approval (085_0203), the development of the TARP is conditional on the investigation outlined in Section 3 identifying a “direct interface between mine spoil and alluvium”. DCPL will develop a TARP (if required) once the investigation and monitoring program (Section 3) has been completed.

Notwithstanding the above, a suggested ‘conceptual’ TARP is outlined below:

Water Quality Triggers

Level 1 Trigger – set trigger for pH, EC based on historical data, e.g. 50th and 80th percentiles → detailed analysis by a Qualified Person to assess likely source of such a result.

Level 2 Trigger – set trigger for pH, EC (as above) → Notification to NOW, plus immediate sampling and laboratory analysis of EC, pH, Eh, cations, anions and metals.

Level 3 Trigger – set trigger for pH, EC → Notification to NOW. Consider actions to prevent or minimise further migration, e.g. the need to install a new bore, or pump from existing bore, to capture any plume.

4.2 Mammy Johnsons River Baseflow Offset Plan

Modelling in HydroSimulations (2014a) suggested that mining would result in baseflow capture of about 0.016 ML/d (16 m³/d) (peak rate of loss is estimated at 0.02 ML/d). This rate of loss is negligible, i.e. at Q90, this reduction is less than 2% of Mammy Johnsons River flow, and at Q95 this reduction is approximately 5% of Mammy Johnsons River flow.

To assess whether baseflow capture exceeds this predicted amount, HydroSimulations recommend the following.

Comparison with modelled groundwater levels: compare modelled groundwater levels in the alluvium near to the transect sites. Deviation between modelled and observed may indicate greater leakage than predicted. This to be done on an annual basis, i.e. in Annual Reviews.

If investigative drilling suggests that alluvium is more extensive than indicated by published geological maps, revision of the conceptual model and numerical model may be necessary. As a result, the predicted baseflow capture may change.

Water Level

Analysis to be carried out with records from High Noon gauging station (**Figure 3**), groundwater levels from new monitoring bore(s) and surveyed elevation of riverbed near 400850, 6425325 (MGA94 zone 56 coordinates, marked roughly on **Figure 3**).

Level 1 – water level falls or remains below river stage for a period (to be determined, maybe weeks) → detailed analysis by a Qualified Person to assess likely source and implication of such a result. Check model predictions.

Level 2 – water level falls or remains below river stage for a period (to be determined, maybe 3-4 months) → Check model predictions, possible need for model recalibration, and prediction of baseflow loss from revised model. Possible need for baseflow offset. Notification to NOW.

HydroSimulations (2014a) predicted that any potential baseflow capture as a result of the Duralie Extension Project (incorporating the Open Pit Modification) would be negligible. In the event that the baseflow capture is determined by either of the methods above to be greater than negligible, it is recommended that an administrative offset be implemented.

The administrative offset should involve DCPL purchasing and retiring a surface water licence to cover estimated future effects – the licence would need to be relatively small (7 ML/a) to cover peak baseflow capture.

5 REFERENCES

- CSIRO (Wilford, J.; Searle, R.; Thomas, M.; Grundy, M.), 2014. Soil and Landscape Grid National Soil Attribute Maps - Depth of Regolith (3" resolution) - Release 1. v3. CSIRO. Data Collection. 10.4225/08/546F06DFDFAC1.
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