Vickery Coal Project

Environmental Impact Statement

APPENDIX B

SURFACE WATER ASSESSMENT

Resource Strategies

WHITEHAVEN COAL

Whitehaven Coal Limited

Vickery Coal Project

Surface Water Assessment

January 2013

FINAL REPORT

Version control

Revision	Date Issued	Author	Reviewed by	Comments
0.1	17/07/2012	E&P	SP	Preliminary Draft
0.2	27/09/2012	E&P	SP	Draft
0.3	17/10/2012	E&P	SP	Final Draft
0.4	31/10/2012	E&P	SP	Final for adequacy review
0.5	25/01/2013	E&P	SP	Addressed comments from agency responses

Summary

This report provides an assessment of the surface water regime in the vicinity of the proposed Vickery Coal Project (the Project) and the surface water impacts associated with the Project.

The Project has a proposed life 30 years, and would involve the development of an open cut mine using conventional mining equipment, haul trucks and excavators to remove up to 4.5 million tonnes per annum of run-of-mine coal and approximately 48 million bank cubic metres per annum of waste rock. Waste rock would be placed in two external emplacements either side of the planned open cut and within mined-out voids.

This Surface Water Assessment reflects a program of investigations and analysis; together with close liaison with the mine planners, that has been undertaken to develop a mine plan and the associated water management facilities necessary to minimise or mitigate the potential surface water impacts associated with the mine. Specifically, this surface water assessment has been developed to address all relevant aspects of the Director-General's requirements, including:

- documenting the existing catchment conditions and the flow regime and water quality in the creeks draining from the Project area;
- assessing proposed water discharge quantity and quality against receiving water quality and flow objectives and assessing potential quality and quantity impacts on affected licensed water users and basic landholder rights;
- assessing potential quality and quantity impacts; including changes in environmental flows, on riparian, ecological, geomorphological and hydrological values of watercourses;
- describing the site water demands, water disposal methods (including volume and frequency of any water discharges), water supply infrastructure and water storage structures necessary to support the mine;
- providing a detailed analysis of site water balance;
- demonstrating that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan; and
- providing a detailed flood impact assessment, which identifies impacts on local and regional flood regimes, including an assessment of the potential for flooding to occur in the open cut and any measures proposed to mitigate potential flood impacts.

Catchment Runoff and Surface Water Quality

Surface water from most of the Project area drains via un-named ephemeral drainage lines that rise in the Vickery State Forest and drain in a westerly direction to join Driggle Draggle Creek which, in turn, drains into Barbers Lagoon, an anabranch of the Namoi River. A small section of the Project area drains in a southerly direction to join Stratford Creek, a minor tributary of the Namoi River that drains into the river about 15 kilometres (km) south west of Boggabri.

In the absence of any flow monitoring on creeks in the immediate vicinity of the Project, the flow regime, pre-, during and post-mining has been estimated using a rainfall-runoff model with parameters derived from Maules Creek (about 20 km north of the Project area). Modelling indicates that the average annual runoff is of the order of 0.22 megalitres per hectare, with zero runoff in many dry years.

The proposed water management facilities for the mine would include two diversion dams to re-direct water that would otherwise drain into the open cut. Runoff modelling indicates that, at the point where the diverted flow would enter Driggle Draggle Creek, the annual runoff is expected to increase over the life of the mine by less than 0.25%. Even in the wettest year expected (based on over the past 112 years of rainfall records), the annual runoff would only be expected to increase by just over 1%.

At the point where the majority of the project site drains into Driggle Draggle Creek average annual runoff would be expected to decrease as a result of the mine subsuming about 14.5 square kilometres of the catchment. Assuming worst case conditions, in which there is no discharge from the sediment basins located around the periphery of the waste rock emplacements, the average annual runoff would be expected to decrease by approximately 6.5% over the life of the mine. In practice, however, the change in flow is expected to be negligible because the waste rock emplacements can be expected to generate more runoff than the natural land surface and 60% of the runoff to the sediment basins would discharge after treatment.

The *Fluvial Geomorphology Assessment* (Fluvial Systems, 2012) undertaken in conjunction with this Surface Water Assessment concludes that the changes in the flow regime in the creeks will not have any significant impact on fluvial geomorphological processes.

At the completion of mining, the Project would result in a 4.3% reduction to the catchment of Driggle Draggle Creek and a 0.01% reduction in the Namoi River catchment.

The limited water quality data available from creeks in the vicinity of the Project (on account of the ephemeral nature of the flow) indicates that the existing water quality has been impacted by agricultural activities. The proposed water management systems for the mine, described in more detail below, are expected to lead to negligible change in water quality in the creeks.

Site Water Use and Management

The proposed mine water management system has been designed to segregate mine water, overburden runoff and ‘clean’ runoff from outside the mine; and to manage water from these sources in a manner that protects the environment and caters for the operating requirements of the mine.

As noted previously, clean water from undisturbed catchments to the east of the open cut, largely from Vickery State Forest, will be intercepted by diversion dams which will provide sufficient water elevation to allow the water to be flow northwards into Driggle Draggle Creek without any need for pumping. The mine layout also provides a riparian corridor that will allow runoff to flow unimpeded southward from the Vickery State Forest into Stratford Creek.

Runoff from all overburden emplacements that drain away from the open cut would be directed into a series of sediment basins from which water would either be transferred to the mine water management system or returned to the local watercourses when water quality criteria have been met. These sediment basins would be designed and operated in accordance with the relevant guidelines for mine sites.

Runoff and groundwater seepage into the open cut, and runoff from the mine infrastructure area (MIA), would be pumped to mine water dams from which it would be reused for operational purposes, principally dust suppression and in the coal crushing process (estimated to average 1,179 megalitres (ML) per year). Mine water surge storage dams would be constructed as necessary to provide storage capacity necessary to hold mine water over prolonged wet periods. All water from the open cut and MIA would be retained in the mine water management system, or in an extreme case, within the open cut. No water from the mine water management system would be discharged to the environment.

Priority for the source of water to be used for operational purposes would be given to water from the open cut and MIA, followed by runoff in sediment basins. Water from these sources would be used in preference to water from licensed external sources for which Whitehaven Coal Limited holds appropriate licences.

Water balance analysis has been undertaken to ascertain the performance of the mine water management system over the life of the mine in all climate sequences represented by 112 years of historic rainfall records. The water balance analysis takes account of all water sources contributing to the mine water management system and all water demands on a day to day basis as the layout of the mine changes over time. The water balance analysis has been used to assess the water storage volume required to minimise the risk of water being retained within the open cut for an extended period while also minimising the requirement for supplementary water from external sources. On the basis of this analysis, a risk based strategy has been developed that would involve the progressive increase in the total mine water storage capacity from 1,400 ML initially to about 2,800 ML from Year 20 to account for the maximum disturbance area anticipated in about mine year 26.

Flooding

Flood analysis has been carried out to assess flood conditions in the vicinity of the mine and MIA in order to ensure that the open cut and MIA would be outside the area likely to be affected by flooding in a 100 year average recurrence interval flood. Analysis has also been undertaken to assess the potential impact of the proposed overpass over the Kamilaroi Highway on flood levels and flow patterns in the vicinity of the proposed private haul road and Kamilaroi Highway overpass.

This analysis utilised the hydraulic model (now held by the New South Wales Office of Environment and Heritage) which provided the technical basis for the Namoi Floodplain Management Plan. Refinements were made to the model to reflect details of the proposed private haul road and Kamilaroi Highway overpass and the floodplain of Stratford Creek to the south of the Project.

The flood analysis indicated that, in a flood equivalent to the 1955 flood (taken to be equivalent to a 100 year average recurrence interval flood), the overpass would constrict flows along Deadmans Gully which would lead to an increase in flood levels of up to 0.47 metres (m) at the overpass and 0.39 m at a location 90 m upstream of the overpass. Small changes in flood levels (in the order of several centimetres) were calculated to occur 1 to 2 km upstream of the overpass in all four major flow paths across the floodplain. The analysis indicated that in a flood the same as the 1955 flood, 13 houses would be affected by a flood level increase of more than 20 millimetres (mm) of which four houses would experience flood level increases in the range of 50 mm to 90 mm. Two houses downstream of the overpass would experience a reduction in flood levels by up to 340 mm.

Page intentionally left blank

Table of Contents

List of Appendices

List of Figures

List of Figures (Continued)

List of Tables

List of Tables (Continued)

Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
AWBM	Australian Watershed Bounded Model
AWD	Available Water Determinations
BoM	Bureau of Meteorology
CAP	Catchment Action Plan
DGR	Director General's Requirements
CHPP	Coal Handling and Preparation Plant
DP&I	Department of Planning and Infrastructure
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EMU	Extraction Management Unit
EPL	Environmental Protection License
FMP	Floodplain Management Plan
LTAAEL	Long-Term Average Annual Extraction Limits
MIA	Mine Infrastructure Area
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
TOC	Total Organic Carbon
TSS	Total Suspended Solids
WSP	Water Sharing Plan

1 Introduction

1.1 Background

This Surface Water Assessment has been prepared by Evans & Peck on behalf of Whitehaven Coal Limited (Whitehaven). This document forms part of the Specialist Consultant Studies Compendium prepared in support of the Environmental Impact Statement (EIS) for the proposed Vickery Coal Project (the Project).

1.2 Location

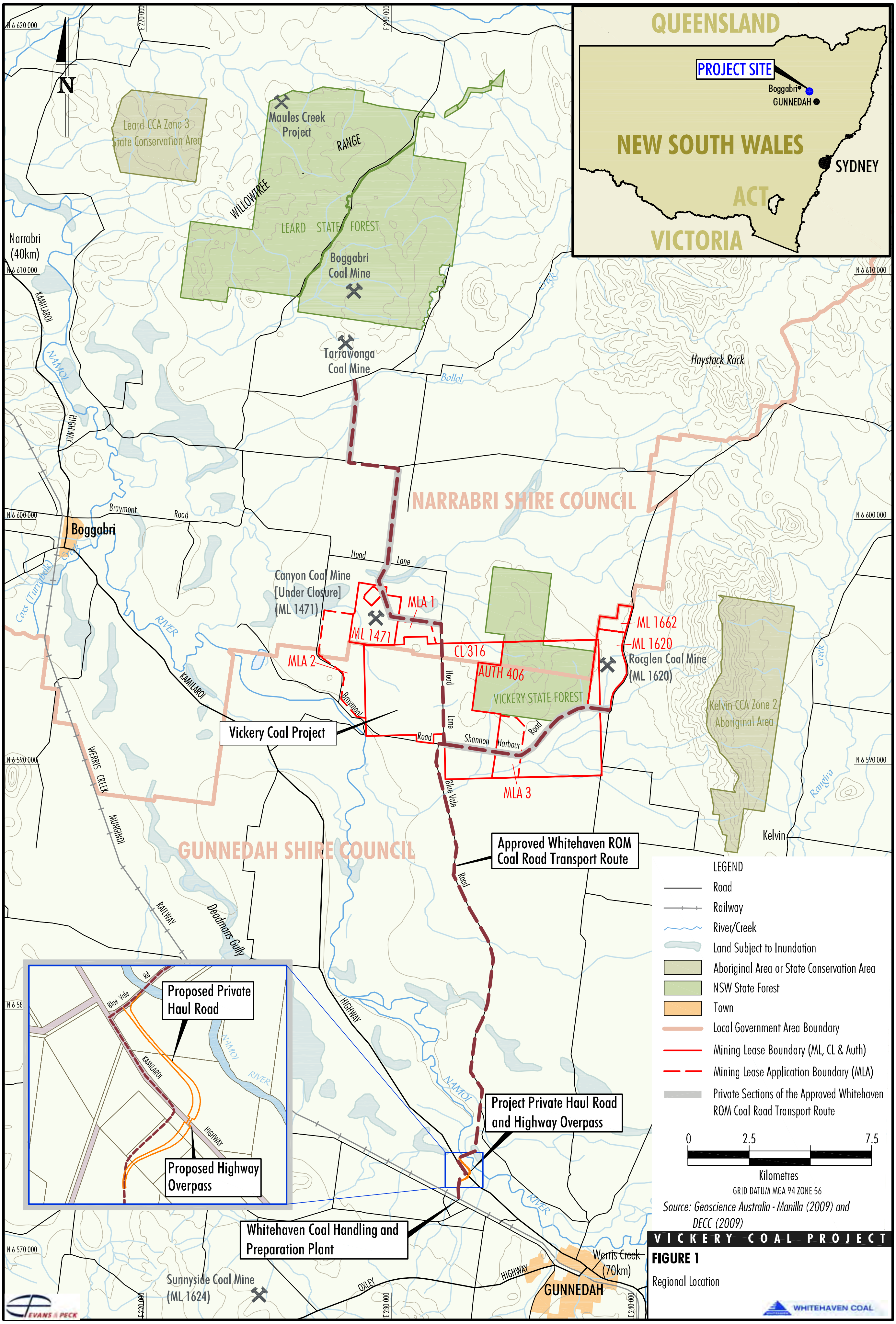
The Project is located approximately 25 kilometres (km) north of Gunnedah and 15 km south-east of Boggabri in the Gunnedah Basin of New South Wales (NSW) (see **Figure 1**).

1.3 Project Description

The proposed life of the Project is 30 years, anticipated to commence in early 2014.

The main activities associated with the development of the Project are listed below:

- development and operation of an open cut mine within Coal Lease 316, Authorisation 406, Mining Lease 1471, Mining Lease Application (MLA) 1, MLA 2 and MLA 3;
- use of conventional mining equipment, haul trucks and excavators to remove up to 4.5 million tonnes per annum of run-of-mine (ROM) coal and approximately 48 million bank cubic metres (Mbcm) of waste rock per annum from the planned open cut;
- placement of waste rock (i.e. overburden and interburden/partings) within external emplacements to the west and east of the planned open cut (i.e. Western Emplacement and Eastern Emplacement) and within mined-out voids;
- construction and use of a Mine Infrastructure Area (MIA) including on-site coal crushing, screening and handling facilities to produce sized ROM coal, workshops, offices and services;
- transport of ROM coal by haulage trucks to the Whitehaven Coal Handling and Preparation Plant (CHPP) on the outskirts of Gunnedah (approximately 20 km to the south of the Project open cut) for processing;
- use of an on-site mobile crusher for coal crushing and screening of up to 150,000 tonnes (t) of domestic specification coal per annum for direct collection by customers at the Project site;
- use an on-site mobile crusher to produce up to approximately 90,000 cubic metres (m^3) of gravel materials per annum for direct collection by customers at the Project site;
- construction and use of a water supply bore, and a surface water extraction point on the bank of the Namoi River and associated pump and pipeline systems;
- construction and use of new dams, sediment basins, channels, dewatering bores and other water management infrastructure required to operate the mine;
- construction and use of new soil stockpile areas, laydown areas and gravel/borrow areas;
- construction of a 66 kilovolt (kV)/11 kV electricity substation and 11 kV electricity transmission line;



VICKERY COAL PROJECT

FIGURE 1

Regional Location

WHC-10-03_App SW_101B

- transport of coarse rejects generated within the Whitehaven CHPP via truck to the Project for emplacement within an in-pit emplacement area;
- transport of tailings (i.e. fine rejects) generated within the Whitehaven CHPP via truck to the Project for emplacement within co-disposal storage areas in the open cut and/or disposal in existing off-site licensed facilities (e.g. the Brickworks Pit);
- realignment of sections of Blue Vale Road, Shannon Harbour Road and Hoad Lane to the east and south of the open cut;
- realignment of the southern extent of Braymont Road to the south of the open cut;
- construction of an approximately 1 km long section of private haul road (including an overpass over the Kamilaroi Highway) between Blue Vale Road and the Whitehaven CHPP;
- ongoing exploration, monitoring and rehabilitation activities; and
- construction and use of other associated infrastructure, equipment and mine service facilities.

Approximately 135 million tonnes of ROM coal would be mined from the open cut during the life of the Project. Mining operations would be conducted up to 24 hours per day, seven days per week.

Figures 2a and **2b** illustrate the Project, including the open cut, two waste rock emplacement areas, the MIA, local road diversions and the private haul road and Kamilaroi Highway overpass.

1.4 Objectives

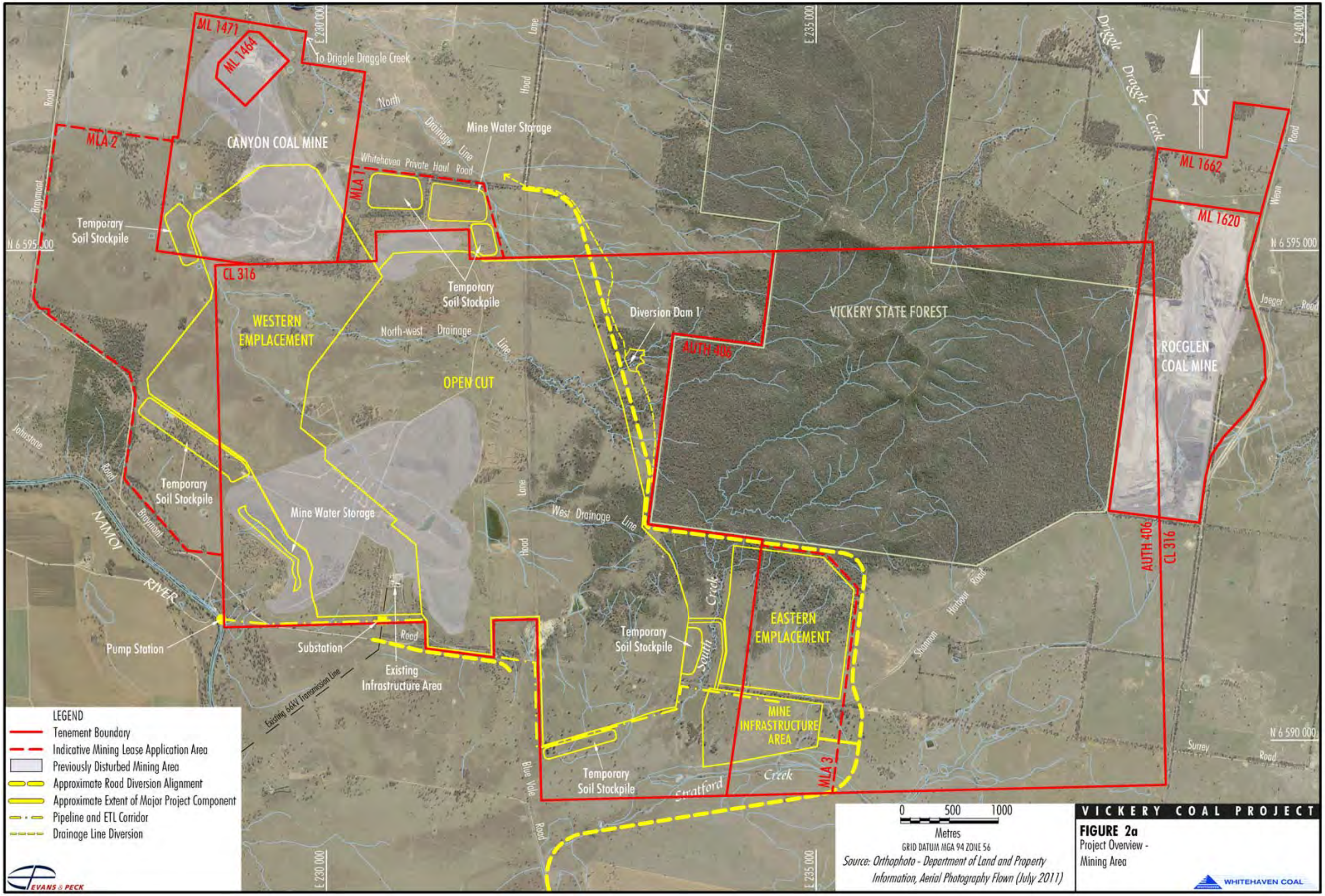
The objectives of this Surface Water Assessment are to:

- document the existing catchment conditions and the flow regime and water quality in the creeks draining from the Project area;
- assess the impacts of any changes in the flow and water quality resulting from the proposed project, and the mitigation actions necessary to minimise the impacts; and
- identify appropriate monitoring and management measures necessary to verify the predicted impacts of the project and initiate any additional mitigation measures.

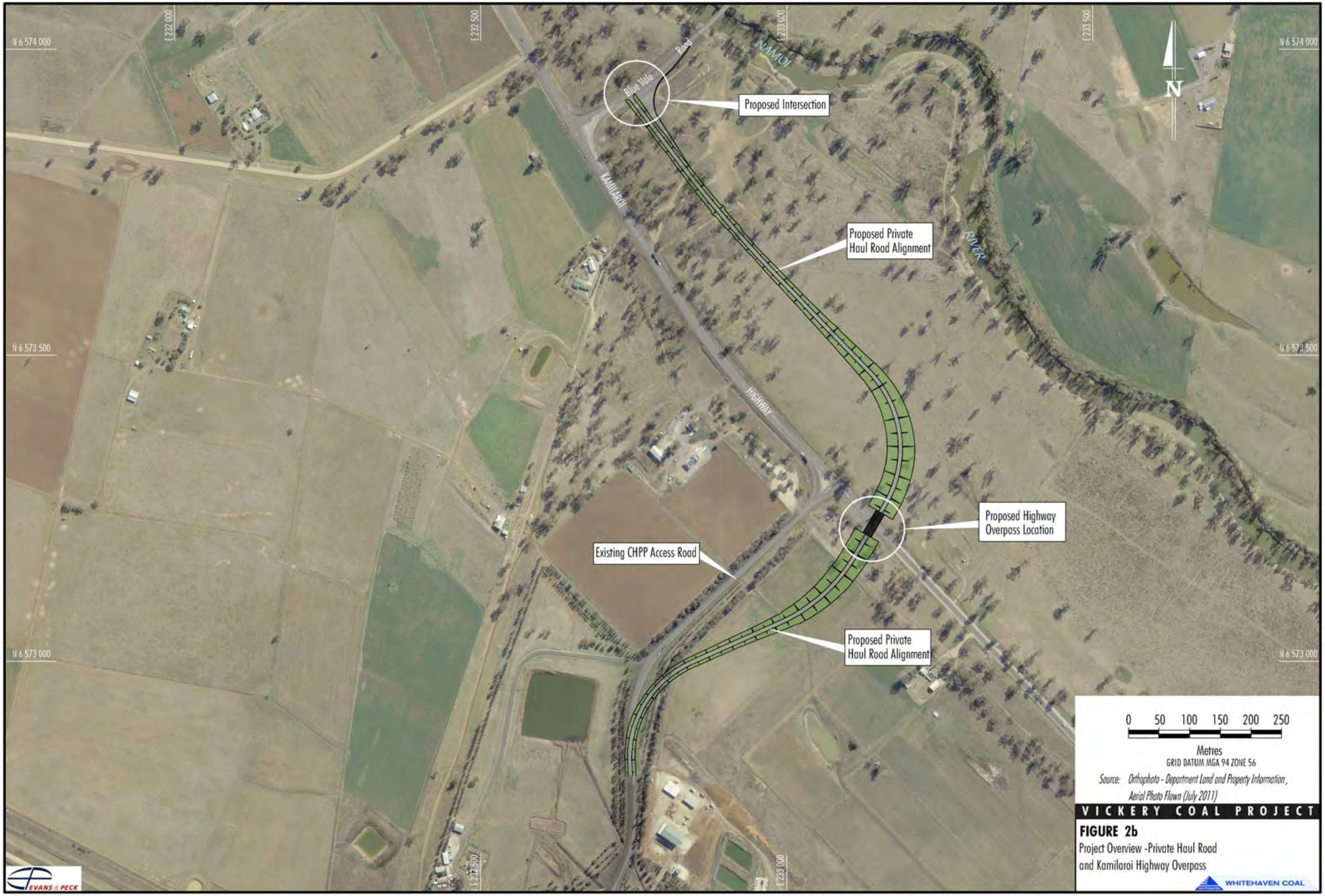
1.5 Key Risks

An Environmental Risk Assessment for all aspects of the project was prepared at a workshop attended by key specialist environmental consultants and Whitehaven representatives on 6 July 2012 (the *Environmental Risk Assessment* report is provided as Appendix M to the EIS).

Table 1 summarises the identified risks relating to surface water and provides an outline of the consideration given to the issue in this Surface Water Assessment together with any relevant mitigating factors or proposed actions and the assessed risk after taking account of the proposed mitigation actions. Note that the wording in the first column corresponds to the risks identified in the Environmental Risk Assessment, but the second column provides specific explanation in the context of this report.



WHC-10-03_App SW_102B



WHC-10-03_App SW_111B

Table 1: Surface Water Related Environmental Risks and Mitigation Proposals

Issue	Consideration of Issue and Mitigation Factors / Proposals	Risk
Insufficient site water flow/use monitoring data to enable model calibration which could cast doubt over predictions of water excess or shortfall.	Water balance modelling based on published data from other mines and benchmarked against observations at Rocglen Mine. Any shortfall would be mitigated by sufficient water licences held by Whitehaven to offset any shortfall and ability to temporarily transfer water allocations between Whitehaven's operations. Any excess of mine water would be managed by adequate sizing of storages (using the open cut as a backup) to ensure retention of all mine water, and conservatism in modelling.	Low
Adverse impacts on downstream water quality parameters that could have consequential effects on ecology or beneficial use.	Mitigated through design and management of erosion and sediment control structures in accordance with the guidelines; and sizing of mine water management storages to retain all mine affected water.	Low
Changes to flooding characteristics due to construction of private haul road and Kamilaroi Highway overpass.	Changes to flood levels and flood hydraulics in the vicinity of the Kamilaroi Highway overpass assessed in the *Flooding Assessment* (**Appendix D** of this report). Impacts would be mitigated through inclusion of culverts in the road design, constructing the structure close to natural ground level as possible and appropriate road design (e.g. batters).	Low
Licensed extraction from the Namoi River.	Mitigated by water extraction in accordance with licence conditions.	Low
Mine water discharge in the event of extreme weather events.	Mitigated by appropriate design/maintenance of erosion controls and sizing of storages.	Low
Increased leakage of, or reduced base flow to the Namoi River due to depressurisation of aquifers.	Mitigated through the location of the final voids away from the Namoi River and the option of storing water in the Blue Vale void to provide a hydraulic gradient towards the Namoi River.	Low
Risk of seepage from storage within Blue Vale void towards the Namoi River.	Mitigated through regular water level and quality monitoring of the Namoi River and Blue Vale void.	Medium
Seepage/runoff from mine disturbance areas bypassing water management systems and migrating off-site with possible downstream contamination.	Assessment considers the likely contaminants present in runoff from disturbed areas. Any potential impact would be mitigated by placement of potentially acid forming or sodic material and sub-economic coal at least 10 metres (m) away from the final land surfaces (as recommended in the *Geochemistry Assessment* – Appendix L to the EIS). Mitigation would also be provided by a suitably sized water management system and regular monitoring.	Low

1.6 Report Structure

The assessment of potential impacts on surface water is closely related to other physical processes within the catchment particularly interaction with the groundwater system. Accordingly this report draws on information provided in the following related reports:

- *Groundwater Assessment* prepared by Heritage Computing (2012) (Appendix A to the EIS); and
- *Fluvial Geomorphology Assessment* prepared by Fluvial Systems (2012) (**Appendix A** of this Surface Water Assessment).

This Surface Water Assessment has been structured in the following manner:

- **Sections 2 – 6** 'set the scene' in terms of the regulatory and physical context;
- **Section 7** provides and analysis of flood conditions in the Namoi valley and the potential impacts on the Project;
- **Section 8** and **Section 9** describe the proposed water management systems within the Project area and the performance of the system in terms of the reliability of water supply and the frequency and volume of discharge under a wide range of possible climate scenarios;
- **Section 10** describes proposals for management of runoff from external catchments that drain into the Project area;
- **Section 11** provides an assessment of climate change impacts; and
- **Section 12** describes the recommended monitoring regime to ensure that the surface water management system performs in the anticipated manner and the Project has minimal impact on external catchments.

Page intentionally left blank

2 Director-General's Requirements

The Director-General's Requirements (DGRs) for the Project under Section 78A (8A) of the *Environmental Planning and Assessment Act 1979* were provided from the Department of Planning & Infrastructure (DP&I) on 19 January 2012.

Table 2 provides a summary of the DGRs relating to surface water and indicates where the specific issues have been addressed within this document. The DGRs are provided in Attachment 1 to the Main Report of the EIS.

Table 2: DGRs Related to Surface Water

	Requirement	Reference
General Requirements	The EIS must include a: ▪ detailed description of the development including environmental protection;	Sections 1.3, 8
	▪ risk assessment of the potential environmental impacts of the development, identifying the key issues for further assessment;	Section 1.5
	▪ detailed assessment of the key issues specified below, and any other significant issues identified in this risk assessment, which includes: - a description of the existing environment, using sufficient baseline data;	Sections 4, 5, 6
	- an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant guidelines, policies, plans and statutes; and	Sections 3, 8, 9, 10
	- a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment; and	Sections 8, 9
	- detailed environmental monitoring programs, including where relevant co-ordination of monitoring programs and protocols with adjoining mining operations to assess cumulative impacts;	Section 12
	▪ consolidated summary of all the proposed environmental management and monitoring measures, highlighting commitments included in the EIS.	Sections 8, 9, 12
Key Issues: Water Resources	The EIS must include: ▪ a detailed assessment of potential impacts on the quality and quantity of existing surface water resources, including:	
	– impacts on affected licensed water users and basic landholder rights; and	Section 3
	– impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows;	Sections 4, 8, 9, 10
	▪ a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Appendix E

Table 2 (Continued): DGRs Related to Surface Water

	Requirement	Reference
Key Issues: Water Resources	▪ an assessment of proposed water discharge quantity and quality against receiving water quality and flow objectives;	Section 6
	▪ assessment of impacts of salinity from mining operations, including disposal and management of coal rejects and modified hydrogeology, a salinity budget and the evaluation of salt migration to surface and groundwater sources;	Section 8.5
	▪ identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*;	Section 3.1
	▪ demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo;	Section 3.1
	▪ a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface water impacts;	Sections 8, 9, 12
	▪ a detailed flood impact assessment, which identifies impacts on local and regional flood regimes, including:	Section 7, Appendix D
	– an assessment of the potential for flooding to occur in the open cut pit; and	Section 7, Appendix D
	– any measures proposed to mitigate potential flood impacts.	Section 7, Appendix D

3 Relevant Legislation, Policy and Guidelines

3.1 Legislation

3.1.1 Water Act 1912 and Water Management Act 2000

The aim of the *Water Management Act 2000* is to provide for the sustainable and integrated management of the water sources of NSW for the benefit of both present and future generations. The *Water Act 1912* and the *Water Management Act 2000* contain provisions for the licensing of water capture and use. If any dams are proposed as part of the Project water management system, consideration must be given to whether the dams need to be licensed.

A controlled activity approval under the *Water Management Act 2000* is typically not required for surface mining activities approved as State Significant Developments.

3.1.1.1 Harvestable Rights

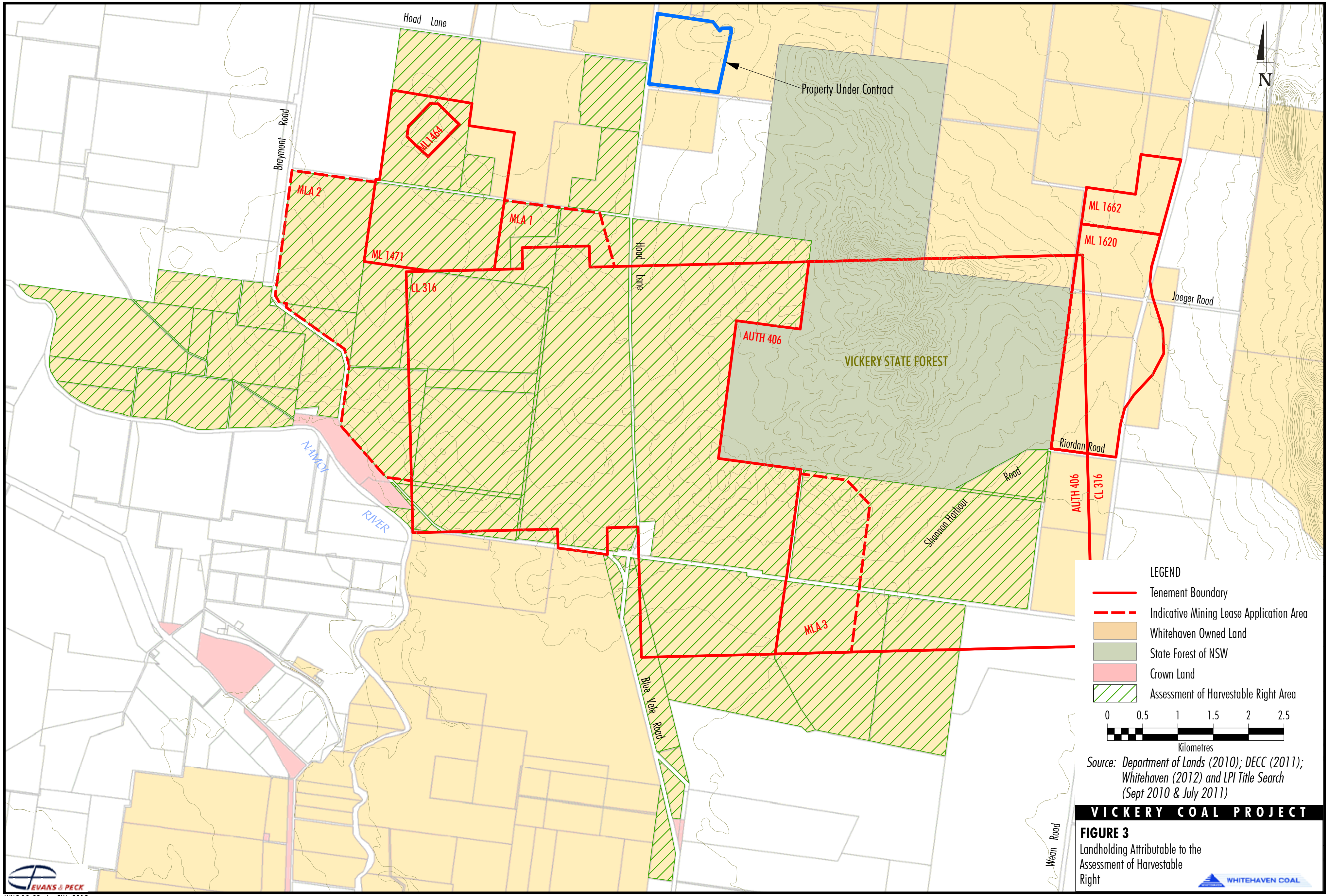
Harvestable rights orders made by the Minister under Section 54 of the *Water Management Act 2000* give a landholder the right to capture 10% of the average regional rainwater runoff on the land by means of a dam or dams having not more than the total capacity calculated in accordance with Schedule 1 of the orders, providing such structures are located on minor streams only (i.e. first and second order streams). This water can, in most cases, be used for any purpose.

The maximum capacity of the harvestable right dam(s) for a landholding is calculated by multiplying the area of the land holding by a location specific multiplier value, available from online maps on the NSW Office of Water (NOW) website.

The multiplier for the Project area is 0.07. The landholding owned by Whitehaven, as shown on **Figure 3,** that is attributable to the Project for purposes of harvestable rights, is 5,596 hectares (ha). Accordingly, the maximum harvestable right capacity is 392 megalitres (ML).

Note that the harvestable right dam capacity, as calculated from the multiplier values, implies that the storage capacity is equal to 10% of the average annual rainfall runoff from the land, but does not specifically nominate how much water can be taken annually, although the *Water Management Act 2000* specifies 10% of the average annual rainfall runoff.

Table 3 lists the identified water storage dams located within the Whitehaven landholding shown on **Figure 3**. The existing capacity of all water storage dams (as opposed to sediment basins for sediment control purposes) is approximately 37 ML which is significantly less than the harvestable right of 392 ML. Accordingly, dams totalling approximately 355 ML could be constructed for the Project. If dams totalling 355 ML were constructed on first or second order streams, no licence would be required. However, any storages constructed on higher order streams would need to be licensed, in which case the total water storage capacity attributable to the related landholding would be a relevant consideration.



VICKERY COAL PROJECT

FIGURE 3

Landholding Attributable to the Assessment of Harvestable Right

WHC-10-03_AppSW_201C

Table 3: Identified Water Storage Dams within the Landholding shown on Figure 3

Dam	Location	Volume (ML)
SD-1 Dam	North of intersection of Shannon Harbour Road and Blue Vale Road.	20
Triangle Dam	North-east of intersection of Shannon Harbour Road and Blue Vale Road.	5
SD-1 (Canyon)	Inside north-west corner of Canyon Coal Mine lease boundary.	<1
SD-2 (Canyon)	Outside the mid-point of western boundary of Canyon Coal Mine lease boundary.	~1
SD-3 (Canyon)	East of the Canyon Coal Mine access road on the north side of the Canyon Coal Mine.	<1
SD-4 (Canyon)	South-east of SD-2, inside the mid-point of western boundary of Canyon Coal Mine lease boundary.	<1
SD-5 (Canyon)	Slightly south-east of SD-4.	~1
SD-6 (Canyon)	South of SD-4 and west of SD-5.	<1
SD-7 (Canyon)	North of the easternmost point of Canyon Mine Site.	<1
SD-8 (Canyon)	East of the mid-point of the southern boundary of Canyon Coal Mine lease boundary.	<1
Canyon Pit West	West on the southern stretch of the Canyon Coal Mine.	~1
Canyon Pit East	East on the southern stretch of the Canyon Coal Mine.	~1
Green Dam	West of L Dam.	~1
Other minor storage dams	Scattered throughout Project area.	<1
Total		**~37**

The *Water Management Act 2000* and associated regulations provide exemption for certain classes of water storage structures:

1. Clause 1 of Schedule 2 of Section 54 of the *Water Management Act 2000* notes that structures built solely for erosion control purposes are exempt from inclusion in a property's harvestable right, providing water is not reticulated or pumped (although it may be fenced off and troughed for stock watering purposes). The *Farm Dams Assessment Guide* (DLWC, 1999) clarifies the intent of this clause in relation to dams that are exempt, "*Dams for the control or prevention of erosion (gully control structures) – provided no water is reticulated or pumped from such dams and the size of the structure is the minimum necessary to fulfil the erosion control function.*"

2. Schedule 1 (clause 4) of the Water Management (General) Regulation, 2011 describes relevant excluded works as follows:

   (4) Dams approved in writing by the Minister for specific environmental management purposes:

   (a) that are located on a minor stream, and

   (b) from which water is used solely for those environmental management purposes.

In addition, the Dictionary of the *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012* defines a runoff harvesting dam as a dam on a hillside or minor stream that captures surface or rainfall runoff.

The taking of water from a runoff harvesting dam requires an access licence and a water supply work approval, except to the extent that the runoff harvesting dam is within an owner or an occupier's harvestable rights entitlement under section 53 of the *Water Management Act, 2000* (in which case it would not require an access licence or water supply work approval).

It is considered that no access licences would be required for Project surface water containments. This conclusion was made on the basis that Project water storages would be relevant excluded works under Schedule 1 (clause 4) of the *Water Management (General) Regulation, 2011* on the assumption the Ministers delegate ultimately approves them on that provision. Such approval should be granted on the grounds that:

- the sediment basins will prevent the contamination of downstream water sources; and
- provide water for dust suppression and irrigation for the rehabilitation of disturbed mining areas.

3.1.2 Protection of the Environment Operations Act 1997

The NSW *Protection of the Environment Operations Act 1997* (PoEO Act) and the *NSW Protection of the Environment Operations (General) Regulation 2009* set out the general obligations for environmental protection. The PoEO Act is relevant to the Project as it contains requirements relating to the prevention of the pollution of waters.

The discharge of water from the Project site must be controlled to an agreed standard to reduce the potential for pollution of the receiving waters. If the Project is approved, Whitehaven would apply for an Environmental Protection License (EPL) under the PoEO Act for the discharge of mine affected water from site (see **Section 12** for further details).

3.2 Policies and Plans

The following sections outline existing policies and plans relevant to the project.

National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is a joint national approach to improving water quality in Australian and New Zealand waterways. It was originally endorsed by the former Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the former Australian and New Zealand Environment and Conservation Council (ANZECC). Since 1992 the NWQMS has been developed by the Australian and New Zealand Governments in cooperation with state and territory governments.

The NWQMS aims to protect the nation's water resources by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development. The main mechanism for promoting this aim has been the publication of a number of water quality guidelines, of which those relevant to this project are referenced below.

NSW Water Quality and River Flow Objectives

NSW Water Quality and River Flow Objectives (WQOs) were established by the NSW Government in September 1999 for the majority of NSW catchments. The WQOs are the agreed environmental values and long-term goals for NSW's surface waters and set out:

- the community's values and uses for rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water); and
- a range of water quality indicators to help assess whether the current condition of waterways supports those values and uses.

The WQOs are consistent with the agreed national framework set out in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) (*ANZECC 2000 Guidelines*) to assess water quality in terms of whether the water is suitable for a range of environmental values, including human uses. The WQOs provide environmental values for NSW waters and the *ANZECC 2000 Guidelines* provide the technical guidance to assess the water quality needed to protect those values.

WQOs have been developed for NSW rivers and estuaries to provide guideline levels to assist water quality planning and management. The streams located within and reporting to the Project site are classified as "Uncontrolled Streams", which have the following WQOs relevant to the Project:

- aquatic ecosystems (maintaining or improving the ecological condition of water bodies and their riparian zones over the long term); and
- livestock water supply (protecting water quality to maximise the protection of healthy livestock).

The aquatic ecosystem objective is consistent with the *ANZECC 2000 Guidelines* default trigger values for slightly disturbed ecosystems in south-east Australia. Further discussion of the ANZECC trigger values adopted for the Project is provided in **Section 6.4**.

The livestock water supply objective is based on four key indicators. These indicators and their numerical trigger values are summarised below in **Table 4**.

Table 4: Livestock Water Supply Guidelines for Uncontrolled Streams in the Namoi Catchment

Indicator	Numerical criteria (trigger values)
Algae & blue-green algae	An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells per millilitre and/or concentrations of microcystins exceed 2.3 micrograms per litre expressed as microcystin-LR toxicity equivalents.
Salinity (electrical conductivity)	Recommended concentrations of total dissolved solids (TDS) in drinking water for livestock are given in Table 4.3.1 (*ANZECC 2000 Guidelines*).
Thermotolerant coliforms (faecal coliforms)	Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100 mL (median value).
Chemical contaminants	Refer to Table 4.3.2 (*ANZECC 2000 Guidelines*) for heavy metals and metalloids in livestock drinking water. Refer to *Australian Drinking Water Guidelines* (NHMRC 2011) for information regarding pesticides and other organic contaminants, using criteria for raw drinking water.

The trigger values for livestock water supply are significantly higher than the trigger values for aquatic ecosystems (**Section 6.4**). The Project is seeking to comply with more conservative aquatic ecosystem trigger values applicable to local watercourses.

State Water Management Outcomes Plan

The *Water Management Act 2000* provides for the establishment of the State Water Management Outcomes Plan (SWMOP) to set out the over-arching policy context, targets and strategic outcomes for the development, conservation, management and control of the State's water sources.

This SWMOP promotes the objects of the *Water Management Act 2000* and its water management principles and seeks to give effect to the NSW Government's salinity strategies. The SWMOP provides for the protection and enhancement of the environmental services provided by aquatic ecosystems while delivering a framework for the use of water to meet human needs, including more secure access licences. It details the Government's commitment to manage the linkages between environment, human health, communities and industries.

The Project is consistent with the objectives of the SWMOP, both within the Project area and on downstream users, as the mine is designed to protect the creek system from potential impacts from the project.

Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012

The WSP for the Namoi Unregulated and Alluvial Water Sources applies to the unregulated water sources in the Namoi basin which comprise sources that are dependent on rainfall and natural river flows, rather than water released from dams, and associated alluvial groundwater systems.

The WSP provides for the sharing of water between the environment, town water supplies, basic landholder rights and commercial uses of water. The volume of water available to meet all competing environmental and extractive needs varies on a yearly and daily basis, depending on the weather, river flows and aquifer characteristics.

Within the WSP, the Project is located within the Bluevale Source (Area 9). The WSP applies to all water sources in the vicinity of the Project, with the exception of the Namoi River itself.

While the requirements of the WSP do not appear to have any direct application to the Project at present, the WSP is a relevant consideration in regard to:

- any potential purchase of a water licence for an unregulated water source to complement the current water access licences for the Namoi River and from groundwater sources; and
- licensing of any incidental take of alluvial groundwater as a result of mining activities.

The commencement of the WSP means that any existing *Water Act 1912* licences will now be governed by *Water Management Act 2000* water access licences, water supply works and water use approvals. The water access licences are therefore separated from land and as a result water trading is enhanced.

Under the WSP an individual licence holder's annual access to water is governed by their entitlement and climatic availability (except for dams that fall under the harvestable rights provisions). However, the combined licence holders' annual access to water is managed through Long-Term Average Annual Extraction Limits (LTAAELs). The LTAAEL applies differently for unregulated surface water and alluvial groundwater sources. For unregulated surface water the LTAAEL applies across all the water sources within the Namoi Extraction Management Unit (EMU) as a group. For the Namoi EMU, of which the Bluevale Water Source is part, the LTAAEL is the annual extraction of water averaged over the period from 1 July 1993 to 30 June 1999 under entitlements issued under Part 2 of the *Water Act 1912.*

In addition to the long-term management rules, the unregulated water sources will also be managed on a day-to-day basis in the WSP through the definition of daily access rules that govern when licence holders are permitted to extract water. Generally, as a minimum, licence holders pumping from an unregulated water source cannot pump when there is no visible flow at their pump site or below the full capacity of a natural pool.

With the commencement of the WSP, the following apply within the Bluevale Water Source:

- the water requirements of persons entitled to domestic and stock rights will be 34.6 megalitres per year (ML/year);
- the share components of authorised domestic and stock access licences will be 5 ML/year; and
- the share components of authorised unregulated river access licences will be 1,635 unit shares.

The WSP includes a range of rules that apply to the transfer of licences within or between water sources. These would only need to be considered in the event that the Project sought additional water licences from within the Bluevale Source.

Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources

The Project falls within the Lower Namoi Regulated River Water Source for the purpose of the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2004*. The Lower Namoi includes the regulated river sections downstream of Keepit Dam to the Barwon River. The WSP commenced on 1 July 2004 and applies for a period of ten years to 30 June 2014. It is a legal document made under the *Water Management Act 2000*. The WSP is implemented by NOW.

The provisions in the WSP provide water for the environmental needs of the river and its ecological processes and direct how water available for extraction is to be shared. The WSP also sets rules for the management of access licences, water allocation accounts, the trading of or dealings in licences and water allocations, the extraction of water, the operation of dams and the management of water flows.

The WSP provides for domestic and stock rights and native title rights – both forms of basic landholder rights which allow some extraction of water from the river without an access licence. All other water extraction, other than for basic landholder rights, must be authorised by an access licence. Each access licence specifies a share component. The share components of specific purpose licences such as local water utility and domestic and stock are expressed as a number of megalitres per year. The share components of licences such as high security, general security and supplementary water access licences are expressed as a number of unit shares.

Table 5 lists Whitehaven's existing water access licenses for the Project the majority of which relate to licences to take water from the Namoi River under the WSP.

Table 5: Summary of Existing Water Access Licenses

Licence No.	WAL No.	Work Approval No.	Ground/River	Amount (ML)	Lot/DP (relating to Work Approval No.)
90AL801777	WAL 2577	90CA801779	River General Security	144	1/1018347
90AL801778	WAL 2578	90CA801779	River Supplementary	15.7	1/1018347
90AL802396	WAL13051	90CA802398	River General Security	96	41/754929
90AL802397	WAL13052	90CA802398	River Supplementary	10.5	41/754929
90AL807001	WAL 12714	90CA807002	Ground	133	1/1034512, 21/754929
90AL819104	WAL 21366[1]	90WA811536	River General Security	350	1/389164, 219/754954
90AL802035	WAL 2683	90WA804771, 90CA802036	River Supplementary	53	1/754929, 3/754929, 4/754929, 19/754929, 20/754929, 3/526448
90AL802034	WAL 2682	90WA804771, 90CA802036	River General Security	486	1/754929, 3/754929, 4/754929, 19/754929, 20/754929, 3/526448
90AL806924	WAL 12681	90CA806925	Ground	47	18/754929
			TOTAL:	**1,335.2**	

[1] It is noted that 350 ML of allocation from WAL 21366 is in the process of being transferred to Whitehaven.

Namoi Catchment Action Plan 2010-2020

The *Namoi Catchment Action Plan 2010 - 2020* (CAP) has been developed to provide the strategic framework for natural resource management in the Namoi Catchment. The CAP utilises a new 'resilience thinking' method of catchment planning, whereby thresholds capable of changing the state of social-ecological systems are identified and targets to avoid reaching those thresholds are established. Various actions for implementation are also listed to assist in achieving each target. The CAP focuses on four primary social-ecological systems – biodiversity, land, water and people. With respect to water, the CAP identifies the following seven thresholds and three targets.

CAP Water Thresholds:

1) *Surface water flow quantity is at 66% of natural (pre-development) condition with a sensitivity to natural frequency and duration.*
2) *Geomorphic condition is good (against benchmark condition).*
3) *Recruitment of riparian vegetation is higher than attrition of individual trees, shrubs or ground cover species.*
4) *Agricultural and urban supply aquifers do not cross into lower levels of beneficial use regarding quality.*
5) *Alluvial aquifers are not drawn down below long term historical maximum drawdown levels.*

6) *Groundwater is within 30 m of surface where there are identified groundwater dependent ecosystems.*

7) *Wetland is not drained, dammed or otherwise physically modified.*

<u>CAP Water Targets:</u>

1) *By 2020 there is an improvement in the condition of those riverine ecosystems that have not crosses defined geomorphic thresholds as at the 2010 baseline.*

2) *By 2020 there is an improvement in the ability of groundwater systems to support groundwater dependent ecosystems and designated beneficial uses.*

3) *By 2020 there is an improvement in the condition of regionally important wetlands and the extent of those wetlands is maintained.*

Namoi Catchment Water Study

As a result of the controversy over the potential impact of coal mining and coal seam gas extraction on water resources of the Namoi Valley, particularly mining or gas extraction that has the potential to affect the fertile alluvial soils of the floodplain of the Namoi River and its main tributaries (Warrah Creek and Mooki River), a Ministerial Oversight Committee was established in 2009 to oversee the preparation of the *Namoi Catchment Water Study* (the Study). The Ministerial Oversight Committee includes representation from the local community, agriculture, mining and coal seam gas extraction industries as well as relevant NSW government agencies.

In August 2010 Schlumberger Water Services (Australia) Pty Ltd was appointed as the Independent Expert for the Study. The Study involved the collation of existing and new data to investigate the risks and to support the construction of a three-dimensional physical based numerical model (the Model) of the catchment water resources that could be used to develop scenarios of mining and gas development and predict their effects. The Model considers all the important physical processes relating to surface water and groundwater aquifers, the interactions between flow and water quality between them and the processes relating to coal and gas development.

The Stage 4 Final Report was submitted to the Ministerial Oversight Committee in July 2012. Relevant of the findings of the study, as set out in the Executive Summary, are:

> *"At a project scale, mining and CSG activities both have the potential to negatively impact groundwater and surface water resources via localised pathways. These local scale pathways, conditions and effects cannot be determined with any degree of accuracy by a catchment-scale study or predicted by a model designed to assess catchment-wide, long-term and cumulative impacts. This highlights the importance of project-specific detailed investigations, supplemented by comprehensive monitoring and appropriate operational management."*

and

> *"The severity or seriousness of an impact can be reduced by mitigation. Prevention of an impact is generally preferable to mitigation and many prevention measures exist to minimise local-scale impacts (spills, discharges etc.). These should be included in the approvals and environmental management plan for each particular development project. On a sub-regional scale, impact prevention options are more limited, potentially placing greater reliance on mitigation.*

> *Effective impact mitigation is reliant on establishing the impact source and having a comprehensive baseline dataset for both water quantity and quality so that impacts can be defined, tracked and mitigation implemented in time. Trigger levels for both water quantity and quality components should be set which define at what magnitude of impact the mitigation measures are activated."*

The Project and the proposed surface water mitigation and monitoring actions conform with these recommendations.

NSW State Rivers and Estuaries Policy

The *NSW State Rivers and Estuaries Policy* contains state-wide objectives for the protection and enhancement of watercourses. The proposed surface water management should be consistent with the State Rivers and Estuaries Policy objectives. The key aspect of this would be to demonstrate that there is no degradation of Driggle Draggle Creek or the Namoi River as a result of mining activities.

NSW Farm Dams Policy

The *NSW Farm Dams Policy* was introduced in 1999. Under this policy it is not necessary to obtain a licence or other consent from the NOW for a farm dam provided:

- they are not collecting flow from a major stream; and
- the combined capacity does not exceed the Maximum Harvestable Rights Dams Capacity for the property.

3.3 Technical and Policy Guidelines

The DGRs provides a list of guidelines identified by DP&I of being of assistance for the preparation of the Surface Water Assessment. Where appropriate these guidelines have been referred to. In particular the following have been used:

- *Managing Urban Stormwater: Soils & Construction – Volume 1* (Landcom, 2004) taken into account in the design of the sediment basins;
- *Managing Urban Stormwater: Soils & Construction – Volume 2E: Mines and Quarries* (NSW Department of Environment and Climate Change [DECC], 2008) taken into account in the design of the sediment basins;
- *Environmental Guidelines: Use of Effluent by Irrigation* (NSW Department of Environment and Conservation [DEC], 2004) for the design of the effluent irrigation system at the MIA;
- *Australian Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) to determine water quality 'trigger' values; and
- *ANZECC Guidelines and Water Quality Objectives in NSW* (DEC, 2006) to determine water quality 'trigger' values.

In NSW, the most relevant and comprehensive guidelines for the design of stormwater controls relating to mines is contained in *Managing Urban Stormwater: Soils and Construction Vol 2E – Mines and Quarries* (DECC, 2008) in conjunction with the references to Volume 1 (Landcom, 2004). The principles of surface water control, including the design of erosion and sediment control structures, have been adopted where applicable in this Surface Water Assessment.

A controlled activity approval under the *Water Management Act 2000* is typically not required for surface mining activities approved as State Significant Development. However the general standards used by NOW in implementing the *Water Management Act 2000* still need to be adhered to. Consideration of the '*Guidelines for Controlled Activities – Riparian Corridors'* and *'Guidelines for Controlled Activities – In-Stream Works*' for watercourse rehabilitation and riparian zone rehabilitation has been included in this Surface Water Assessment.

Page intentionally left blank

4 Surface Water Environment

4.1 Rainfall/Climate

The Project is situated in the Namoi River Valley between tropical and temperate climatic zones and between the belts of subtropical highs and mid-latitude westerlies. The climate in the area is characterised by mild to hot summers and cool winters. The highest temperatures occur throughout December, January and February, with the coolest temperatures occurring in July. Autumn and spring are generally mild, while winters are cool to cold with overnight lows reaching close to an average of 0^{o}C during winter months.

Whilst rainfall is reasonably well distributed throughout the year, there is a slight peak in the summer months and marginally lower rainfall in autumn. On average, January is the wettest month of the year and April is the driest. The wetter months of December, January and March also have a reasonably low number of mean rain days, suggesting the higher volumes of rainfall are associated with higher intensity storms falling over shorter periods of time (such events are important when designing appropriate surface water management structures). The region is also susceptible to extended periods of drought.

Climate data has been collated and assessed that is representative of the Project area as well as the catchment for Maules Creek, which has been used to derive parameters for modelling of runoff from natural catchments representative of the Project area (see **Section 5** and **Appendix B**). The Bureau of Meteorology (BoM) stations that historic climate data was obtained from for the Project are listed in **Table 6** below.

Table 6: Climate Stations used for Calibration/Validation and Project Area Modelling

Station Number	Station Name	Start Date	End Date
Rainfall			
054021	Barraba (Mount Lindsay)	1886	open
054024	Barraba (Log Cabin)	1966	open
055044	Boggabri (Retreat)	1899	open
055076	Boggabri (Kanownda)	1899	open
061048	Kelvin (Kahana)	1903	open
055007	Boggabri Post Office	1884	open
Evaporation			
055024	Gunnedah Resource Centre	1948	open

Table 7 contains the rainfall statistics for Boggabri (Retreat) (Station 055044) (1899 – 2010) which has been used for the analysis of runoff from natural catchments in the vicinity of the Project; and has been used as the basis for the site water balance assessment. Statistics for the pan evaporation data obtained for Gunnedah Resource Centre (Station 055024) (1948 – 2010) are provided in **Table 8.**

For the purposes of modelling catchment runoff, Boughton (2010) recommends the use of potential evapotranspiration data. Monthly potential evapotranspiration specifically for the project area was derived by interpolation of the spatial data from the digital version of the *Climatic Atlas of Australia: Evapotranspiration* (Version 1.0, BoM, 2002).

Table 7: Rainfall Statistics (mm) for Boggabri (Retreat)

Month	Mean	Min	10th percentile	Median	90th percentile	Max
Jan	72.5	0.0	14.9	61.9	152.5	234.3
Feb	61.5	0.0	7.7	47.3	136.4	254.9
Mar	42.3	0.0	1.8	34.5	99.0	164.0
Apr	35.4	0.0	0.4	29.3	81.4	148.5
May	38.3	0.0	1.1	30.5	93.3	146.0
Jun	43.5	0.0	9.3	38.2	82.0	196.2
Jul	42.4	0.0	6.4	34.5	84.0	147.5
Aug	37.1	0.0	5.0	30.7	72.2	158.8
Sep	39.8	0.0	3.8	36.8	85.9	138.6
Oct	50.6	0.0	8.7	46.4	91.5	239.4
Nov	57.2	0.0	13.7	46.8	113.7	250.0
Dec	61.7	0.0	10.2	55.2	119.6	181.6
Annual	**579.3**	**231.5**	**382.6**	**580.3**	**776.3**	**1,038**

Table 8: Pan Evaporation Statistics (mm) for Gunnedah Resource Centre

Month	Mean	Min	10th percentile	Median	90th percentile	Max
Jan	239.5	160.6	196.6	239.5	279.9	326.2
Feb	192.5	76.0	160.9	190.8	223.1	256.8
Mar	185.7	97.1	149.6	185.7	220.0	266.1
Apr	131.3	63.7	109.3	131.3	154.6	190.0
May	84.6	45.0	68.4	84.6	100.7	124.5
Jun	57.9	35.5	47.5	57.9	64.8	83.7
Jul	60.1	26.3	48.7	60.1	70.5	99.1
Aug	85.0	40.0	69.7	85.0	100.5	123.8
Sep	119.2	62.4	93.6	119.2	146.6	201.8
Oct	165.4	81.3	139.4	165.4	200.1	240.8
Nov	199.3	111.2	166.5	199.3	233.7	306.4
Dec	241.5	150.6	200.8	241.5	281.9	353.2
Annual	**1,752**	**1,018**	**1,457**	**1,760**	**1,948**	**2,329**

As noted above, the climate is extremely variable and the area can experience extended drought periods as well as periods of rainfall significantly above the average. This variability, which needs to be considered in relation to shortage or excess of mine water, is illustrated by the data in **Table 9**. This shows that, for instance, the minimum and maximum rainfall over 5 years has been ±25% of the long term average.

A further indication of the variability of the climate is shown in the cumulative departure of rainfall from the long term average in **Figure 4**. The figure shows that the area has experienced extended drought periods (graph sloping downwards to the right), particularly an extended drought in 1935 – 1948 and other significant droughts in 1979 – 1983 and 1992 – 1996. Although it contained some drier years, the period 1948 – 1978 was predominantly wetter than the long term average.

Table 9: Rainfall over Consecutive Years (mm/year) for Boggabri (Retreat)

	Average Rainfall over Consecutive Years (mm/year)					
	1 Year	2 Years	3 Years	4 Years	5 Years	10 Years
Average	579	581	581	582	582	582
Minimum	232	355	417	420	433	480
10th Percentile	383	441	468	488	495	525
Median	580	573	588	583	587	581
90th Percentile	776	731	699	677	669	641
Maximum	1,038	908	794	753	712	700

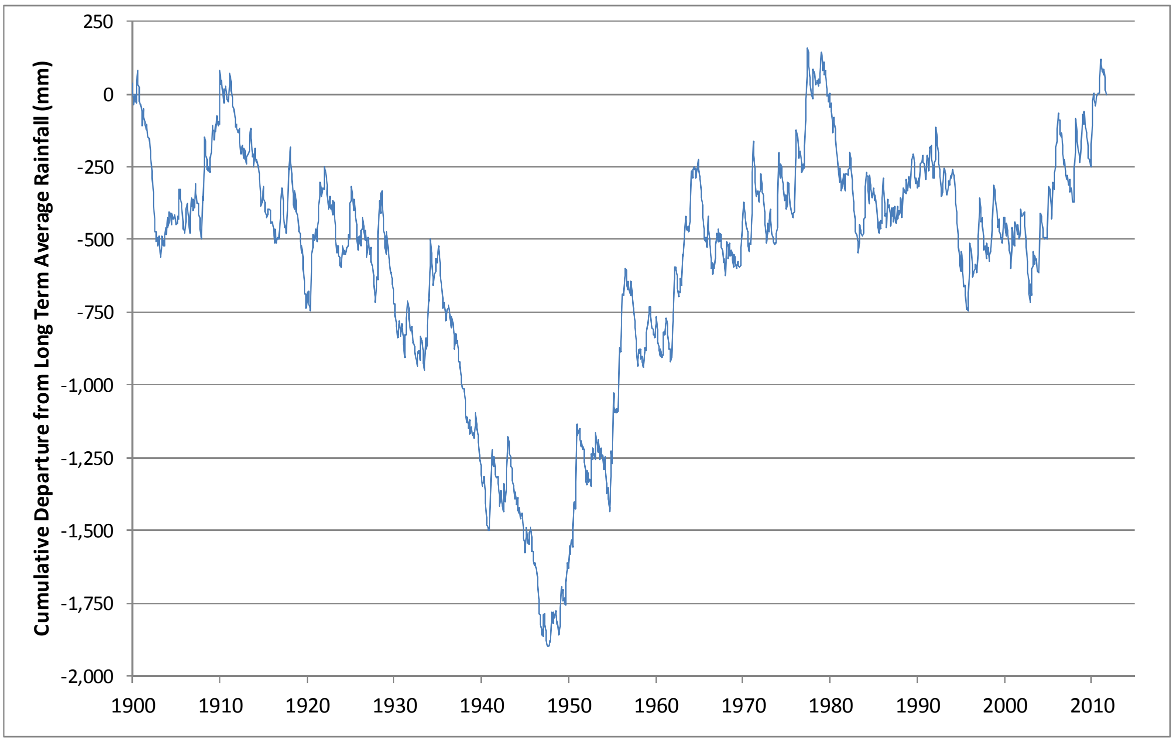


Figure 4: Cumulative Departure from Long Term Average Rainfall – Boggabri (Retreat)

Table 10 summarises the average distribution of daily rainfall for daily rainfall Boggabri (Retreat).

Table 10: Distribution of Daily Rainfall for Boggabri (Retreat)

Rainfall	Average Days per Year	Percentage of Time
Days with rainfall > 0.1 mm	53.9	14.8%
Days with rainfall < 2 mm	9.9	2.5%
Days with rainfall 2 – 5 mm	11.5	3.4%
Days with rainfall 5 – 10 mm	13.1	3.6%
Days with rainfall 10 – 20 mm	12.0	3.3%
Days with rainfall 20 – 50 mm	7.5	2.1%
Days with rainfall > 50 mm	0.8	0.2%

4.2 Topography

The local area is divided by a ridgeline that runs diagonally from the north-east to the south-west. The highest point along this line is roughly located in the middle of Vickery State Forest at approximately 479 m Australian Height Datum (AHD).

The ridge tops and mid-slopes of Vickery State Forest higher than 360 m AHD are moderately sloped, with gradients fairly consistent at approximately 25-30%. Slopes then tend to flatten out below this level, with gradients ranging from 5% to 0% across much of the site of the proposed mine.

4.3 Vegetation

The majority of the Project area has been cleared for agricultural and mining purposes and mainly consists of dry sclerophyll woodland and forest with dominant species of White Box, White Cypress Pine, Narrow-leaved Ironbark and Silver-leaved Ironbark, and derived native grasslands of these communities.

4.4 Land Use

The Project is located within a rural area. With the exception of the Vickery State Forest, the surrounding land is primarily utilised for traditional agricultural pursuits comprising of a combination of livestock grazing and crop cultivation.

The majority of the Project area is grazing land, some of which is rehabilitated land from former mining activities associated with the historical Vickery Coal Mine (**Figure 5**) and the more recent Canyon Coal Mine which ceased mining in 2009.

Figure 5: Rehabilitated Land within the Project Area

4.5 Soils and Land Management Areas

An *Agricultural Resource Assessment* for the Project has been prepared by McKenzie Soil Management (2012) and is presented in Appendix G of the EIS. The *Agricultural Resource Assessment* identified that the main soil types within the Project area are Dermosols and Sodosols, with the main Soil Landscape Units being gentle slopes of 3-10% on sedimentary parent materials, and recent drainage line deposits and colluvium derived from a mix of basic volcanic and sedimentary parent materials (McKenzie Soil Management, 2012).

4.6 Fluvial Geomorphology

A *Fluvial Geomorphological Assessment* for the Project (Fluvial Systems, 2012) is provided as **Appendix A** to this Surface Water Assessment.

The majority of the drainage lines in and around the vicinity of the Project are classified as Valley-Fill type. Drainage lines of this categorisation generally exhibit:

- highly episodic ephemeral flow;
- indistinct and discontinuous channel form;
- cohesive fine-grained bed material;
- no large woody debris (unless situated within a woody area); and
- low energy.

Occasional shallow knick-points are present in the drainage lines but only demonstrate a downstream scoured channel length less than 20 m. Headwater streams have a well-defined channel of flow in bedrock with course-grained bed material. Moderate amounts of large woody debris are evident in the headwaters within Vickery State Forest which are of low to moderate energy. The downstream end of Driggle Draggle Creek is sufficiently large to form a defined meandering channel.

The fluvial geomorphology report includes an assessment of the potential impacts of changes to the contributing catchment areas associated with diversion of the North-West Drainage Line along the eastern boundary of the Project area and the reduction in the catchment areas of the West Drainage Line and North-West Drainage Line. The hydrologic impacts of these changes are described in **Section 10.1**.

4.7 Riparian Vegetation

Riparian vegetation is described in detail in the *Ecological Assessment* (Niche Environment and Heritage, 2012) provided as Appendix E to the EIS.

Riparian habitat is characterised by a dominant over-storey of *Eucalyptus camaldulensis* (River Red Gum) within 30 m of the top-of-bank along the Namoi River and major tributaries.

White Box - Yellow Box - Blakely's Red Gum Woodland vegetation community is located in a thin strip along South Creek just north of Shannon Harbour Road. The mid-storey is open with a groundcover dominated by native grasses. It is considered that this vegetation community exists as a relatively natural open wood and dominated by White Box (*Eucalyptus albens*) and Blakely's Red Gum (*E. blakelyi*) and sub-dominant White Cypress Pine (*Callitris glaucophylla*).

4.8 Aquatic Ecology

An aquatic ecology assessment of two ephemeral drainage lines (the North-West Drainage Line and South Creek) within the Project area was prepared by Niche Environment and Heritage (2012) and is provided as part of Appendix E to the EIS. A habitat assessment and aquatic survey (macroinvertebrates, amphibians and fish) was undertaken on 29 February and 1 March 2012.

The Project area contains a number of first and second order drainage lines, although none are named watercourses and most are low lying areas with no defined channel or creek bed. The drainage lines are ephemeral, only holding water following flooding events, as occurred in February 2012.

Based on physio-chemical data, macro-invertebrate assemblages and the absence of native fish, the stream lines within the Project area were classed as being in poor health with limited aquatic habitat opportunities (Niche Environment and Heritage, 2012).

5 Surface Hydrology

The Project lies within the Namoi River catchment area with all areas of the site ultimately draining to the Namoi River. The Namoi River at Gunnedah has a catchment of 17,000 square kilometres (km^2), of which 5,700 km^2 is regulated by Keepit Dam. The catchments of the Mooki River, Cox's Creek and the Namoi River between Keepit Dam and Boggabri form the region known as the Liverpool Plains, which has an area of approximately 12,000 km^2. Between Gunnedah and Boggabri, the Namoi River is characterised by a wide floodplain and gentle catchment slopes.

5.1 Regional Hydrology

The *Surface Water Assessment* for the Tarrawonga Coal Project (Gilbert & Associates, 2011) describes the regional flow regime of the Namoi River.

Flow in the Namoi River is regulated by three major water storages:

- Keepit Dam - constructed on the Namoi River upstream of the Peel River confluence in 1960 with a storage capacity of 427,000 ML.
- Chaffey Dam - constructed on the Peel River upstream of Woolomin in 1979 with a storage capacity of 62,000 ML.
- Split Rock Dam - constructed on the Manilla River in 1988 with a storage capacity of 397,000 ML.

Water is released from these major water storages for irrigation, for industrial and domestic/urban requirements in the Namoi River catchment, and as environmental flows. The closest gauging station to the Project on the Namoi River is located at Boggabri (419012), just upstream of the Bollol Creek confluence with the Namoi River (**Figure 6**). The Boggabri gauging station commands a catchment area of 22,600 km^2 and has an estimated mean annual flow of 836,209 ML or 6% of the average annual rainfall (Gilbert & Associates, 2011).

Streamflow in the Namoi River at Boggabri is characterised by strong flow persistence with flows exceeding 1.6 megalitres per day (ML/day) on 95% of days. Zero flow is recorded on 1.5% of days. Over the full period of available data, streamflow in the Namoi River at Boggabri has a median of 403 ML/day and an average of 1,695 ML/day. These flow characteristics are typical of large regulated catchments principally operated to provide irrigation water supply during the irrigation season.

Additional operational gauging stations have also operated in the region to the north of the Project (Maules Creek gauging stations [419044 and 419051]) and to the west of the Project (Coxs Creek gauging station [419032]) (**Figure 6**).

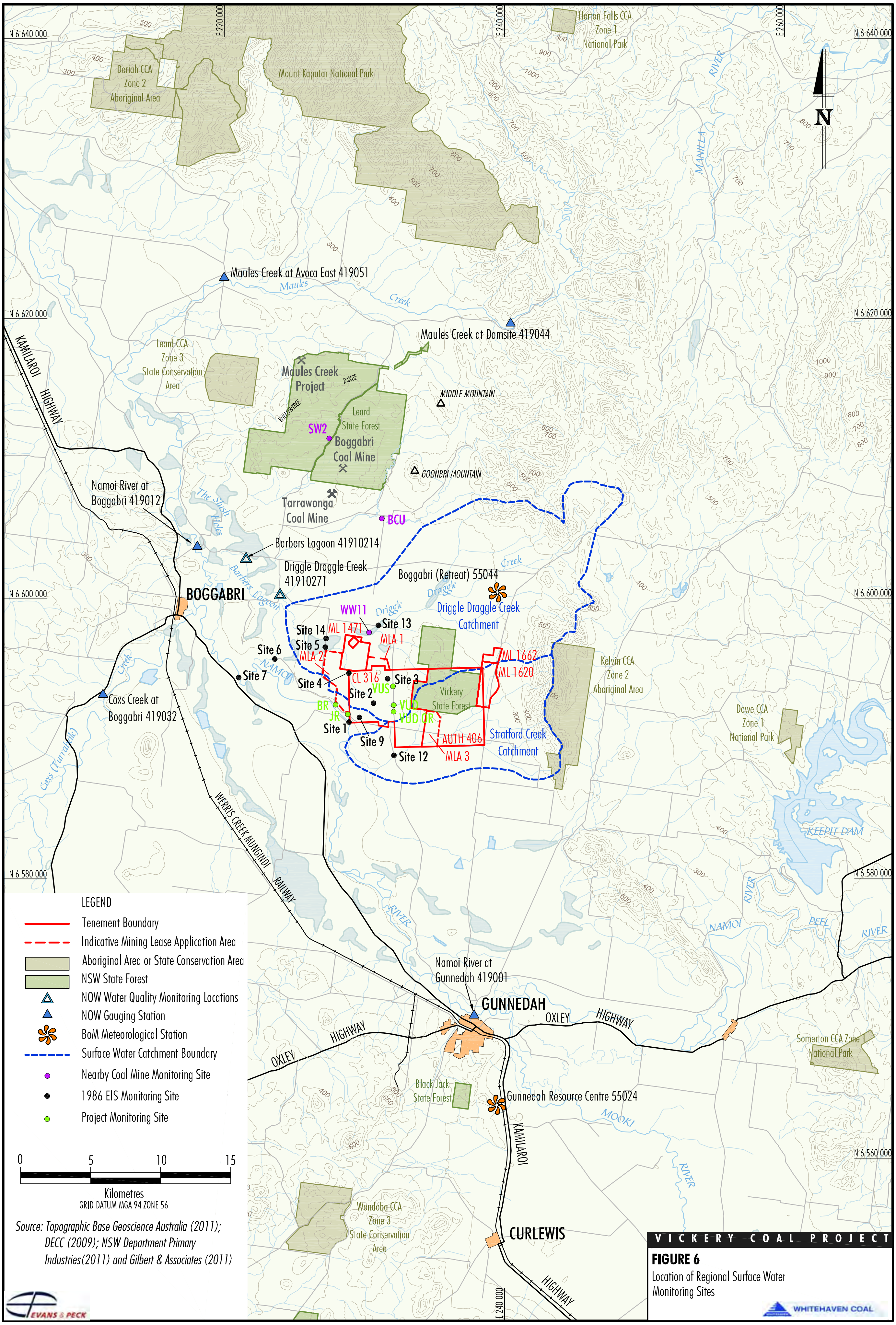


FIGURE 6
Location of Regional Surface Water Monitoring Sites

WHC-10-03_App SW_104C

5.2 Local Hydrology

A number of intermittent streams drain across or rise within the Project area. These streams are highly ephemeral and only flow for short periods after prolonged or heavy rain and can be dry for many years.

For the purposes of this report, the creeks and drainage lines that convey runoff into and within the Project area (**Figure 2a**) have been designated as follows:

- **'Driggle Draggle Creek'**, which runs in an east – west direction to the north of the Project area, has a catchment of about 170 km^2 at a location where it is joined by a tributary that drains from the Project area (North Drainage Line – see below). Tributaries that drain into Driggle Draggle Creek upstream of the Project area include Bayley Park Creek to the north, Glenrock Creek and Barneys Spring Creek to the north-east, and Wean Creek to the east, all if which drain into Driggle Draggle Creek in close proximity north of Vickery State Forest. These creeks collectively drain from the southern sides of Haystack Rock and Rioters Hill in the north-east and the western sides of Round Hill, Mount Surprise and the main ridgeline running north-south through the Kelvin State Forest. Closer to the Project area, the North Drainage Line, the North-West Drainage Line and West Drainage Line all join Driggle Draggle Creek to the north of the Project area. Downstream of the Project area, Driggle Draggle Creek mostly flows in a south-westerly direction and drains into Barbers Lagoon and eventually the Namoi River to the west. In the area of relevance to this report, Driggle Draggle Creek is a fifth order stream according to the Strahler classification system.
- **'Stratford Creek'** comprises two main drainage lines that flow in a westerly direction and join shortly before draining into the Namoi River. The northern drainage line runs in an east – west direction just south of the proposed MIA and drains the south-eastern portion of the Project area (via South Creek) and the western side of the main ridgeline that runs north-south through the Kelvin State Forest (the eastern side is drained via the southern branch of the creek). At the junction with South Creek, Stratford Creek is a fourth order stream and has a catchment area of about 65 km^2.
- **'South Creek'** mostly drains from a southern portion of the Vickery State Forest and flows in a southerly direction between the open cut to the west and the Eastern Emplacement to the east. At the point where it joins Stratford Creek just south-west of the MIA, South Creek is a fourth order stream with a catchment area of 4.3 km^2.
- The **'West Drainage Line'** drains from the central portion of the Project area, including a large part of the proposed open cut area. The drainage line conveys runoff in a north-westerly direction until it joins the North-West Drainage Line to the north-west of the Project. At the point where it leaves the area to be affected by mining, the drainage line is a third order stream and has a catchment area of 5.9 km^2.
- The **'North-West Drainage Line'** drains in a north-westerly direction from the northern portion of the Project area, including the northern part of the proposed open cut area. The West Drainage Line drains into the North-West Drainage Line shortly before it joins Driggle Draggle Creek to the north-west of the Project area. At the point where it leaves the area to be affected by mining, the drainage line is a third order stream and has a catchment area of 6.1 km^2.

- The **'North Drainage Line'** drains form the north-eastern portion of the Project area, including the north-eastern tip of the proposed open cut area. It drains in a north-westerly direction until it joins Driggle Draggle Creek to the north-west of the Project area (upstream of where the West Drainage Line joins Driggle Draggle Creek). At the point where it joins Driggle Draggle Creek, North Drainage Line is a third order stream and has a catchment area of 7.1 km^2.

5.3 Flow Regime

There are no flow gauges located on any of the streams in the vicinity of the Project area which would allow direct analysis of the existing flow regime. Therefore, in order to characterise the flow regime for the Project area, modelling has been undertaken using the Australian Watershed Bounded Model (AWBM). Details of modelling process are provided in **Appendix B**.

Historic rainfall and evaporation data, in conjunction with 24 years of recorded daily flow data from Maules Creek (approximately 28 km north) have been used to derive model parameters that represent local runoff conditions (see **Appendix B** for details). The model parameters were then applied to the Project area rainfall and evaporation data to estimate runoff from catchments in the vicinity of the Project. **Table 11** sets out the parameter values adopted from the calibration of the Maules Creek runoff data and applied to the Project area rainfall and evaporation data.

Table 11: AWBM Parameters for the Maules Creek Catchment

C1	C2	C3	A1	A2	A3	BFI	K_{base}	K_{surf}
20.2	205.0	410.0	0.134	0.433	0.433	0.300	0.830	0.250

Table 12 summarises the statistics for the two creeks of interest based on the AWBM parameters in **Table 11**:

- South Creek, where it exits Vickery State Forest (catchment area = 3.6 km^2); and
- North-West Drainage Line, where it exits Vickery State Forest (catchment area = 0.86 km^2).

Table 12: Modelled Runoff for the Catchments Draining into the Project Area

Statistic	South Creek	North-West Drainage Line
Average Runoff (mm/year)	22.59	
Runoff as % of Rainfall	3.9	
Average Runoff (ML/year)	81	19
Minimum Year – 1901/1902 Water Year(ML/year)	7	2
10th Percentile Year – 1937/1938 Water Year (ML/year)	33	8
Median Year – 1966/1967 Water Year (ML/year)	70	17
90th Percentile Year - 1907/1908 Water Year (ML/year)	141	34
Maximum Year – 1899/1900 Water Year (ML/year)	344	83

The *Surface Water Impact Assessment* for the Maules Creek Coal Project (WRM, 2011) quotes runoff data collected from two small catchments (300 ha and 6,600 ha) in 1983/1984. These data comprising runoff volume for single days (7 and 5 storms respectively for the two catchments) were analysed to derive AWBM parameters which indicated that, because of the size of the catchment, model parameters for Maules Creek tended to underestimate the flow. However, because of the very limited dataset quoted in the WRM (2011) report, this Surface Water Assessment has adopted the parameters in **Table 11** derived from the calibration of AWBM using the 24 years of daily flow data from Maules Creek, as described previously.

5.4 Peak Flows

Peak flows at three locations within or near the Project area have been estimated using the Probabilistic Rational Method for small ungauged catchments in eastern NSW as set out in Chapter 5 of *Australian Rainfall & Runoff* (Institution of Engineers Australia, 1998). These locations are:

- **South Creek**, where it exits Vickery State Forest (catchment area = 3.6 km^2);
- **South Creek,** near Shannon Harbour Road; and
- **North-West Drainage Line**, where it meets the open cut in Year 26 (catchment area = 2.94 km^2).

Rainfall intensity-frequency-duration data for the Project area was obtained from the BoM web site (accessed on 29/9/2011): (http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml). In addition, the Probable Maximum Flood (PMF) for South Creek near Shannon Harbour Road was calculated based on *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (BoM, 2003).

Results of the analysis are summarised in **Table 13**.

Table 13: Estimated Design Flows

Average Recurrence Interval (years)	Peak Flow (m^3/s)		
	South Creek (Vickery State Forest)	South Creek (Shannon Harbour Road)	North-West Drainage Line
1	1.2	2.0	1.1
2	2.4	3.8	2.1
5	4.3	7.2	3.9
10	6.5	10.9	6.0
20	10.1	16.3	9.1
50	16.2	27.3	14.5
100	23.3	37.8	21.0
PMF	-	348	-

m^3/s = cubic metres per second

Further analysis of flooding is provided in **Section 7** and **Appendix D**.

Page intentionally left blank

6 Surface Water Quality

This section summarises the available surface water quality information for region and the drainage lines in the vicinity of the Project. As there is only a limited amount of water quality data available for creeks and drainage lines within the Project area, data for various creeks and other water bodies in the region has been drawn from the following three sources:

- NOW database records for regional monitoring sites;
- surface water quality monitoring conducted by Whitehaven in the immediate vicinity of the Project (2011 and 2012);
- the Namoi Valley Coal Project EIS (Vickery Joint Venture, 1986) for the original Vickery Coal Mine; and
- publically available documentation containing details of water quality monitoring conducted at nearby mine sites. Only mine sites with negligible upstream mining activity were included.

Detailed water quality data is provided in **Appendix C**.

6.1 Regional Water Quality

Regional water quality data is available for the Namoi River at Gunnedah (419001), and further downstream at Barbers Lagoon (downstream of Bollol Creek) (41910214) and Driggle Draggle Creek at Boggabri (41910271). Two regional surface water quality monitoring sites are also located on Maules Creek at Damsite (419044) and Avoca East (419051). Maules Creek flows into the Namoi River some 25 km to the north-west of the Project (**Figure 6**).

Water quality of the Namoi River and Maules Creek is generally characterised by moderate alkalinity and elevated electrical conductivity (EC) relative to the default trigger values for upland rivers (>150 m altitude) in the *ANZECC 2000 Guidelines* (**Table 14**). EC values in the Namoi River at Gunnedah (419001) have ranged between 200 microSiemens per centimetre (µS/cm) and 900 µS/cm every year since 2001 and there is no significant trend to the data (Schlumberger Water Services, 2011).

Average total nitrogen and total phosphorous concentrations have also been elevated relative to guideline trigger values for aquatic ecosystems. Phosphorous and nitrogen are sourced from effluent, agricultural runoff and in-stream processes (Schlumberger Water Services, 2011).

Table 14: Summary of Regional Average Water Quality Data

Location (refer Figure 6)	Parameter					
	pH	EC (µS/cm)	Alkalinity (mg/L)	Turbidity (NTU)	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)
Namoi River (and Lagoons)						
• Gunnedah (419001)	8.06	497	204	67.3	0.72	0.14
• Barbers Lagoon (downstream of Bollol Creek) (41910214)	7.70	348	-	304	-	-
• Driggle Draggle Creek at Boggabri (41910271)	6.99	117	-	-	-	-
Maules Creek						
• Damsite (419044)	7.70	537	-	21	-	-
• Avoca East (419051)	7.56	351	141	13.5	0.43	0.15
ANZECC 2000 Guidelines Default Trigger Values						
• Aquatic Ecosystems [Default]	6.5-7.5	30-350	-	2-25	0.25	0.02
• Primary Industries [Default]	5.0-9.0	-	-	-	-	-
• Livestock Drinking Water [Default]	-	3,125	-	-	-	-

Source: Gilbert & Associates (2011).
mg/L = milligrams per litre.
NTU = Nephelometric turbidity units.

Highest turbidities are recorded in the lower sections of the Namoi River (Schlumberger Water Services, 2011). Most sediment is derived from disturbance within catchments, stream bed and bank erosion, or direct access by livestock (Thoms *et al*., 1999). As stated in Schlumberger Water Services (2011):

> *"In summary the early studies, including Nancarrow (1998), concluded that prior to 2000, the chemical water quality of the Namoi River system was generally moderate to poor, with high levels of nutrients, areas contaminated by agricultural chemicals, and areas with on-going salinity problems. While trends for parameters such as salinity, turbidity and nutrients varied in the short term, longer term trends showed little signs of a decline through time."*

As also reported in Schlumberger Water Services (2011), surface water quality data between 2002 and 2007 has been analysed in a study carried out by the NOW in the Namoi catchment (Mawhinney, 2011), with the following conclusions:

- EC values typically exceeded trigger levels for the protection of aquatic ecosystems, but were suitable for irrigation.
- Turbidity levels increased with distance down the catchment and are predicted to fall as beds and banks are stabilised.
- High total phosphorous and nitrogen were detected, although there was no corresponding significant growth of blue/green algae.

High phosphorous and nitrogen in the Peel River below Tamworth were attributed to sewage treatment discharges and urban runoff.

6.2 Project Area and Surrounds

The locations of monitoring sites from which data has been collated are shown on **Figures 6** and **7**.

6.2.1 Project Area

As of the date of this report, five rounds of surface water quality monitoring had been conducted by Whitehaven for the Project area. The locations of the monitoring sites are shown on **Figure 7.** A summary of the monitoring to date is provided in **Table 15**, together with the default *ANZECC 2000 Guidelines* 'trigger values' for upland rivers in south-eastern Australia.

The *Namoi Valley Coal Project EIS* (Vickery Joint Venture, 1986) provided surface water quality monitoring data at eleven sites in the general vicinity of the Project. The locations of these monitoring sites are shown on **Figure 6**. A summary of the monitoring data from these sites have been reproduced in **Table 15.** The report did not identify the number of samples collected or the duration of the sampling program.

6.2.2 Surrounding Mine Site Data

The following three water quality monitoring sites (**Figures 6** and **7)** have been identified from publically available documentation as having negligible upstream catchment area affected by mine sites:

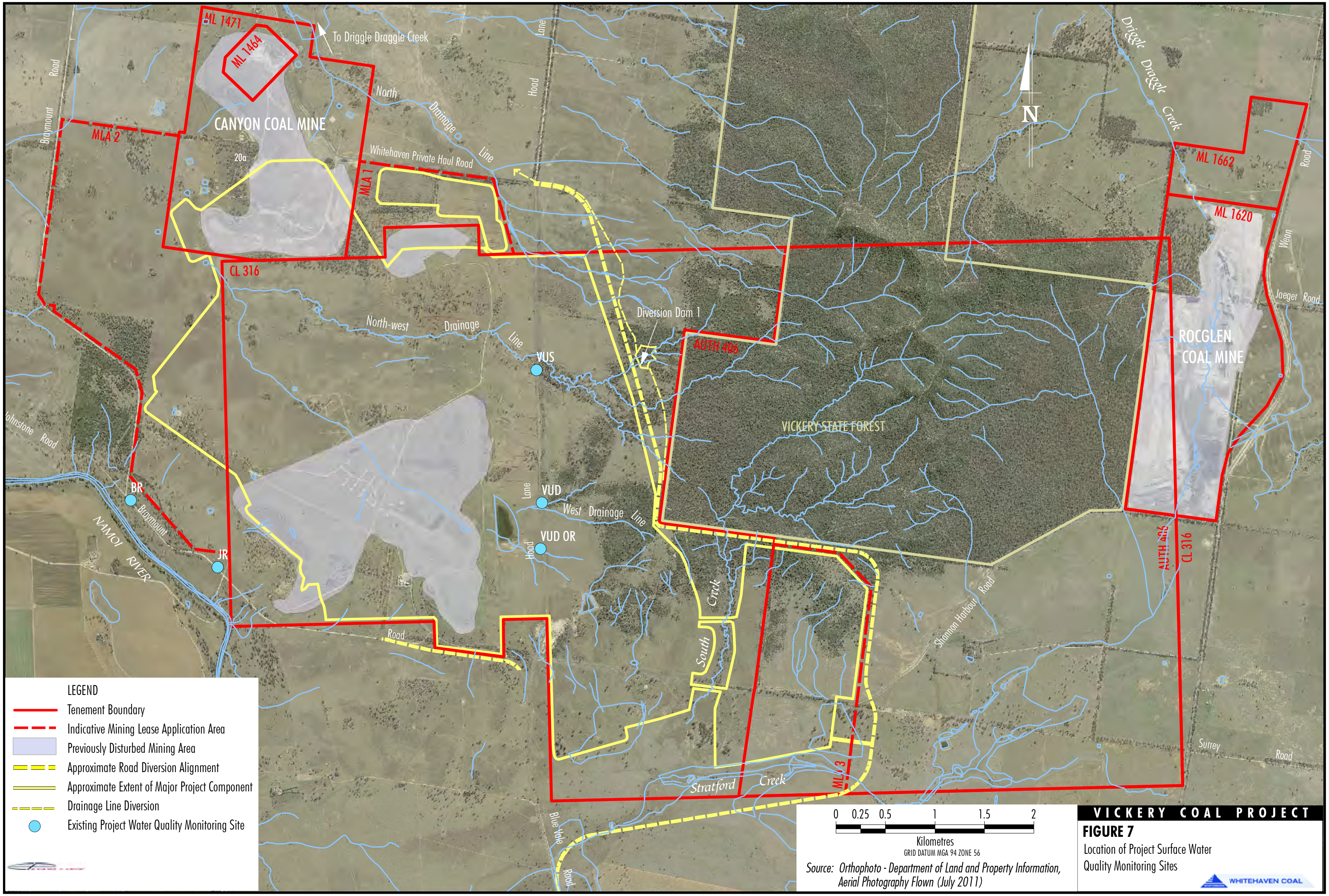
- WW11 (monitored as part of Canyon Coal Mine);
- BCU (monitored as part of Tarrawonga Coal Mine); and
- SW2 (monitored as part of Boggabri Coal Mine).

With the exception of site WW11 (which has a very small area of the Rocglen Coal Mine within its catchment), these sites have zero mining activity in their associated upstream catchments. **Table 15** provides a statistical summary of the key parameters measured for these sites, together with the default *ANZECC 2000 Guidelines* 'trigger values' for upland rivers.

6.3 Assessment

Whilst the data in **Table 15** indicate some variation between the monitoring sites, common features include:

- Generally low EC indicating negligible sources of salt in the catchments. The average EC for the 1986 EIS data appears anomalous and is possibly due to concentration of salt in a pool as a result of evaporation during an extended period of no rainfall or flow.
- pH is generally consistent with the *ANZECC 2000 Guidelines* default trigger ranges (with some exceptions in each of the differently sourced sets of data).
- Generally low total suspended solids (TSS) but with occasional significantly higher values reflecting the episodic nature of sediment transport.



WHC-10-03_AppSW_202C

Table 15: Surface Water Quality Monitoring Results – Project Area and Surrounds

	EC (lab) (µS/cm)	pH (lab)	TSS (mg/L)
ANZECC Default 'Trigger Values'	30 – 350	6.5 – 7.5	-
Project Monitoring Data			
Number of Samples	23	23	23
Minimum	27	3.9	8
Average	91	6.9	57
Maximum	224	7.5	318
1986 EIS Report Data			
Number of Samples	11	11	9
Minimum	96	6.8	18
Average	456	8.1	77
Maximum	2,489	9.1	221
Site WW11			
Number of Samples	18	18	18
Minimum	55	6.4	12
Average	100	7.0	80
Maximum	170	8.1	280
Site BCU			
Number of Samples	8	8	8
Minimum	63	6.7	20
Average	139	6.9	165
Maximum	275	7.3	616
Site SW2			
Number of Samples	4	4	4
Minimum	33	5.9	32
Average	62	7.0	77
Maximum	86	7.8	110

6.4 ANZECC Water Quality Criteria

For the purposes of assessing the potential impact of mine operations on water quality, the *ANZECC 2000 Guidelines* water quality criteria are relevant considerations. The data in **Table 15** indicates that the pH in drainage lines unaffected by mining generally complies with the default trigger values for ecosystem protection in upland rivers as set out in the *ANZECC 2000 Guidelines*.

It should be noted that the *ANZECC 2000 Guidelines* provide **default** 'trigger values' for different indicators of water quality parameters as either a *'threshold value'* or as a '*range of desirable values'*. Where an indicator is above a threshold value or outside the range of desirable values; '*there may be a risk that the environmental value will not be protected*'. The purpose of these 'trigger values' is to provide a 'trigger' for action or further investigation. They are not prescribed limits or discharge standards.

The *ANZECC 2000 Guidelines* also state that: *"Trigger values are conservative assessment levels, not 'pass/fail' compliance criteria. Local conditions vary naturally between waterways and it may be necessary to tailor trigger values to local conditions or 'local guidelines'."*

Furthermore, the Guidelines state that two years of monthly sampling is regarded as sufficient to provide an indication of the local ecosystem variability and to provide a basis for derivation of 'trigger values' appropriate to conditions in a particular creek system. For physical and chemical stressors for slightly or moderately disturbed ecosystems, such as that surrounding the Project area, the Guidelines recommend the use of the 20^{th} and 80^{th} percentile values of the data obtained from an appropriate reference system as the basis for revised 'trigger values'. On the basis of the monitoring data contained in **Table 15**, appropriate trigger values for the creeks influenced by the Project are set out **Table 16**.

Table 16: Proposed Water Quality 'Trigger Values'

Parameter	Proposed 'Trigger Value' Range
EC (µS/cm)	50 – 1,300
pH	4.5 – 8.0
TSS (mg/L)	20 – 200

The proposed trigger values in **Table 16** do not represent 'limits'. Rather, they represent ranges in which the majority of observations can be expected. Future observations can be expected outside this range on occasions. The 'trigger' for further investigation would be if readings outside these ranges occurred persistently in a particular location or showed a consistent trend. Under those circumstances, further investigation would be required to ascertain whether the cause was related to mining activities and, if so, what mitigation actions would need to be taken.

7 Flooding

7.1 Namoi River Flooding

The Project is located on the edge of the Namoi River floodplain. The Namoi River Basin is located west of the Great Dividing Range and forms part of the Barwon-Darling River system. It is bounded by the Nandewar Range to the north, the Great Diving Range to the east and the Warrumbungle Range to the south. Extending over 350 km from the head of the McDonald River westward to Walgett, the basin covers some 43,000 km^2 (SMEC, 2003).

Major floods at Gunnedah occur between January and March. Moderate flooding can occur in any month, but is rare in April and May. Major flooding generally results from heavy rain associated with cyclonic depressions and persists for several days to several weeks. During major flooding, extensive areas of the floodplain are inundated by shallow, slow moving water.

7.2 Regulation of Development on the Namoi River Floodplain

Planning and management of activities in the floodplains of NSW rivers is the responsibility of the Office of Environment and Heritage (OEH).

The OEH manages rural flood risks for those areas west of the Great Dividing Range under the NSW Government's Flood Prone Land Policy. This is achieved through the administration of Part 8 of the *Water Act 1912*, under which the *Carroll to Boggabri Floodplain Management Plan* (FMP), which covers the reach of the Namoi River that the Project is located adjacent to, has been adopted and gazetted. The FMP was based on the findings of *the Carroll to Boggabri Flood Study and Compendium of Data* (SMEC, 2003) (the Flood Study).

The relevant guiding principles documented in the FMP are:

- floodplain development should not cause significant redistribution of floodwater and allowance should be made to ensure that existing local drainage behaviour is maintained;
- there should be no detrimental impact from floodplain development on any individual landholder or community infrastructure including changes in peak flood levels and changed drainage times;
- sufficient pondage must be retained on the developed floodplain so that flood peak travel time is not unduly accelerated to downstream areas nor flood height increased; and
- storm blow out areas from development areas must be proportionally aligned to the natural drainage system.

The FMP also acknowledges that structural works are unlikely to be approved in floodways unless it can be demonstrated that they would not adversely affect the hydraulic function of the floodway and requirements of the floodplain.

Particular issues that have been considered for this project are:

1. For permanent structures within the designated FMP area such as the Eastern Emplacement, consideration has been given to its potential impact in terms of loss of floodplain storage and potential constriction of flow conveyance leading to elevated flood levels or diversion of flows.

2. Roads (and associated bridges and road works) vested in Local or State Government transport agencies are prescribed works under Part 8 of the *Water Act 1912* and the regulations of the *Water Management Act 2000*. While these works do not require an approval under these pieces of legislation, agencies are required to assess the impacts of these works under the *Environmental Planning and Assessment Act* 1979. These provisions have been considered in relation to the proposed relocation of sections of Shannon Harbour Road and Blue Vale Road and the private haul road and Kamilaroi Highway overpass.
3. Consideration has been given to the risk of either floodwater entering the open cut at the time when extraction is occurring along the southern boundary of the open cut by an assessment of flood levels in South Creek and backwater effects from the Namoi River along Stratford Creek.

Exemptions under Section 4.1 of the *Environmental Planning and Assessment Act 1979* (Clause 89J) do not include part 8 of the *Water Act 1912*. Accordingly, construction of any works impinging onto the active floodplain would be assessed by the OEH according to the provisions and principles outlined in the FMP. This would include an assessment of the effects of any works to be constructed in the floodplain on flow distribution, flow velocities and flood levels on the remainder of the floodplain and particularly on adjacent properties. The hydraulic criteria applicable to the assessment of flood control structures, as outlined in the FMP, are:

- **Natural Flooding Characteristics -** works should not result in a significant departure from the natural flooding or drainage pattern of the floodplain (after taking into account the existing floodplain development);
- **Hydraulic Capacity** - works should not reduce the hydraulic capacity and continuity of floodway areas;
- **Pondage and Flow Duration** - works should not significantly impact on pondage duration on the developed floodplain or cause flood peak travel time to unduly accelerate to downstream users; and
- **Redistribution** - acceptable increases in flood heights and percentage redistribution of peak flood discharges, as a result of structural works on the floodplain, would be assessed against the relevant criteria in the FMP.

7.3 Flood Assessment

An assessment of the potential impacts of the Project on flood conditions in the Namoi River and its immediate floodplain has been carried out to address the hydraulic criteria identified above. The flood modelling assessment is provided in **Appendix D**.

The assessment focused on two specific areas where facilities associated with the Project might affect, or be affected by, flood conditions in the Namoi River between Gunnedah and Boggabri, namely:

- the extent of the open cut and MIA located to the south of Shannon Harbour Road; and
- the private haul road and Kamilaroi Highway overpass area near the Whitehaven CHPP approximately 5 km west of Gunnedah.

As flooding in these areas is predominantly due to mainstream flooding, the existing hydraulic model for the Namoi Valley between Carroll and Boggabri (SMEC, 2003) has been adopted to represent ‘base case’ conditions. The Flood Study (SMEC, 2003) utilised all available records of flood levels, photographic evidence and observed flood extent to calibrate hydrologic and hydraulic models of flooding in the Namoi Valley between Carroll and Boggabri.

The relevant data files representing the channels, floodways, floodplain and inflow hydrographs for various historic floods for this assessment were provided by the Inland Flood Unit of the OEH. OEH also provided copies of a LiDAR survey undertaken for purposes of defining the floodplain topography for incorporation in the hydraulic model.

Flood records in the Namoi valley extend back to 1864 when a flood level equivalent to 9.85 m on the Gunnedah gauge was recorded. Other significant floods occurred in 1908 and 1955 (9.65 m and 9.60 m respectively on the Gunnedah gauge). On the basis of the historic record the Flood Study identified the flood of February 1955 as having an Annual Exceedance Probability (AEP) of 1% at Gunnedah.

Following the preparation of the Flood Study, the draft *Carroll-Boggabri Floodplain Management Study* was prepared (Webb, McKeown & Associates, 2005) under the direction of the Carroll-Boggabri Floodplain Management Committee, which included representatives of state agencies, local government, rural industry groups and landholders. A ‘Reference Flood’, which combined elements of the observed floods of 1955 and 1984, was adopted to manage potential impacts of floodplain development in a manner that adequately represented flood conditions in different parts of the valley.

Following consultation with the Inland Flood Unit of OEH, the 1955 flood was adopted for the assessment of potential impacts of the mine related proposals in the reach of the Namoi River between Gunnedah and Boggabri.

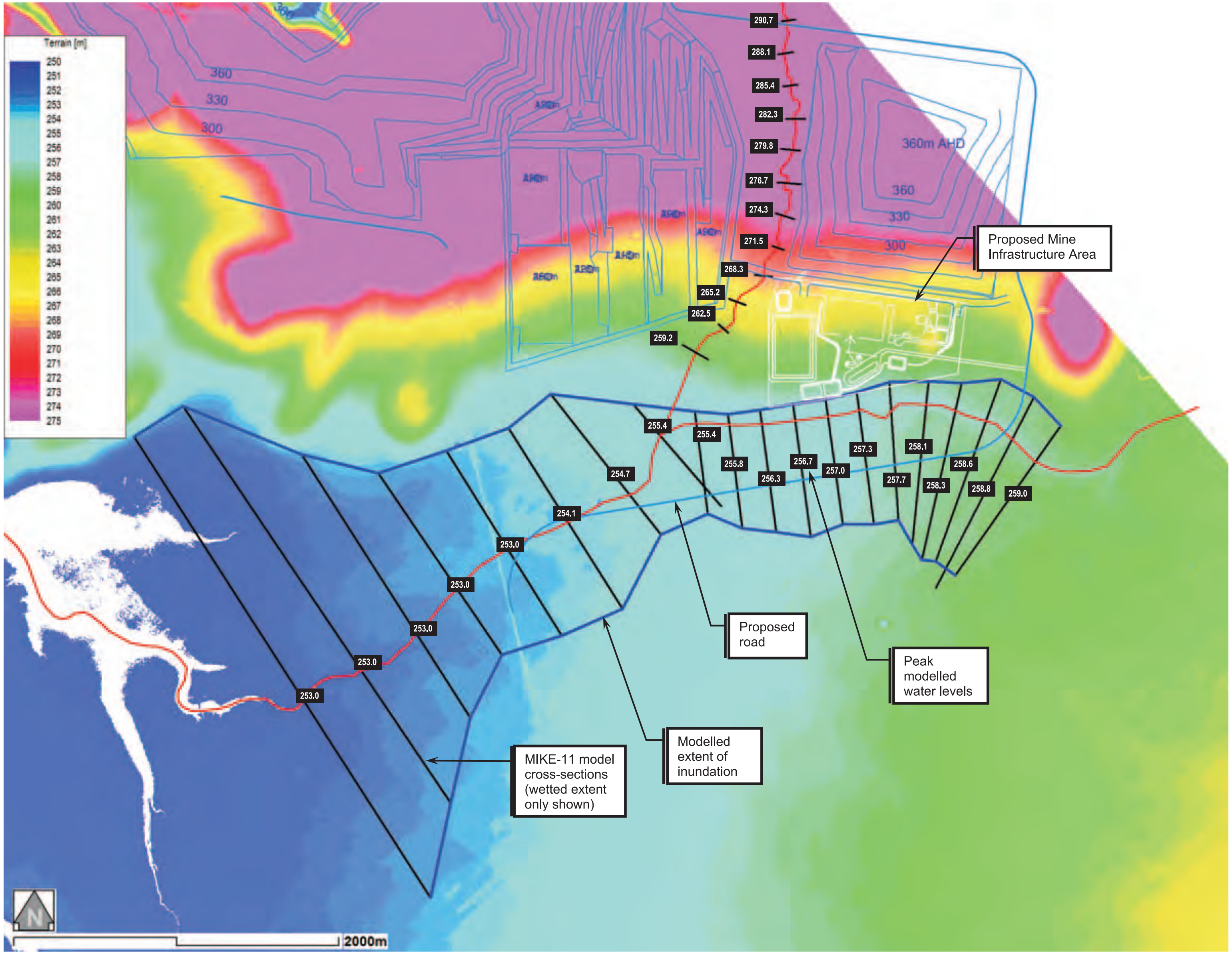
Section 8 of the Flood Study (SMEC, 2003) provides an assessment of the impacts that various constructed levees have had on flood levels and flows along different reaches of the river system. The model data files representing the ‘with levees’ conditions could not be located in the OEH archives or those of the original consultants. Accordingly, it was agreed with OEH that the ‘pre levees’ data files be used as the basis for assessing any significant changes in flood levels of flow distribution associated with the Project.

This approach was considered acceptable as the majority of the levees appear to be located a significant distance from the area of interest. Any increases in flood levels due to the presence of levees would also be present in the proposed simulation and the relative changes in flood levels between the existing and proposed scenarios would remain the same (or insignificantly different).

7.3.1 Flooding to the South of the Open Cut and MIA

Figure 8 shows the proposed layout of the Project relative to the Namoi River and Stratford Creek, which drains into the river from the east. As Stratford Creek is not separately identified in the existing Namoi Valley flood model, the flooding conditions associated with this creek system in the vicinity of the mine were modelled as follows:

- the 1% AEP flood hydrograph along the creek was estimated using the hydrologic modelling program XP-RAFTS;



Source: Worley Parsons (2012)

VICKERY COAL PROJECT

FIGURE 8

Modelled Extent of 1955 Flood Event (1% AEP Local Flow) for Undeveloped Site Conditions

EVANS & PECK

WHITEHAVEN COAL

WHC-10-03 EA AppSW_001B

- additional cross-sections were added to the Namoi River MIKE11 flood model to represent the topography of the floodplain and channel of Stratford Creek on the east bank of the Namoi River, including South Creek that flows through the mine site from the north. To ensure consistency with the topography in the Namoi River MIKE11 flood model, topographic data for the cross-sections were extracted from the same LiDAR dataset; and
- flood levels along Stratford Creek were assessed for conditions in which the peak of the flood from Stratford Creek was coincident with the peak of the 1955 flood in this reach of the Namoi River.

Figure 8 shows the modelled extent of flooding and flood levels along Stratford Creek for a local 1% AEP event (3 hour storm) in conjunction with the peak of the 1955 flood simulation in the Namoi River. The dark blue line in the figure represents the flood extent drawn manually over the LiDAR data.

In planning the layout of the mine, consideration has been given to locating infrastructure and the waste emplacement areas outside the floodplain and potentially flood affected areas so as to avoid any loss of floodplain storage or redirection of flow.

The proposed MIA layout is shown as white line-work in **Figure 8** and is shown to be located largely outside of the 1955 (1% AEP) flood extent. As such, no impact on existing flood characteristics along Stratford Creek would be anticipated (and hence detailed modelling of the post-construction scenario has not been conducted). Blue Vale Road is proposed to be realigned across the Stratford Creek alignment. The road is proposed to be constructed on-grade in the vicinity of the vicinity of South Creek. Minimal filling or earthworks would be required and therefore local catchment flows would discharge across the road with minimal obstruction.

7.3.2 Flooding in the Vicinity of the Proposed Kamilaroi Highway Overpass

A private haul road and highway overpass is proposed to allow coal trucks from the Project to deliver coal to the Whitehaven CHPP without needing to access the Kamilaroi Highway (**Figure 2b**).

Additional cross-sections were added to the Namoi River MIKE11 flood model to represent the topography of the streams and floodplain in the vicinity of the proposed overpass. To ensure consistency with the topography in the Namoi River MIKE11 flood model, topographic data for the cross-sections were extracted from the same LiDAR dataset. Details of the alignment and levels of the proposed overpass were then superimposed onto the existing LiDAR data to simulate the post-development scenario.

The wider floodplain of the Namoi River, as it passes by the site of the proposed overpass, is represented by several parallel branches (Deadmans Gully, Namoi River and Landry Lagoon) within the original Namoi River MIKE-11 model. The extents of the cross-sections of the individual branches were limited to enable a more complex representation of the individual branches across the width of the floodplain. Accordingly, the new cross-sections in the vicinity of the proposed overpass were limited at the extents defined by the cross-sections upstream and downstream of the overpass location.

The majority of the overpass structure would be constructed above the modelled 1955 peak flood levels identified from the Flood Study (SMEC, 2003). It was conservatively assumed that the passage of water through the proposed structure would be limited to a bridge opening for the Kamilaroi Highway and a culvert structure to convey Deadmans Gully flows through the overpass.

The 1955 flood event was simulated for both the existing topography scenario and the assumed post-development scenario with the overpass structure, bridge and culvert incorporated within the appropriate cross-sections. The flood level, afflux, channel velocity and flow distribution results for the private haul road and Kamilaroi Highway overpass area for the existing and post-development scenarios are provided in **Appendix D**.

The modelling indicates that the overpass structure would result in the constriction of flows in Deadmans Gully. The impact on peak flood levels within Deadmans Gully was estimated to be 0.47 m at the overpass and 0.39 m at a location 90 m upstream of the overpass. Small changes in flood levels (in the order of several centimetres) were calculated to occur 1 to 2 km upstream of the crossing in all four major flow paths across the floodplain. As the various streams that constitute the floodplain area in the vicinity of the overpass are interlinked in the model, it is difficult to determine the specific impacts on the individual streams or the aspects of the proposed overpass that cause the greatest impacts.

Flows enter Deadmans Gully from the Namoi River upstream of the crossing, approximately 3 km east of the proposed overpass. This first occurs when the Namoi River is at a flood level of around 260.4 m AHD at this location.

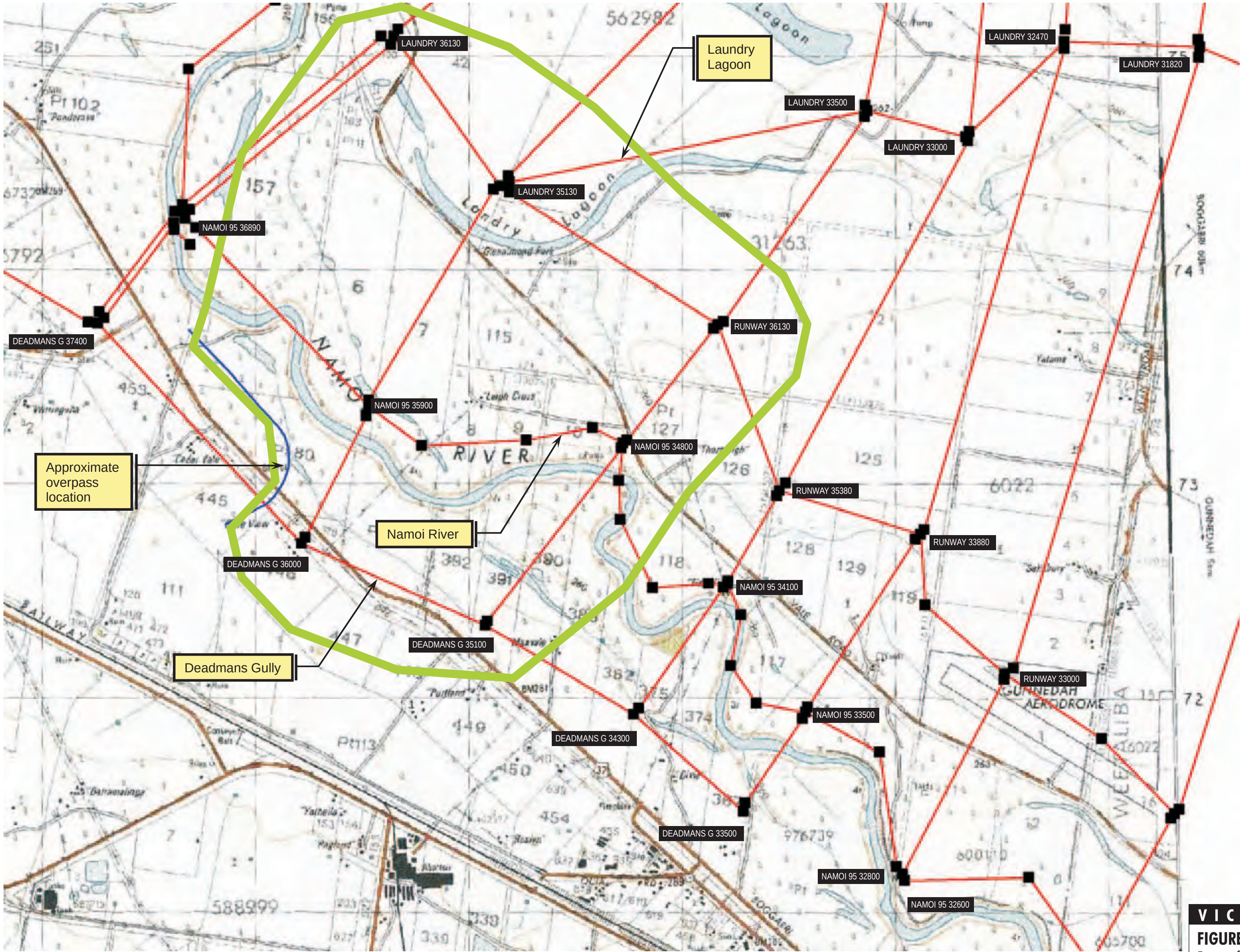
Downstream of this location it is assumed that floodwater is freely transferred between the Namoi River and Deadmans Gully during times of high flow (i.e. when flooding is above 260.4 m AHD). It is also likely that flows would enter Deadmans Gully during more common events. However, at this stage smaller floods have not been modelled so it is not possible to identify the impacts caused by the overpass for smaller events.

The eastern extent of the proposed overpass as it runs along the Kamilaroi Highway is located within a designated ‘floodway’ area adjacent to the Namoi River, according to the FMP (Webb, McKeown & Associates, 2006). The model results indicate that under existing conditions, the 1955 flood depth at the Kamilaroi Highway (in the vicinity of the proposed overpass) would be approximately 0.85 m. Since a substantial amount of flow in the Namoi River would be able to travel around the proposed overpass, the anticipated increase in flood height at the Kamilaroi Highway is 0.09 m. This impact was calculated to have dissipated towards the north-western extent of the overpass. This scenario would result in a continuous flood surface between the Namoi River and Deadmans Gully and floodwaters would transfer between the two low points.

Figure 9 shows the approximate extent (outlined in green) to which flood level impacts of 0.03 m or more are expected to occur. The estimated increase in the 1% AEP flood level at various dwellings in the vicinity of the overpass (see **Figure 10** for numbering) is listed in **Table 17**.

Table 17: Estimated Change in 1% AEP Flood Levels

Dwelling Number	Change (m)	Dwelling Number	Change (m)
1	0.04	12	-0.10
2	0.06	13	0.08
3	0.03	14	0.03
4	0.02	15	0.03
8	0.05	18	0.07
9	0.03	19	0.03
10	0.09	21	0.03
11	-0.34		

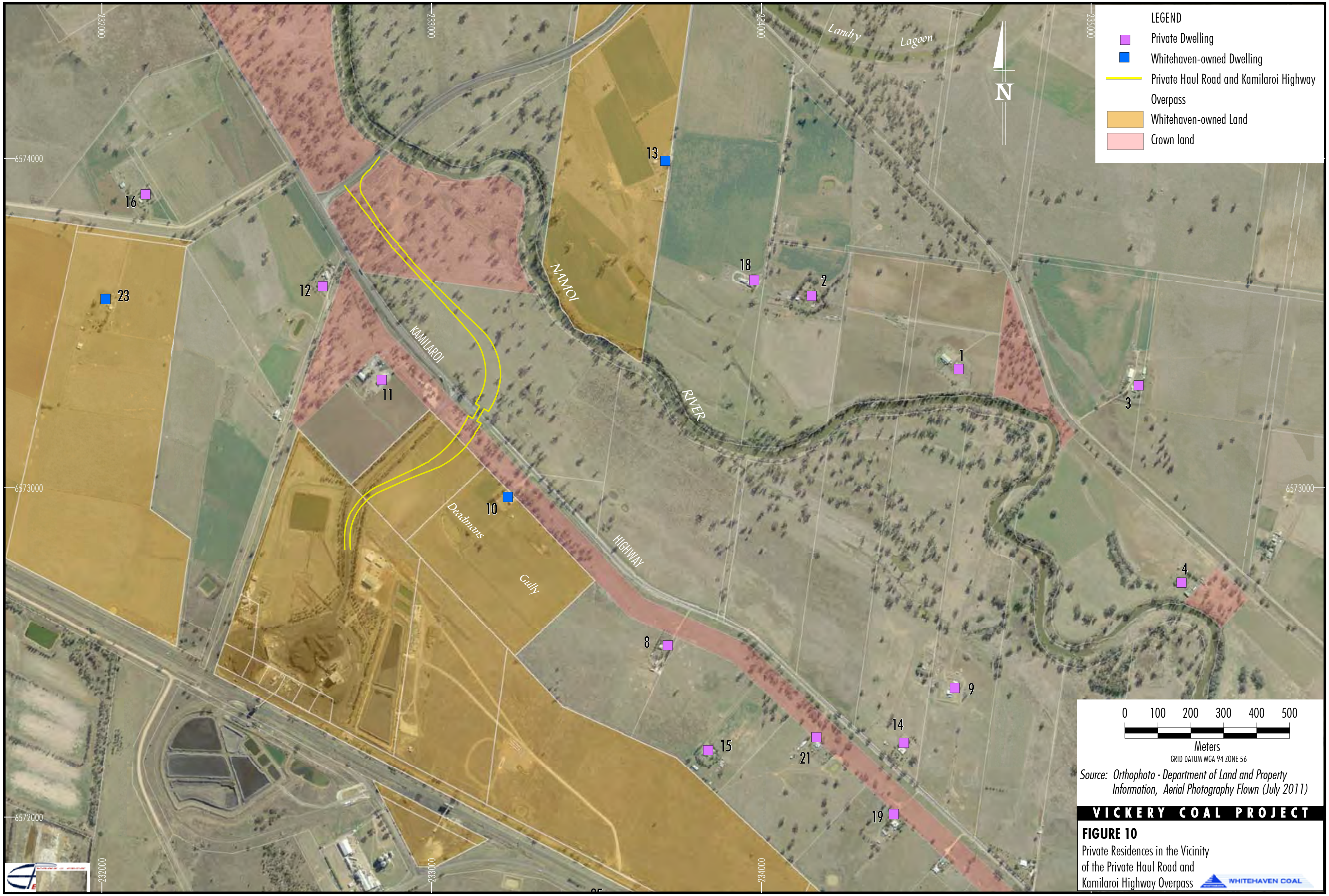


Source: Worley Parsons (2012)

VICKERY COAL PROJECT

FIGURE 9

Extent of Maximum Impact on Flood Levels from Overpass Structure



WHC-10-03_AppSW_203C

The flood modelling indicates that as a result of construction of the private haul road and Kamilaroi Highway overpass, there would be negligible increase (if any) to channel velocities between existing and post-development conditions in the vicinity of the infrastructure and across the wider floodplain (**Appendix D**). Consequently, there would be negligible impact on stream power and thus negligible impact on the stability of the channel and floodplain, including the travelling stock route.

7.4 South Creek

Flood flows and levels have been analysed for a range of floods near the downstream end of South Creek adjacent to the south-east corner of the open cut and the MIA. Flood flows were analysed using the Probabilistic Rational Method (*Australian Rainfall & Runoff* – Engineers Australia, 1998) for two locations of interest (**Figure 11**):

- Shannon Harbour Road; and
- downstream of Shannon Harbour Road where South Creek is closest to the south-eastern corner of the open cut.

Rainfall intensities were calculated for storms ranging from 1 to 100 years average recurrence interval (100% to 1% Annual Exceedence Probability [AEP]) and for the PMF using the rainfall intensity data from the BoM website (http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml) and *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (Bureau of Meteorology, 2003) respectively. The analysis conservatively assumed that at the time of the design storm the sediment basin for the Eastern Emplacement would be full and the runoff from the emplacement would contribute to the peak flow in the creek.

For the purposes of flood level estimation, Shannon Harbour Road was assumed to act as a broad crested weir. Flood levels downstream of Shannon Harbour Road were calculated using Manning's equation based on an indicative cross-section from the edge of the open cut to the edge of the MIA derived from the available topographic data with levees assumed along the edge of the open cut and MIA. **Table 18** summarises the results of the analysis.

Table 18: Estimated Flows and Flood Levels on South Creek

Flood Event (AEP)	Peak Flow (m^3/s)	Flood Level (m AHD)	
		Shannon Harbour Road	S-E Corner of Pit
100%	2	269.0	264.3
50%	4	269.1	264.4
20%	7	269.1	264.5
10%	11	269.1	264.5
5%	16	269.1	264.6
2%	27	269.2	264.7
1%	38	269.2	264.8
PMF	348	270.1	266.6

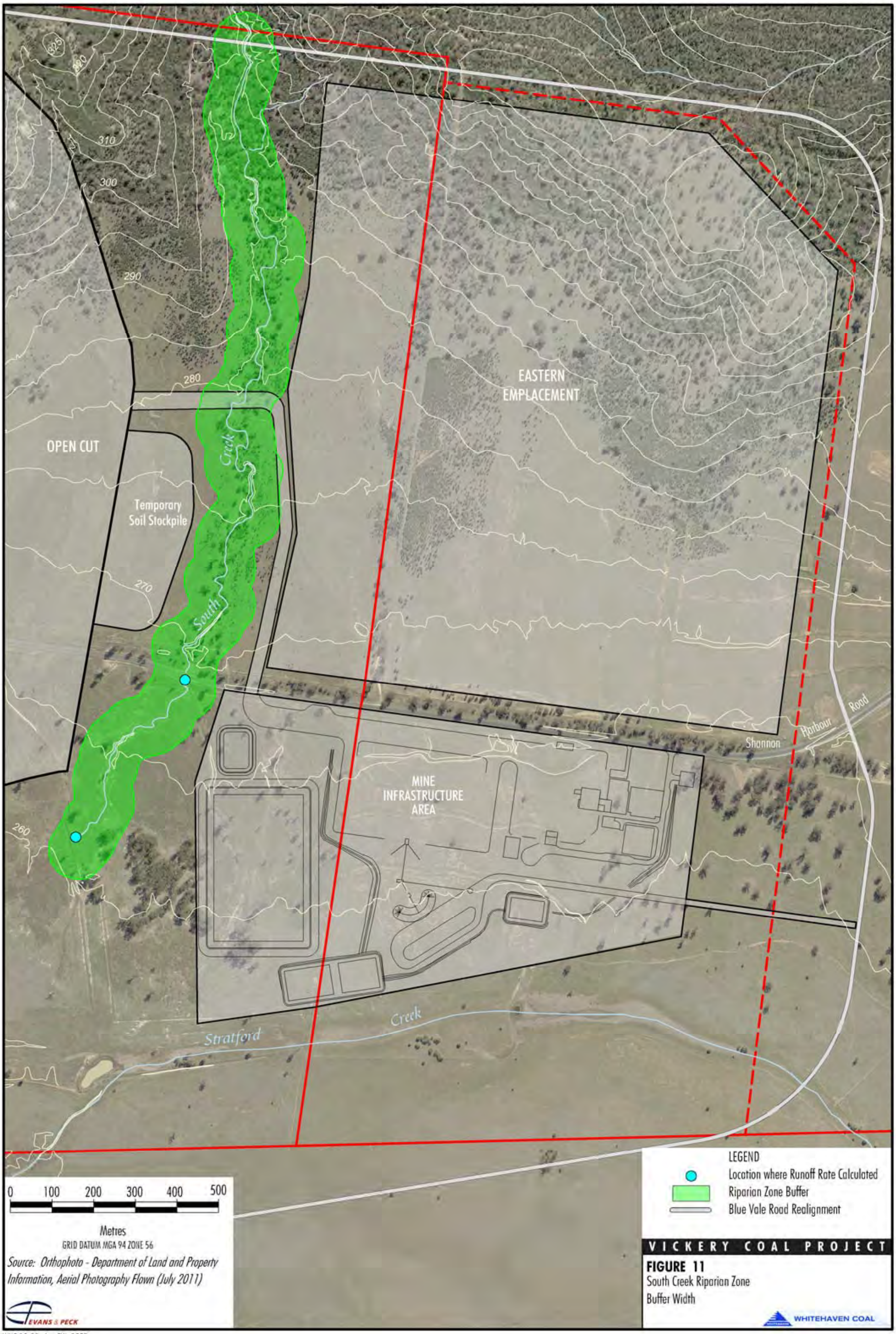


FIGURE 11
South Creek Riparian Zone Buffer Width

WHC-10-03_App SW_105D

The existing ground level at the edge of the open cut in the vicinity of South Creek is approximately 264.5 m AHD. The analysis indicates that flooding from South Creek has the potential to drain into the open cut, even for relatively frequent floods. For the two locations assessed the 1% AEP flood level is estimated to be about 0.3 to 0.5 m above the natural ground level at the edge of the open cut, while the PMF level would be approximately 2.5 m above natural ground level.

A permanent flood protection bund approximately 3 m high would be constructed around the open cut to protect it against a PMF event during operations and following mine closure. This flood protection bund would be located outside the area affected by the flooding from the Namoi River and Stratford Creek in a 1% AEP flood (see **Section 7.3.1**). The bund would have minimal effect on flood conditions along South Creek and would have negligible impact on flood conditions along Stratford Creek.

The flood levels quoted in **Table 18** and the suggested levee heights are indicative only and would need to be reviewed prior to mining in this area to take account of any backwater effects from flooding in Stratford Creek and more detailed analysis of the flood profile along South Creek using surveyed cross sections and hydraulic analysis using HEC-RAS or a similar program.

Page intentionally left blank

8 Operational Water Management System

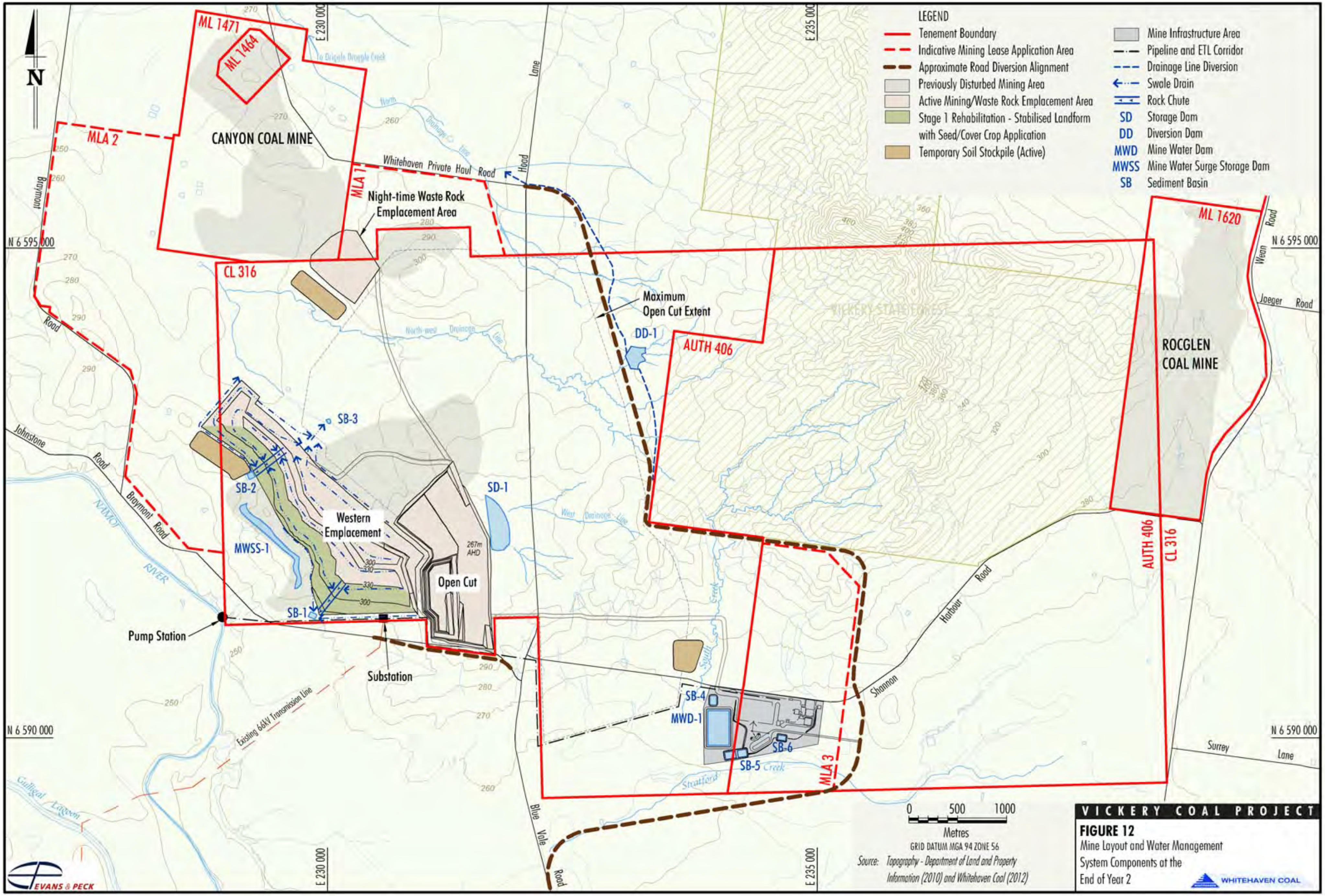
This section describes the operational water management system throughout the life of the Project. The water management system has been developed to comply with accepted best practice principles for mine site water management, and to satisfy the Project's specific objectives and design criteria, as summarised in **Section 8.1.1**.

Section 8.1 describes the progressive development of the Project water management system, while **Sections 8.2, 8.3** and **8.4** detail the system inflows, and proposed mine water storages and consumption processes, respectively. The drainage management of the waste emplacements is addressed in **Section 8.5**.

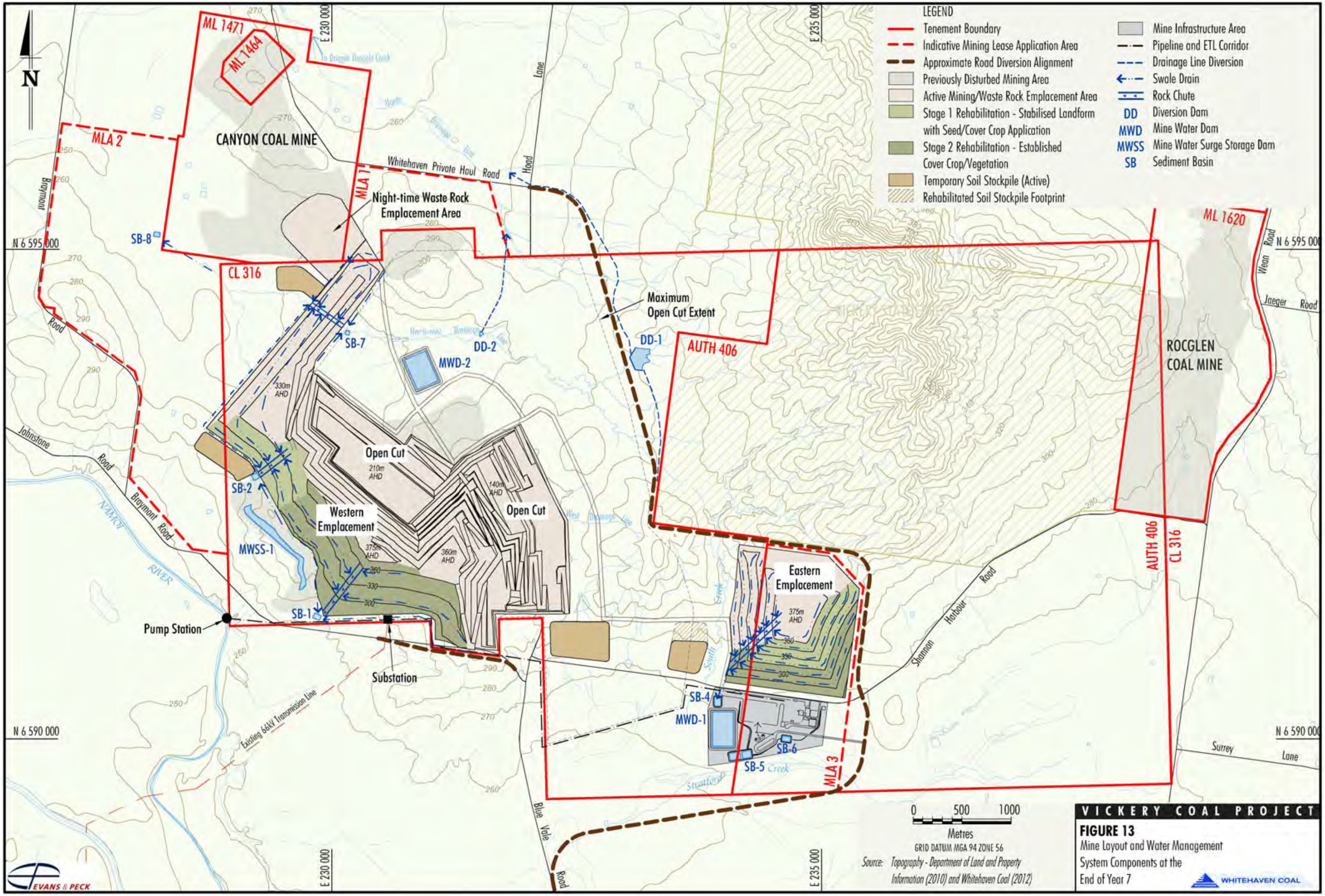
8.1 Proposed Project Water Management System

The proposed Project water management system would be progressively developed over the life of the mine, as detailed in **Section 8.1.2**. The water management system would comprise the construction and operation of interconnected water management structures as shown on **Figure 12** to **Figure 15** including:

- Sediment Basins – a network of sediment basins (designated SB-1 to SB-4 and SB-7 to SB-10) would be progressively constructed to manage runoff from the waste emplacements, and any undisturbed areas that naturally drain to the site of each basin. Runoff collected in these basins would either be transferred to the mine water dams or discharged once the water quality meets discharge quality criteria;
- Sediment Basins (SB-5 and SB-6) – constructed to collect runoff from the MIA. All runoff collected in these basins would be transferred to the mine water dams;
- Mine Water Dams – two mine water dams (MWD-1, and MWD-2 or MWD-3) would be in operation at any one time during the mine to accept water pumped from the open cut, the MIA and, if required to supplement supply, water transferred from the sediment basins. Water in the mine water dams would be used as required for mine operations, including dust suppression and coal crushing;
- Mine Water Surge Storage Dams (MWSS-1 and MWSS-2) – constructed to provide additional capacity for storage of excess mine water during extended wet weather when the mine water dams are near capacity. Initially, MWSS-1 would be created by constructing an embankment across the south-eastern end of the existing Blue Vale void. MWSS-2 would be constructed towards the end of the mine life when the active open cut and waste emplacement area would be large;
- a Storage Dam – an existing storage dam (SD-1) would be utilised in the early operation of the mine as a source of water for mine operations;
- Diversion Dams – (DD-1 and DD-2) would be constructed to divert runoff from undisturbed catchments and prevent it entering the open cut. The primary purpose of these dams is to raise the water level sufficiently to allow diversion across the landscape to a point where the water can drain into an existing stable drainage system. Water for mine operations would only be extracted from these dams when all internal sources have been utilised. (Water balance modelling (**Section 9**) indicates that additional water for mine operations is most likely to be required during any dry years that occur in the early years of the mine);



WHC-10-03_App SW_106C



WHC-10-03_App SW_107C

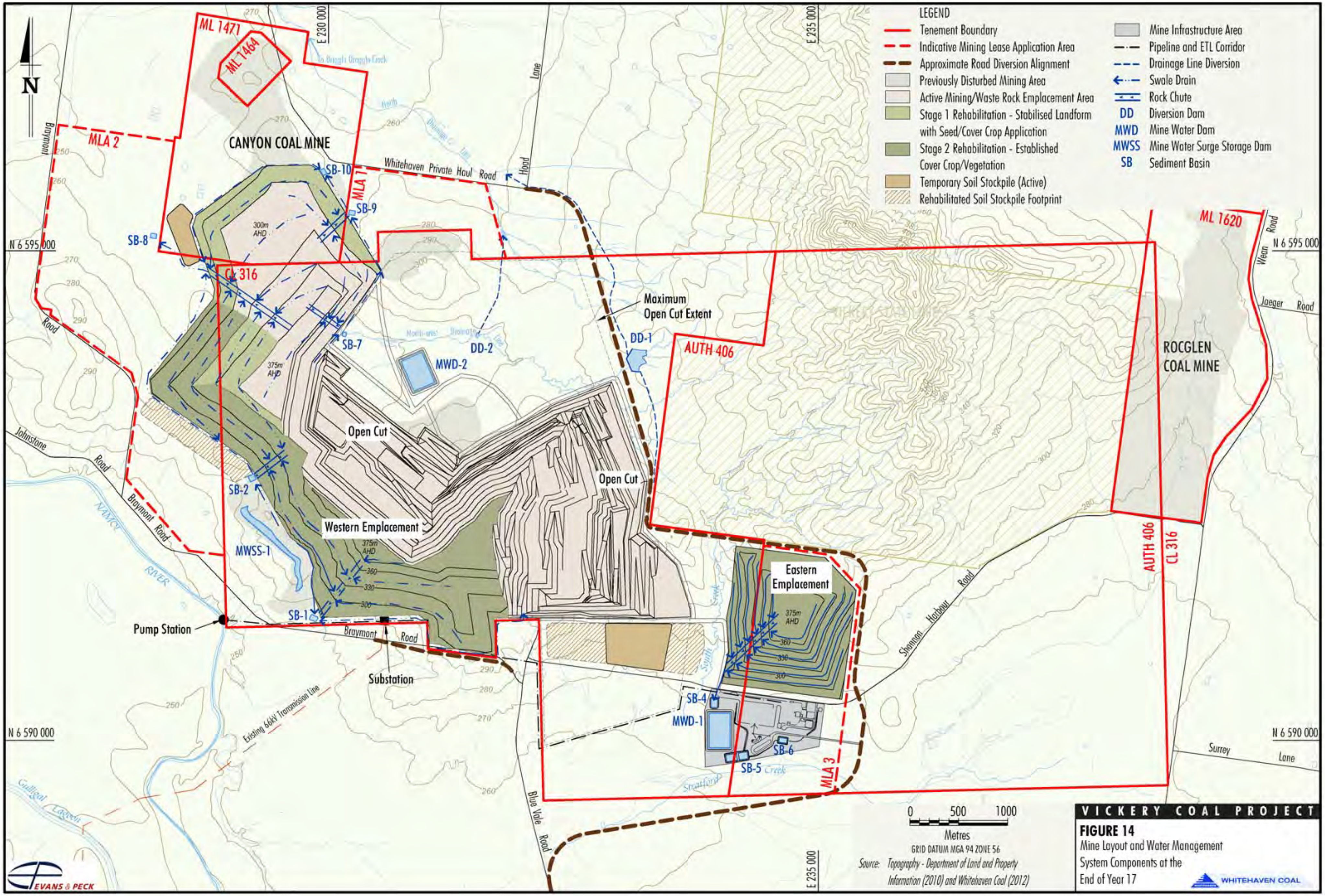
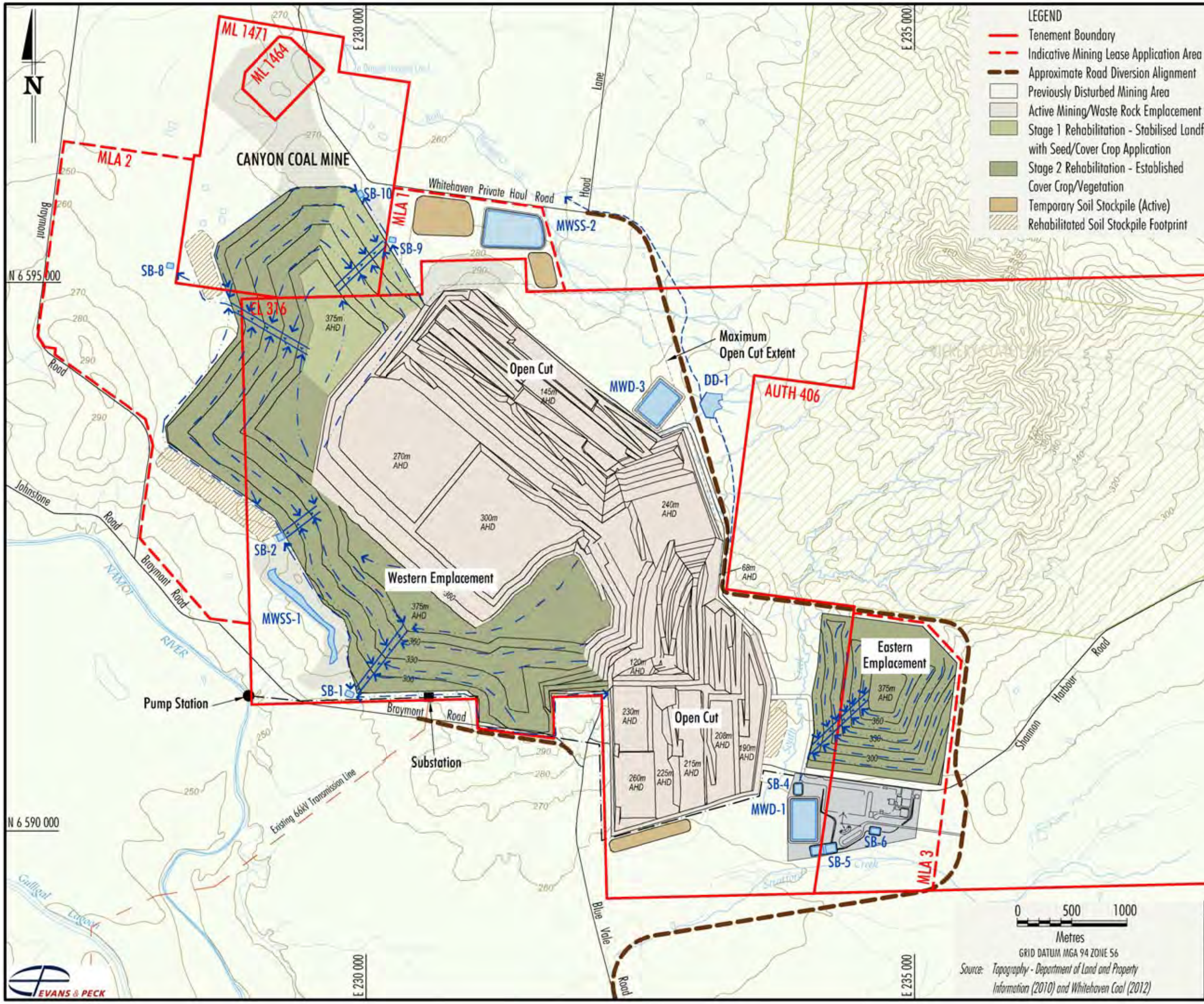


FIGURE 14
Mine Layout and Water Management System Components at the End of Year 17

WHC-10-03_App SW_108C



VICKERY COAL PROJECT

FIGURE 15

Mine Layout and Water Management System Components at the End of Year 26

EVANS & PECK

WHITEHAVEN COAL

WHC-10-03_App SW_109C

- Namoi River Pump Station – a surface water pump on the bank of the Namoi River and a groundwater bore would provide raw water from licensed sources. In times of shortage of mine water, these sources would be used to provide supplementary supply;
- Supporting Structures - drains and diversions, including rock chutes and swale drains, would be progressively constructed to direct mine runoff into sediment basins and to divert undisturbed runoff away from active mining areas; and
- MIA Services – Potable supply would be by tanker truck. Effluent would be treated by an on-site package treatment plant and effluent would be disposed of by means of an irrigation system designed and operated in accordance with the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC, 2004).

8.1.1 Objectives and Design Criteria

The water management system has been developed to comply with accepted best practice principles for mine site water management, as well as to provide a project specific solution which satisfies the Project's objectives and design criteria.

The objectives and design criteria of the site water management system are to:

- protect the integrity of local and regional water resources;
- separate runoff from undisturbed, rehabilitated and mining affected areas;
- design and manage the system to operate reliably throughout the life of the mine in all seasonal conditions, including both extended wet and dry periods;
- provide sufficient water for use in mining operations, including in extended dry weather periods;
- provide sufficient storage capacity in the system to store, treat and discharge runoff as required, including in extended wet weather periods;
- develop facilities required for the long-term functioning of the water management system as soon as practicable and to minimise the number of facilities that would be subsumed by mining activities during the Project life;
- avoid the requirement for water to be pumped wherever possible; and
- minimise the number of licensed discharge points.

To effectively develop a water management system that addresses the above objectives and design criteria, runoff has been classified into four distinct categories:

- ***Undisturbed Area Runoff*** – runoff from catchments that have not been disturbed by mining activities. Undisturbed Area Runoff may be diverted around mining activities to downstream receiving waters.
- ***Rehabilitated Mine Area Runoff*** – runoff from rehabilitated mine areas that have established stable vegetation cover. This runoff is expected to have similar water quality characteristics to Undisturbed Area Runoff. The water management system has been designed to allow runoff from these areas to be discharged without control.
- ***Disturbed Area Runoff*** – runoff from active spoil emplacement areas and areas under active rehabilitation. The water management system has been designed to capture this runoff and to:
  - transfer it to the mine water management system for reuse in mine operations; or

  - discharge it off-site after retention for sufficient time to allow settlement of sediment to achieve the required water quality (50 mg/L TSS).

- ***Mine Water*** – water collected in sumps in the open cut as a result of runoff from the open cut itself or active waste emplacement areas reporting to the open cut; and runoff from the MIA. As this water has been in contact with active mining areas it is unlikely to be suitable for uncontrolled release. The water management system is designed to contain and re-use this water on site.

As described in **Section 8.1.2**, the water management system considers each type of runoff throughout the Project life.

8.1.2 Progressive Development of the Water Management System

The progressive development of the water management system, as depicted in **Figure 12** to **Figure 15**, accounts for the ongoing development of the open cut and mine areas, as well as for the continuing prompt rehabilitation of sections of the waste rock emplacements once the final level and landform has been achieved. The progressive development of the mine as depicted in these figures provides the basis for the final landform and associated drainage systems depicted in **Figure 16**. Water management structures, such as sediment basins, storage dams and drains, as well as indicative drainage pathways, are detailed on each figure. The accompanying schematics to these water management system mine plans are shown in **Figure 17** and **Figure 18**.

8.1.2.1 Year 2 Mine Layout

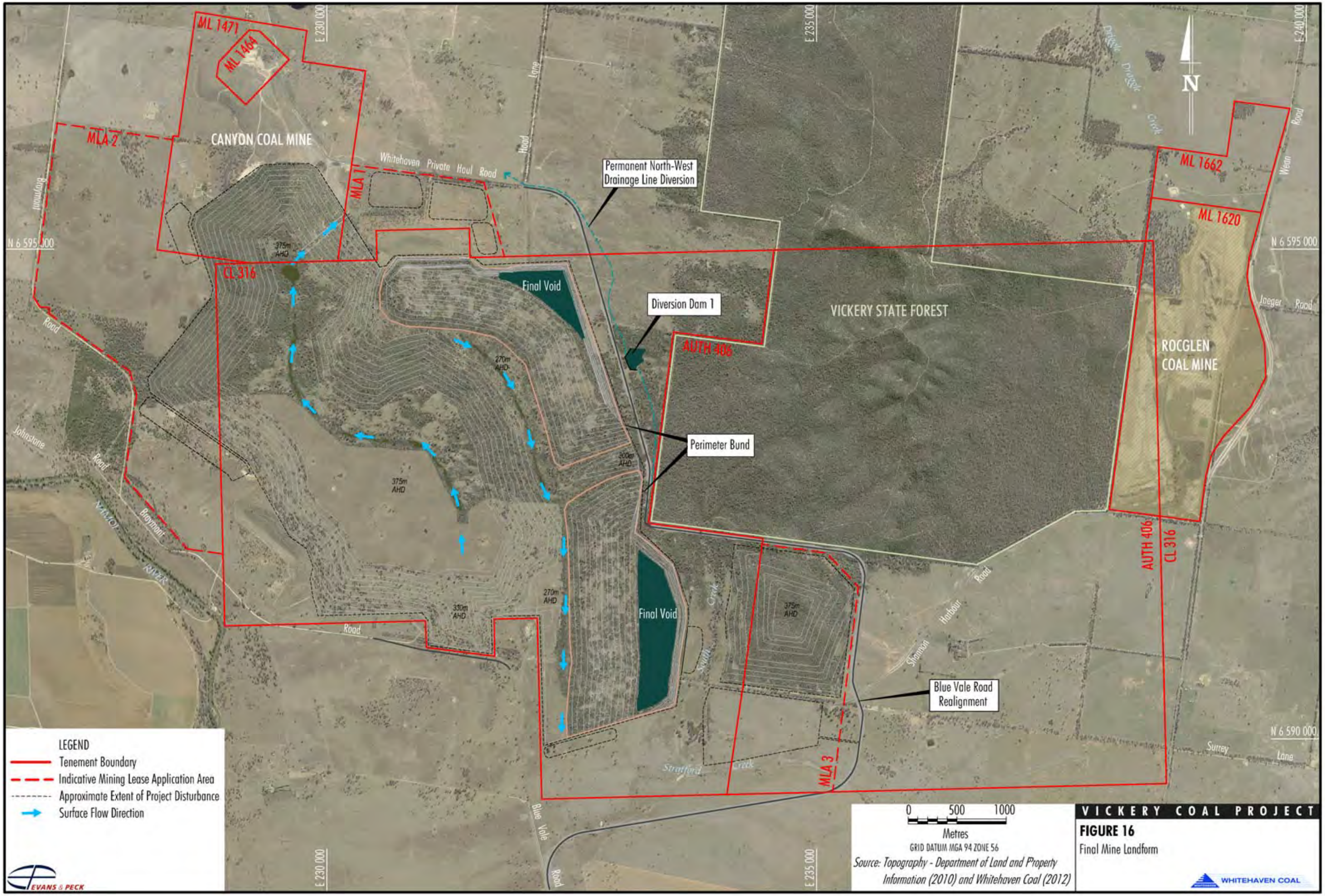
Figure 12 depicts the proposed surface water management system in Year 2 of mine operation, and **Figure 17** provides the corresponding schematic.

At this early stage of the Project, the Western Emplacement would be developing. A series of drainage swales and rock chutes would be progressively constructed around the emplacement to direct and capture runoff. Runoff from active emplacement areas would be directed back towards the open cut where practicable. Three sediment basins (SB-1, SB-2 and SB-3) would be constructed to capture the remaining mine affected runoff from the Western Emplacement.

Water in the existing storage dam (SD-1), located at the eastern edge of the open cut, would be used for mine operations.

A mine water dam (MWD-1 - 400 ML 'turkeys nest') would be constructed adjacent to the MIA. MWD-1 would have the ability to source water from the open cut, SB-1, SB-2 and SD-1, and would be able to directly manage water levels between them. Importantly, mine water would be able to be pumped from MWD-1 to MWSS-1, allowing large volumes of water to be stored in the mine water management system during wet periods.

At the time that the Blue Vale Road realignment is constructed to run along the eastern side of the mine footprint, diversion dam DD-1 would be constructed to the east of the road diversion. Contour banks would be constructed to direct runoff into the dam and allow overflow to drain in a northerly direction into a minor tributary of Driggle Draggle Creek.



Source: Topography - Department of Land and Property Information (2010) and Whitehaven Coal (2012)

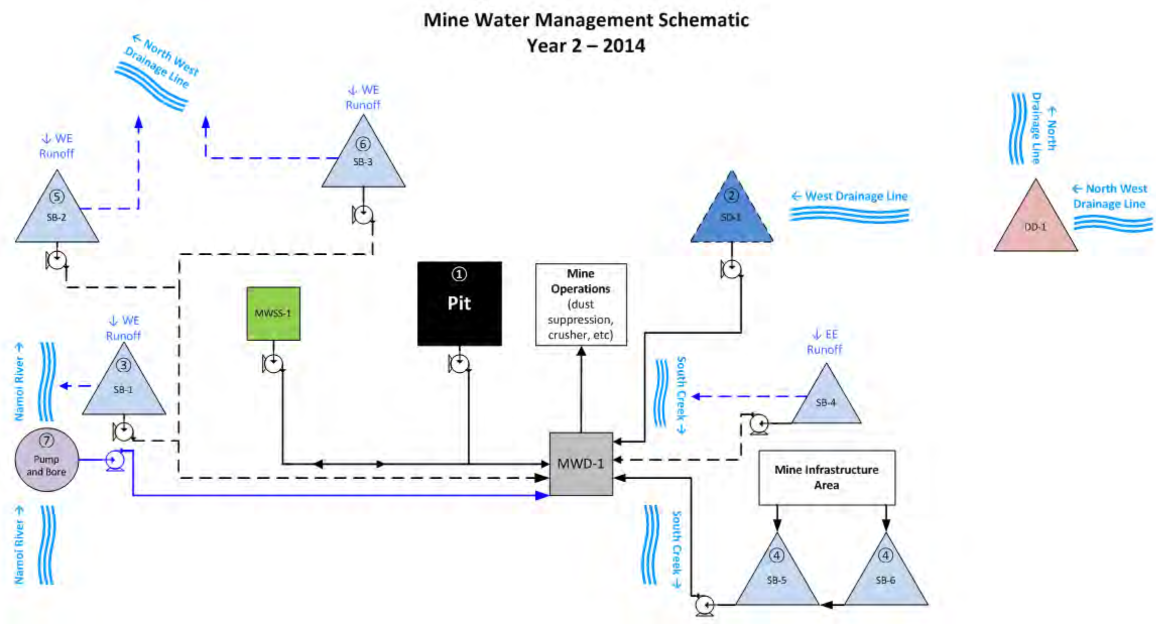
VICKERY COAL PROJECT

FIGURE 16

Final Mine Landform

WHC-10-03_App SW_110E

Figure 17: Schematic Diagrams of the Mine Water Management System for Years 2 and 7



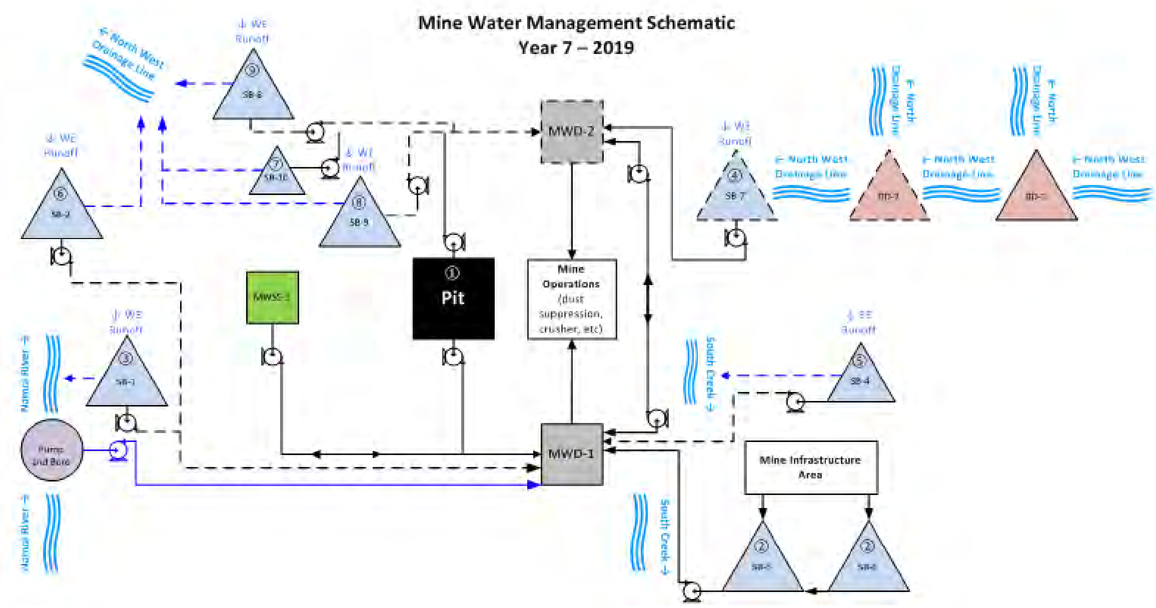
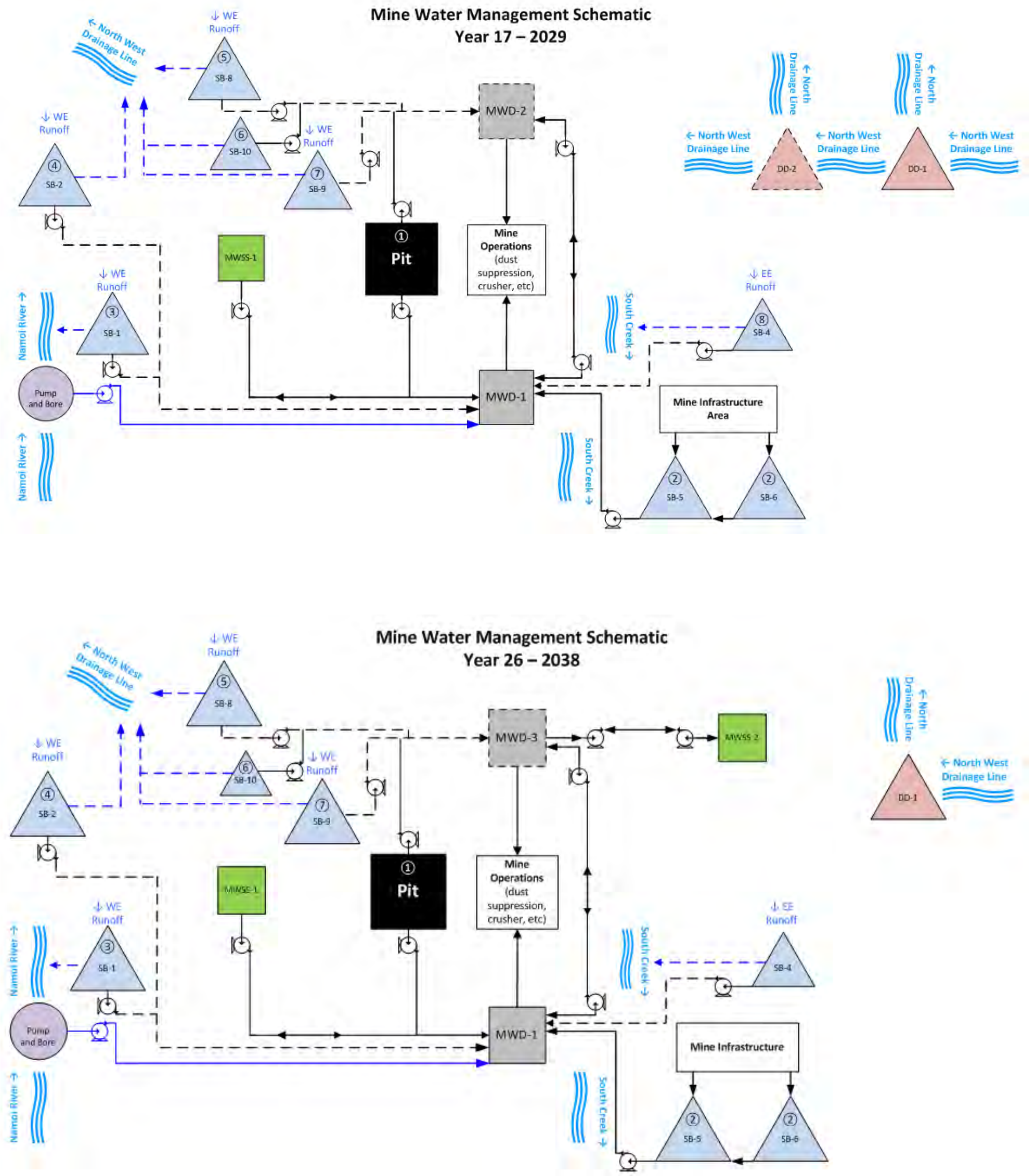


Figure 18: Schematic Diagrams of the Mine Water Management System for Years 17 and 26



8.1.2.2 Year 7 Mine Layout

Figure 13 depicts the proposed surface water management system for Year 7 of mine operations, and **Figure 17** provides the corresponding schematic.

The mine plan for Year 7 shows the expansion of the open cut to the north-west, the establishment of the Eastern Emplacement, and the expansion of the Western Emplacement to the north and to the west. At this stage both SD-1 and SB-3 would have been subsumed by the increased mine footprint, and the most northern point of the Western Emplacement would have blocked the North-East Drainage Line. In order to limit the area of undisturbed catchment that could drain into the open cut, a second diversion dam would be constructed at a location where, with a minimal depth of channel cut, water could be drained northwards into a minor tributary of Driggle Draggle Creek.

A second mine water dam (MWD-2) would be constructed by this time to provide capacity for storage of runoff from the enlarged mine footprint.

Runoff from the southern and south-western sides of the Western Emplacement would continue to be directed to, and managed by, SB-1 and SB-2. The catchment draining to SB-1 would be fully rehabilitated in Year 7 and therefore SB-1 could be allowed to discharge without management control.

Two new sediment basins, SB-7 and SB-8 would be constructed to manage the additional mine affected runoff from the enlarged Western Emplacement. In addition to mine affected runoff from the emplacement, SB-7 would capture undisturbed area runoff from the area to the north of the open cut.

A new sediment basin (SB-4) would be constructed at the north-west corner of the MIA to capture all mine affected and rehabilitated mine area runoff from the Eastern Emplacement. A series of swale drains and rock chutes would be progressively constructed around the emplacement to direct runoff to the sediment basin.

All other water management system elements would continue to operate consistent with Year 2 mine operations, as described in **Section 8.1.2.1.**

8.1.2.3 Year 17 Mine Layout

Figure 14 depicts the proposed surface water management system in Year 17 of mine operation, and **Figure 18** provides the corresponding schematic.

The mine plan for Year 17 shows the expansion of the open cut to the east and west, the full rehabilitation of the Eastern Emplacement and significant rehabilitation of the Western Emplacement.

Runoff from the Western Emplacement would continue to be directed to, and managed by, SB-1, SB-2, SB-7 and SB-8. Additionally, two new sediment basins (SB-9 and SB10) would be constructed at the north end of this emplacement to manage additional runoff.

Catchments draining to SB-1 and SB-4 would be fully rehabilitated in Year 17, and therefore these sediment basins could be allowed to discharge without management control.

All other water management system elements would continue to operate consistent with Year 7 mine operations, as described in **Section 8.1.2.2**.

8.1.2.4 Year 26 Mine Layout

Figure 15 depicts the proposed surface water management system in Year 26 of mine operation, and **Figure 18** provides the corresponding schematic.

The mine plan for Year 26 shows significant advancement of the open cut to both the north, east and south, although the total area of the open cut would have remained relatively consistent with the Year 17 mine plan. The Western Emplacement would have increased in size to the north-east, with large areas being fully rehabilitated. MWD-2 and DD-2 would have been subsumed by the developing mine footprint.

As MWD-2 would have been subsumed by the open cut, a replacement mine water dam (MWD-3) would be constructed adjacent to the north-east corner of the open cut. Similar to MWD-2, this mine water dam would have the ability to source water from the open cut, and would be able to pump to and from MWD-1. If required, MWD-3 would be able to source water from SB-9, SB-10 and DD-1.

If required, a second mine water surge storage dam (MWSS-2) would be constructed immediately north of the open cut to manage surplus mine water during wet periods.

Catchments draining to SB-1, SB-2 and SB-8 would be fully rehabilitated in Year 27, and therefore these sediment basins could be allowed to discharge without management control.

All other water management system elements would continue to operate consistent with Year 17 mine operations, as described in **Section 8.1.2.3**.

8.1.2.5 Final Landform Layout

Figure 16 shows the post mine landform. The rehabilitated mine landform would comprise an elevated landform comprising gently sloping upper plateau areas and outer batters sloping at 10 degrees. The top surface plateau areas would drain via wide swale drains to a series of rock lined chutes over the batters.

The landform would include two final voids (designated the Northern Void and the Southern Void) each containing pit lakes (surface water areas of approximately 27 ha and 49 ha respectively [**Section 11.2.2**]) and two rehabilitated backfilled areas (approximately 217 ha and 198 ha respectively) which would be below the surrounding ground level and would, therefore, drain internally. Perimeter bunds would be constructed around both of the voids to prevent runoff or floodwater draining into the voids.

8.2 System Inflows

The water management system has been developed to account for all system inflows, namely, rainfall runoff, stream flow, incident rainfall and groundwater infiltration. The System Water Balance described in **Section 9** quantifies these system inflows.

The open cut would become a major collection point for rainfall runoff, incident rainfall, groundwater and infiltration through waste emplacements. Water flowing into the open cut would accumulate in sumps, and would either be pumped to the two mine water dams (MWD-1, and MWD-2 or MWD-3 depending on the year of operation) or accessed by water carts directly.

Groundwater inflows to the open cut have been modelled (see *Groundwater Assessment* [Heritage Computing, 2013], Appendix A to the EIS) and are taken into account in the water balance assessment described **Section 9**.

8.3 Mine Water Storage

In accordance with the water management system's objectives and design criteria, the system has been designed to provide sufficient capacity to store, treat and discharge runoff as required, even in extended periods of above average rainfall. However, in the event that the main mine water storages are near or at capacity, any excess mine water would be retained in the open cut while runoff collected in the sediment basins would be managed so as to only discharge water of appropriate sediment concentration (TSS typically 50 mg/L).

As detailed in **Section 8.1**, the main mine water storages would be the mine water dams and the mine water surge storages. Additionally, the network of sediment basins would provide further capacity in the system. Mine water would not be stored in the diversion dams or sediment basins.

Table 19 summarises the lifetime, catchment area and, if applicable, the estimated required storage volume for each water storage structure in the water management system.

8.4 Water Consumption

In accordance with the water management system's objectives and design criteria, the system has been designed to provide a reliable source of water for use in mining operations, including dust suppression, crushing operations and vegetation establishment, even in extended periods of below average rainfall. All water used in mine operations (excluding potable water) would be primarily sourced from runoff reporting to the open cut and MIA. As detailed in **Section 8.1**, mine water may also be sourced from other sediment basins, mine water dams, mine water surge storages or the storage dam if, and when, required.

Although the water consumption requirements of the Project and the water balance of the system would fluctuate with climatic conditions and the development of the mine, the water management system has been designed to be adaptable; if additional water is required for operational use, water may be supplied from licensed external sources.

Fluctuations in water consumption have been accounted for in the site water balance model (refer to **Section 9**) in accordance with the mine plan.

Table 19: Indicative Catchment Areas and Capacities of Water Storages

Area	Water Storage	Permanency	Approximate Lifetime[1]	Existing Facilities[2]	Approximate Catchment Areas (ha)	Settling Zone (ML)	Settlement Zone (ML)	Indicative Required Volume (ML)
Diversion Dams								
North-East Drainage Line	DD-1[3]	Permanent	Year 1 - 30	None	169	n/a	n/a	80
	DD-2[3]	Temporary	Year 7 – 17+	None	292	n/a	n/a	20
Storage Dams								
West Drainage Line	SD-1	Temporary	Year 1+ only	Large dam (~20 ML)	205	n/a	n/a	20
Sediment Basins								
Western Emplacement	SB-1	Permanent	Years 1 - 30	Small existing farm dam	103	20	10	30
	SB-2	Permanent	Years 1 - 30	Small existing farm dam	45	9	4	13
	SB-3	Temporary	Year 1 - 3	None	32	6	3	9
	SB-7	Temporary	Year 7 – 17+	None	264	51	25	76
	SB-8	Permanent	Year 2 - 30	Small existing farm dam	252	48	24	73
	SB-9	Permanent	Year 17 - 30	None	325	63	32	95
	SB-10	Permanent	Year 17 - 30	None	85	16	8	24
Eastern Emplacement	SB-4	Permanent	Year 4 - 30	None	257	49	25	74
Mine Water Dams								
Adjacent to MIA	MWD-1	Permanent	Year 1 - 30	None	n/a	n/a	n/a	400
Within Open Cut Extent	MWD-2	Temporary	Year 7 – 17+	None	n/a	n/a	n/a	400
	MWD-3	Temporary	Year 17 – 26+	None	n/a	n/a	n/a	400
Mine Water Surge Storages								
Blue Vale Void	MWSS-1	Permanent	Year 1 - 30	Blue Vale Void	n/a	n/a	n/a	1,000
North of Open Cut	MWSS-2	Temporary	Year 24 - 30	None	n/a	n/a	n/a	1,000

Notes:

1. The approximate lifetime for facilities are based on the staged mine plan layouts in **Figure 12** to **Figure 15**. Actual years when facilities are required would depend on a more detailed definition of staging.
2. The 'small existing farm dams' have been estimated to have an approximate capacity of no more than 1 ML each. Clearly, these dams are far too small for the indicative required sediment basin volumes listed above. As a result, construction of significantly larger sediment basins would be required at approximately the same location in order to make use of the existing downstream drainage line for conveyance of overflow.
3. The required elevation for DD-1 and DD-2 is 300 m AHD and 280 m AHD, respectively. Some excavation of these diversion drainage routes and establishment of diversion structures would be required.

8.5 Waste Emplacement Drainage Management

The concept drainage design for the waste emplacement areas has been developed in accordance with the *Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfield* (Draft, Department of Land and Water Conservation [DLWC], 2002a) and *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries* (DECC, 2008). The concept drainage design has been developed for the life of the mine, as shown in **Figure 12** to **Figure 15**.

The concept drainage design for the waste emplacements involves the creation of a number of sub-catchments to be progressively developed over the life of the mine. Gently graded swales and contour banks would be constructed to drain runoff to strategically located rock chutes. A typical worst-case drainage swale would have gradient of 1 in 70, with a drop of 30 m over more than 2 km. Overburden drainage systems and structures would be progressively constructed and rehabilitated to ensure appropriate drainage conditions at all times.

During the life of the mine, all overburden runoff would be collected in either the open cut or sediment basins. As described in **Section 8.1.1** this runoff would be either suitably treated and discharged off-site or reused in mine operations.

The Eastern and Western Emplacements would be progressively rehabilitated during the life of the mine, as depicted in **Figure 12** to **Figure 15**, to reduce the volume of mine affected water requiring treatment.

The *Geochemistry Assessment* (Geo-Environmental Management, 2012 - Appendix L to the EIS) indicates that, although the majority of overburden and inter-burden has low sulphur content and is expected to be non-acid forming with a low salinity risk, a small quantity of the strata contains increased sulphur concentrations which present a risk of being potentially acid forming. The identified potentially acid forming strata typically occur as non-continuous units of mixed (finely inter-bedded) layers immediately adjacent to some of the coal seams and most of these materials are expected to only have a low capacity to generate acid.

Although the majority of the overburden and inter-burden is expected to be non- or slightly sodic a relatively small amount of material, (which occurs within most of the different material types sampled including the weathered and fresh siltstone, conglomerate, mudstone, carbonaceous mudstone, and mixed lithology materials) is expected to be moderately to highly sodic.

Geo-Environmental Management (2012) recommends that the following materials be treated as potentially acid forming and not be placed within the outer 10 m of the final surfaces or within the outer 10 m of the basal footprint for each emplacement:

- mudstone and strata occurring within 1 m of the coal seams (i.e. immediate roof and floor rock); and
- any sub-economic coal that would be placed in the waste rock emplacements.

Geo-Environmental Management (2012) also recommends that, in order to ensure long-term stability and erosion control for the waste rock emplacements the final surfaces (top and batter slopes) be treated with gypsum and/or constructed using materials that have low sodicity.

8.6 Sediment Basin Design and Operation

The sizing and management of the Sediment Basins have all been designed in accordance with the *Managing Urban Stormwater: Soils & Construction* (Landcom, 2004) criteria for 'fine' or 'dispersive' sediments.

The indicative total sediment basin volumes have been calculated based on the following formulas and assumptions (parentheses indicate references to Landcom 2004):

Dam Volume = Settling Zone + Sediment Storage Zone (p 6-22 (i))

Where:

- *Sediment Storage Zone* = 50% of Settling Zone (Soil Types D & F) (Table 6.1)
- *Settling Zone* = 10 x C_v x R x A (p 6-22 (i)(i))
- Cv (Volumetric Runoff Coefficient) = 0.5 Appendix F
- R (90^{th} percentile of 5-day rainfall depths for Gunnedah) = 38.4 mm (Table 6.3a)
- *A (Catchment Area)* (p 6-22 (i)(i))

8.7 Water Conveyance Structures

In accordance with the requirements set out in Table 6.1 of *Managing Urban Stormwater: Soils & Construction – Volume 2E: Mines and Quarries* (DECC, 2008), all hydraulic conveyance structures such as contour banks, drainage swales, drop structures, rock chutes and spillways will be designed to remain stable in the event of a 100 year storm.

9 Simulated Performance of Water Management System

Water balance analysis has been undertaken to assess the performance of the water management system that has been described in **Section 8** in terms of:

- security of water supply for operational purposes; and
- frequency and volume of discharge from the sediment control dams.

Details of the water balance, the data used for the analysis and the results are provided in **Appendix E**.

9.1 Methodology

The water balance model of the Project has been set up to represent the daily inflows and outflows from each of the separate elements of the water management system as set out in **Table 20,** and to reflect the changes in the structure of the water management system over the life of the mine as depicted in **Figure 17** and **Figure 18**.

Table 20: Components of the Project Water Balance Model

Inflows	Outflows and Losses
Catchment runoff reporting to each sediment basin.	Water required for dust suppression.
Catchment runoff reporting to the open cut and MIA.	Water required for operation in the MIA including coal crushing and vehicle washdown.
Groundwater inflow to the open cut.	Controlled discharge from sediment basins in accordance with the guidelines.
Direct rainfall onto the surface of the storages.	Evaporation and seepage losses from the water storages.
Raw water supply (when required) from licensed water sources.	Off-site spills from sediment basins.
Transfers between water storages.	

The model has been set up in a manner that permits an assessment of the risk of shortfall or discharge at any stage of the mine life. This is achieved by modelling the progressive development of the mine over 30 years combined with 110 climate scenarios representing all the different sequences of 30 years of rainfall represented in the historic climate record.

The model utilises 112 years of the daily rainfall record from Boggabri (Retreat) which commenced recording in 1899. For the purposes of providing as many rainfall sequences as possible, the rainfall record after 2011 was simulated by repeating the rainfall sequence starting in 1899.

A fundamental premise of the proposed water management system, which is reflected in the water balance model, is that, in accordance with the objectives set out in **Section 8.1.1**, it provides clear separation of water of different quality:

- runoff draining into the site from undisturbed land would, where possible, be diverted away from the operational area;
- runoff draining from waste emplacements would be captured in sediment basins that would be sized and operated in accordance with the relevant guidelines and either be transferred to the water management system or discharged off site once the suspended solids concentration has reduced to a level suitable for off-site discharge;
- water collected in the open cut (runoff from the open cut itself and surrounding overburden) as well as groundwater inflow would be directed into the water management system to meet operational needs; and
- runoff from the MIA, which would include runoff from ROM coal stockpiles, would be directed into the same water management system as the water collected within the open cut.

The model contains the following key elements:

- daily rainfall and evaporation data derived from historic records;
- a rainfall-runoff model which uses the AWBM model with different parameters to represent the runoff characteristics of different surfaces;
- water demands which reflect the changing area that requires water for dust suppression and the requirements for other purposes such as coal crushing; and
- water storage model which accounts for all inflows, transfers water demands and losses from the water storages.

The model includes a range of operating rules that reflect the rate at which water can be transferred between storages and limits on the volume of water in a particular storage before water can be pumped in or out.

The model assumes that all water demands would be met, preferably from within the water management system, supplemented with outside supply from a licensed source if necessary. The model also assumes that all water collected within the open cut or draining from the MIA is retained within the water management system and does not discharge from the site. If necessary during extremely wet periods, excess water would be temporarily stored within the open cut.

9.2 Model Data

9.2.1 Climate Data

For purposes of water balance modelling, the following climate datasets have been used:

- daily rainfall from Boggabri (Retreat): July 1899 – June 2011 (summarised in **Table 7**);
- daily pan evaporation data from Gunnedah Research Station: July 1948 – July 2011 (summarised in **Table 8**); and
- monthly potential evapotranspiration for the site from the digital version of the *Climatic Atlas of Australia: Maps of Evapotranspiration* (Version 1.0, BoM, 2002).

As recommended by Boughton (2010), the monthly potential evapotranspiration data was used to account for evaporation and evapotranspiration losses from the contributing catchments in the rainfall-runoff component of the water balance model (see **Section 9.2.4**).

9.2.2 Catchment Areas

For modelling purposes, catchment areas and the state of the surface (active emplacement, progressive rehabilitation, fully rehabilitated, etc.) were determined from mine layout plans (**Figure 12** to **Figure 15**). In general it has been assumed that changes in the mine layout between these years would occur in a linear manner. Exceptions to this were situations when it was known that a step change could occur, such as completion of rehabilitation of an area reporting to a particular sediment basin, which could then be allowed to drain off-site without the need for management in order to achieve sediment control.

The results of the analysis of contributing catchment areas are shown in **Figure 19** and **Figure 20**.

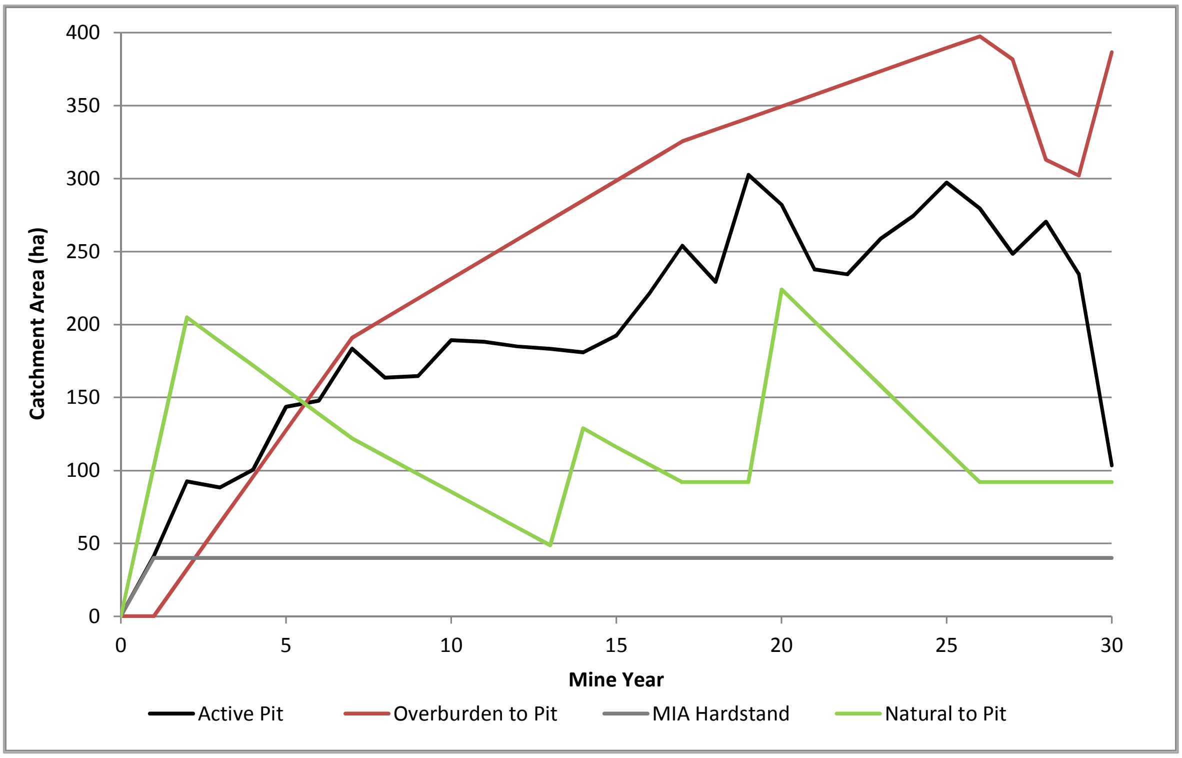


Figure 19: Progressive Development of Catchment Areas

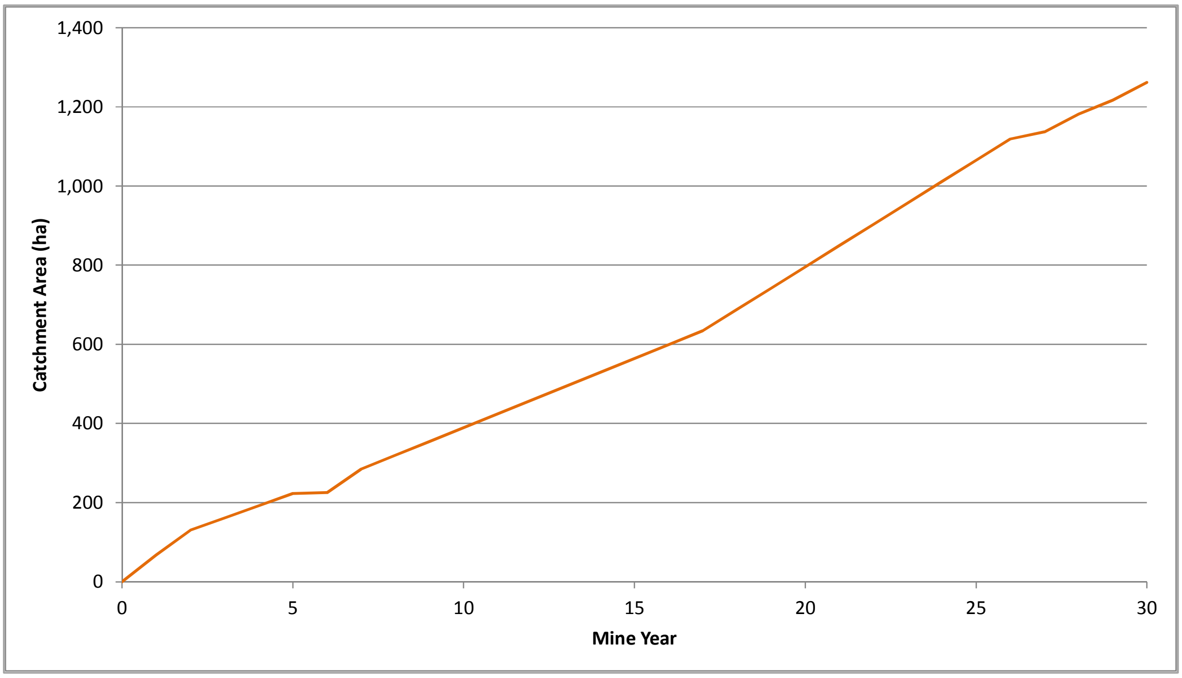


Figure 20: Progressive Development of Western Emplacement Catchment

9.2.3 Water Storage

The mine plan involves a number of water storage structures for different purposes details of which are set out in **Table 19**:

- diversion dams that are only intended to provide a structure from which water can be diverted away from the active mining area and the flow rate controlled by means of a restricted spillway. It is not intended that water would be drawn from these dams for operational purposes;
- sediment basins from which water can either be transferred to the water management system or discharged off-site once the suspended solids concentration has reduced to a level suitable for off-site discharge;
- sediment basins located within the MIA. Any water collected in these basins would be transferred to the water management system and would not be discharged off-site, except in the rare event of an overflow; and
- a number of storages within the water management system including a surge storage dam located in the remnant Blue Vale void and a second surge storage to be developed, if necessary, towards the end of the mine life.

Table 19 also sets out the sequence in which the various storages are constructed or decommissioned. These changes over time are reflected in the water balance model.

9.2.4 Runoff Modelling

For this study the AWBM model (Boughton, 1984; Boughton & Chiew, 2003; Boughton, 2010) has been used to estimate daily runoff volumes from the various catchments depicted in **Figure 19** and **Figure 20**. AWBM is a rainfall-runoff model which uses daily rainfall and evapotranspiration to estimate the runoff depth from land surfaces with different runoff generating characteristics. AWBM was developed for Australian catchments and has the advantage of maintaining a relatively simple structure (and relatively few parameters), whilst adequately representing the key runoff processes. Further details of the structure and operation of the AWBM model are provided in **Appendix B** of this Surface Water Assessment. The runoff depth calculated by AWBM is converted to a volume of runoff by multiplying by the relevant catchment area.

For purposes of selecting appropriate parameters to represent the runoff characteristics of the various surfaces, parameters derived from various sources were tested to determine the volume and flow distribution that would occur using the entire 112 year daily climate dataset complied for this Surface Water Assessment (see details in **Appendix E**). The runoff characteristics were also benchmarked against inferred runoff characteristics for the Rocglen Coal Mine based on observed occurrence of mine discharge events in 2009-10. On the basis of this testing and benchmarking, soil moisture storage characteristics for different land surfaces (defined by the AWBM parameter 'AveCap') were adopted as set out in **Table 21**, which also lists the runoff as a percentage of rainfall from the full historic climate record.

Table 21: Percentage Runoff for AWBM Parameters Representing Different Land Surfaces

Land Surface	'Ave Cap'	Runoff %
Natural	269	3.8%
Rehabilitated	88	5.6%
Partially Rehabilitated	68	10.0%
Bare Spoil	74	11.6%
Open Cut	18	31.2%
Hardstand	4	57.7%

9.2.5 Water Demands

The water requirements for dust suppression on haul roads and hardstand areas are closely related to the daily weather (since hot windy days can be expected to generate dust). Thompson and Visser (2002) studied the water requirements for dust suppression on mine haul roads and demonstrated a robust relationship between water requirements for dust suppression and the potential evaporation on the day, while taking into account any incident rainfall. An algorithm based on the work of Thompson and Visser (2002) has been benchmarked against estimated mine water use at two mines in the Hunter Valley and has been adopted for the site water balance model. This element of the water balance model takes account of:

- the area of active haul road;
- daily rainfall; and
- daily evaporation.

The modelling of water requirements for dust suppression also takes account of the water application requirements specified for "Level 2" control of dust, as adopted for the dust emissions analysis for this project. "Level 2" dust suppression assumes an application of 2 litres per square metre per hour in order to maintain surface moisture content of 3.5% on the working surface. For a notional 10 hour day when water loss could occur because of incident solar radiation and wind, this equates to 20 mm depth of water application. For modelling purposes, the depth of water application was taken as function of the difference between pan evaporation and incident rainfall with a maximum of 20 millimetres per day (mm/day).

Water requirements within the MIA, including dust suppression on the coal crusher and vehicle wash-down has been estimated by Whitehaven at 0.16 ML/day. The water balance model includes provision for this daily use.

9.2.6 Groundwater

Two aspects of the interconnection between the surface water management system and groundwater have been assessed in the *Groundwater Assessment* (Heritage Computing, 2013) (Appendix A to the EIS) and are represented in the water balance model:

- groundwater inflow to the open cut; and
- leakage from the base of the Blue Vale void into shallow coal seams.

Figure 21 shows the estimated groundwater inflow to the open cut which has been taken into account in the water balance model. Because of the size of the open cut and the length of its perimeter any groundwater inflow during dry weather would be lost as evaporation at the seepage face. Accordingly, the water balance model includes a facility that only includes groundwater as a component in the water balance when surface runoff is retained in the open cut.

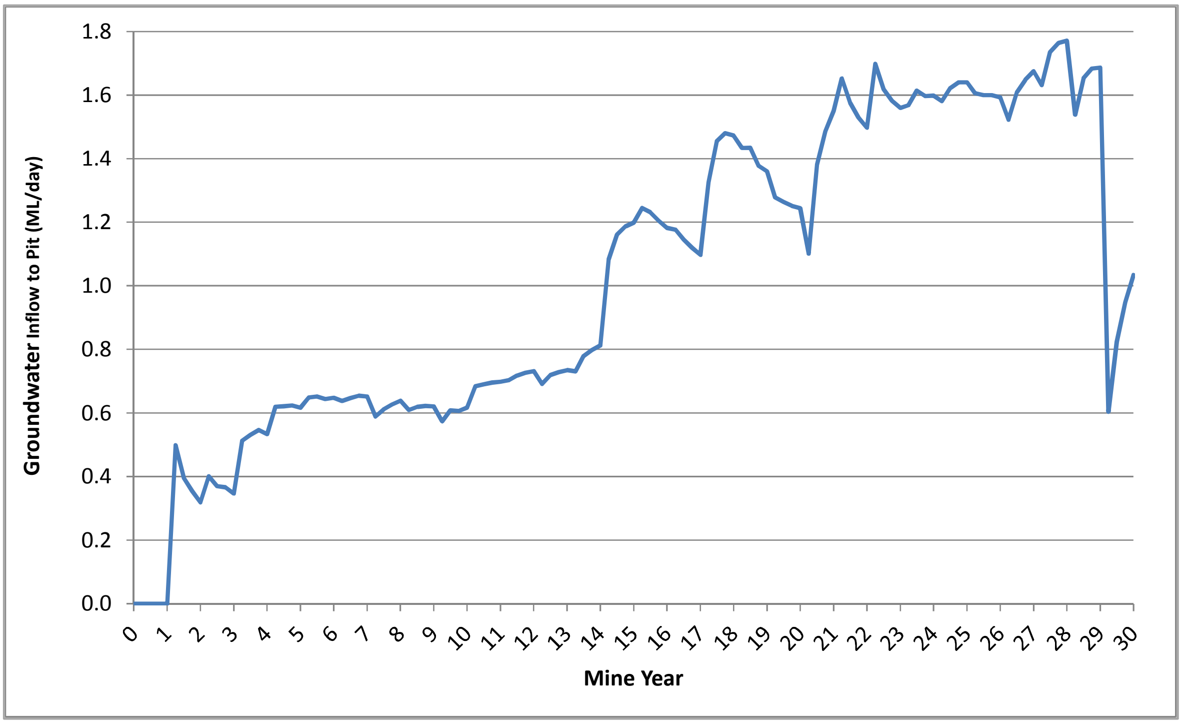


Figure 21: Estimated Daily Groundwater Inflow to the Open Cut

Groundwater modelling indicates that for a water level in the Blue Vale void of 265 m AHD, the flow out of the open cut would be 81 cubic metres per day, corresponding to a loss of 2.5 mm/day. This loss has been included in the water balance model for all days on which there is water stored in Blue Vale void.

9.2.7 External Water Sources

Whitehaven has a number of water access licences for the Project for water from the Namoi River and groundwater sources (see **Table 5**). In addition, Whitehaven holds other water access licences that relate to its other mine operations in the area and could be temporarily transferred for use by the Project if required.

For purposes of water balance modelling, it has been assumed that access to water from these sources would only be undertaken on a 'campaign' basis in which 25-100 ML would be transferred into the water management system when total water in the mine water system fell below a specified level.

Note that the water balance modelling conservatively assumes that supplementary water is not taken from the sediment basins, other than in accordance with the assumed operating rules as described in **Section 9.3**. In practice, water would be taken from these sources prior to extracting water from the Namoi River or the groundwater bore.

9.3 Water Transfers and Storage Operating Rules

As described above the water management system for the Project comprises a number of water sources and storages which would be interlinked with pumps and pipes. For purposes of characterising the overall water balance of the water management system the indicative operating rules and assumptions listed below have been adopted. (The water management operating rules would be further developed at the time of the preparation of the site Water Management Plan (WMP) following Project approval, and would be reviewed as part of the periodic review of the WMP – see **Section 12.4**):

- all water required for dust suppression on haul roads and hardstand areas, and for operations within the MIA, is assumed to be drawn from one of the MWDs. In practice, intermediate water cart fill points would be established adjacent to the larger sediment basins and water would be taken from these dams when it is available;
- up to Year 7 the model assumes that runoff captured in the sediment basins would be transferred to the water management system on the same basis as would be required if the retained water was held for 5 days following a runoff event in order to sediment to settle;
- the model assumes a limit of 20 ML/day for transfer of water from the open cut to the MWDs;
- the model assumes a limit of 10 ML/day for:
  - transfer from the MIA sediment basins to MWD-1; and
  - transfer between any of the mine water dams and the MWSSs depending on the volume held in the MWDs and the available 'air space' in the MWSSs;

- transfer of water into, or out of, the MWDs is assumed to occur according to the following priorities and rules:
  - water from the MIA sediment basins is automatically transferred to MWD-1 at the nominated rate until the basins are empty;
  - if the combined volume of the MWDs is less than 90% of available capacity, water is transferred from the open cut at the nominated rate;
  - if the combined volume of the MWDs exceed 90% and the MWSSs are not full, water would be transferred to the MWSSs;
  - up to Year 7, if the volume of MWD-1 is less than 70% of capacity, and there is water held in the sediment basins, water would be transferred from the sediment basins at a rate equivalent to that required to empty the basin in five days;
  - if the combined volume in the MWDs is less than 50% of the capacity and there is water held in the MWSSs, water would be transferred back to the MWDs at the nominated rate; and
  - if the combined volume in the MWDs falls to less than 5% of the total capacity, water is imported from an external source. For simplicity of modelling the volume imported is assumed to be 5% of the capacity of the MWDs;
- water required for dust suppression is based on the evaporation excess for the day (see **Section 9.2.5**) multiplied by the length of active haul road. Analysis of the mine plan indicates that the maximum length of haul roads amounts to 28 km. However, Whitehaven has advised that a maximum of 21 km would be active at any one time. To account for this, and the progressive growth in the length of haul road over the mine life, the water balance model accounts for the progressive growth in haul road length in the following manner:
  - for haul road lengths up to 5 km, all the haul road is assumed to require watering; and
  - for haul road lengths between 5 km and 28 km, 75% of the additional haul road length is assumed to require water.

9.4 Water Balance Model Results

For purposes of demonstrating the performance of the system, a selection of the consolidated model results is presented below.

9.4.1 Behaviour of Key Water Storages

Figure 22 to **Figure 25** show the volume of water retained over the life of the mine in the MWDs (combined), the MWSSs and the open cut for climate sequences in which the start of mining corresponds with 1 July in 1920, 1930, 1940 and 1950 (denoted by the number in the top left hand corner of each graph).

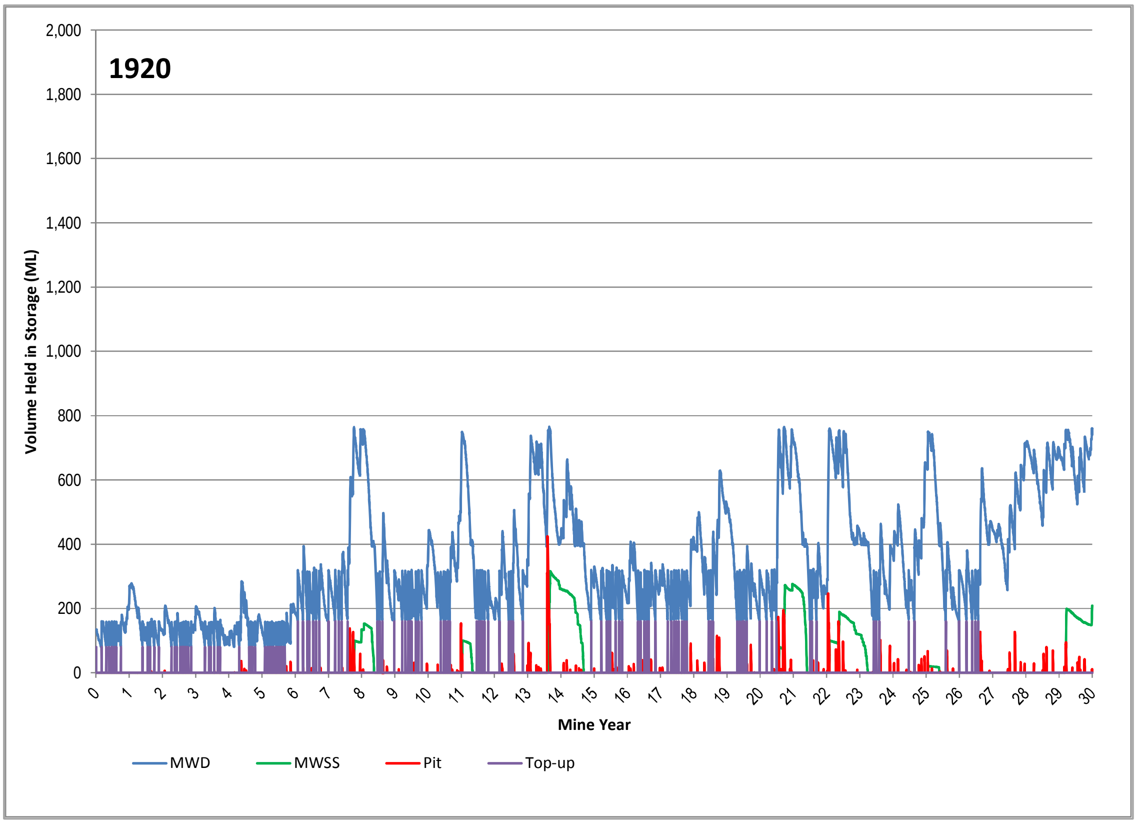


Figure 22: Volume of Water Held in Various Storages and Top-up Water over the Life of the Mine for a Climate Sequence Starting in July 1920

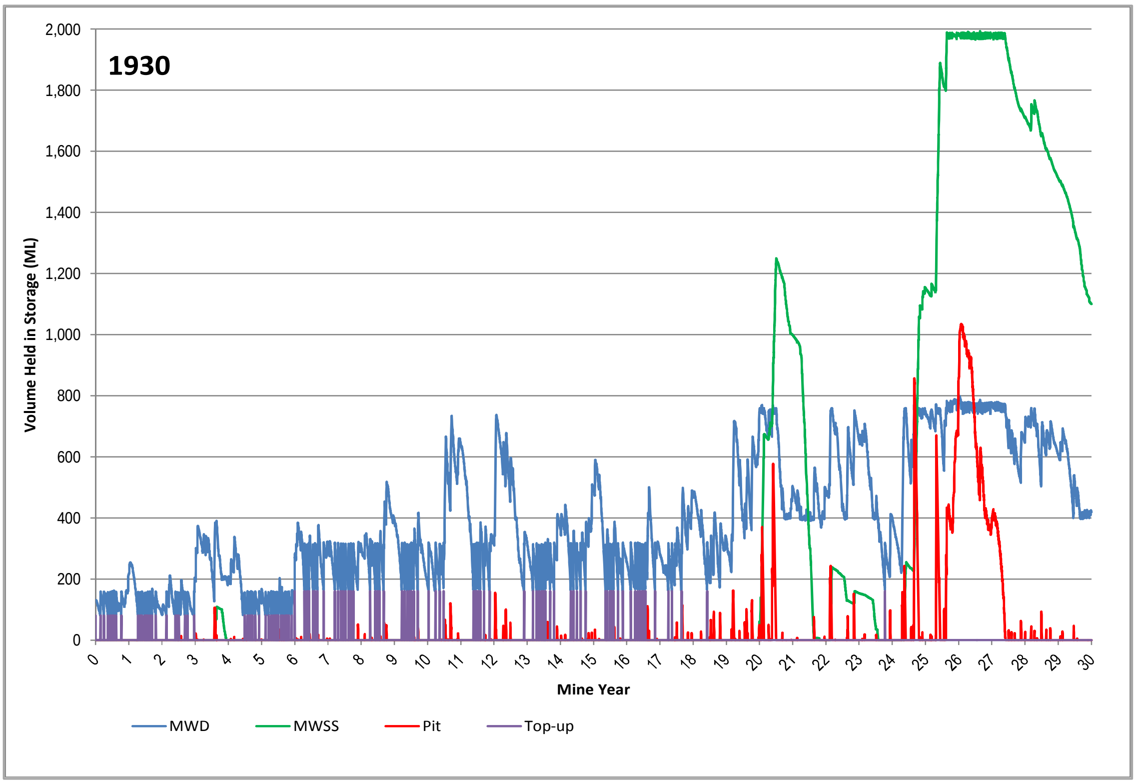


Figure 23: Volume of Water Held in Various Storages and Top-up Water over the Life of the Mine for a Climate Sequence Starting in July 1930

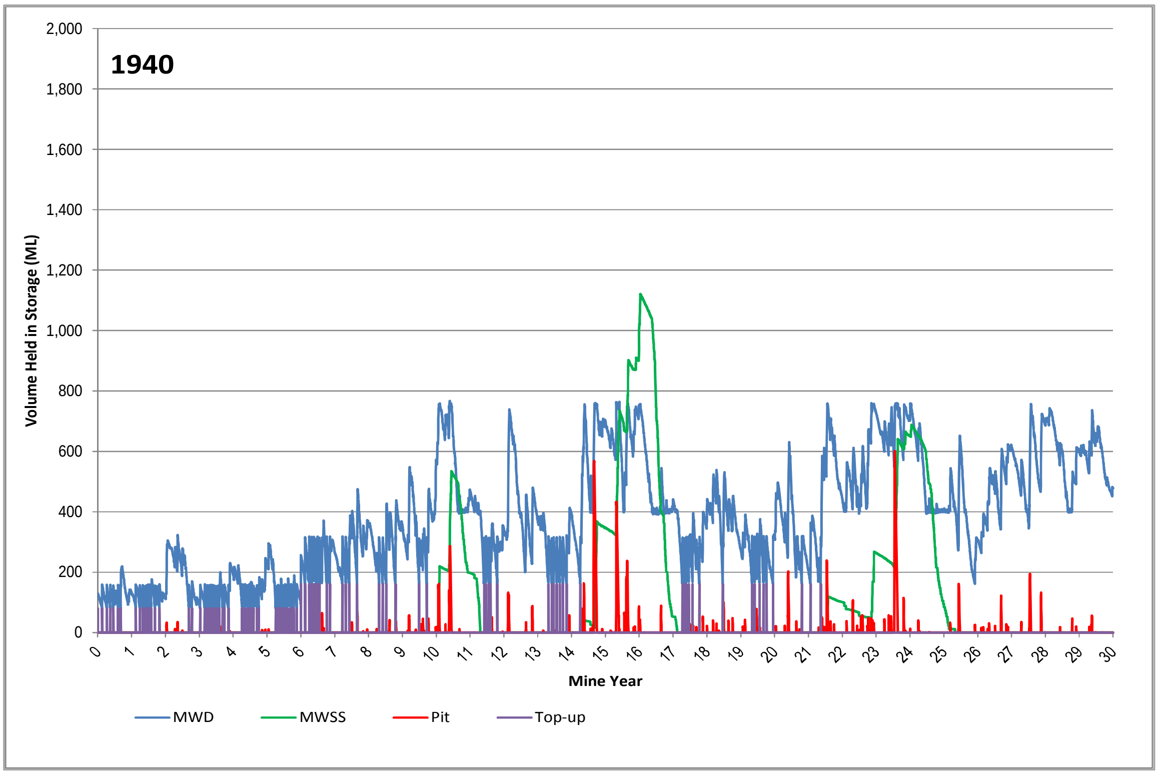


Figure 24: **Volume of Water Held in Various Storages and Top-up Water over the Life of the Mine for a Climate Sequence Starting in July 1940**

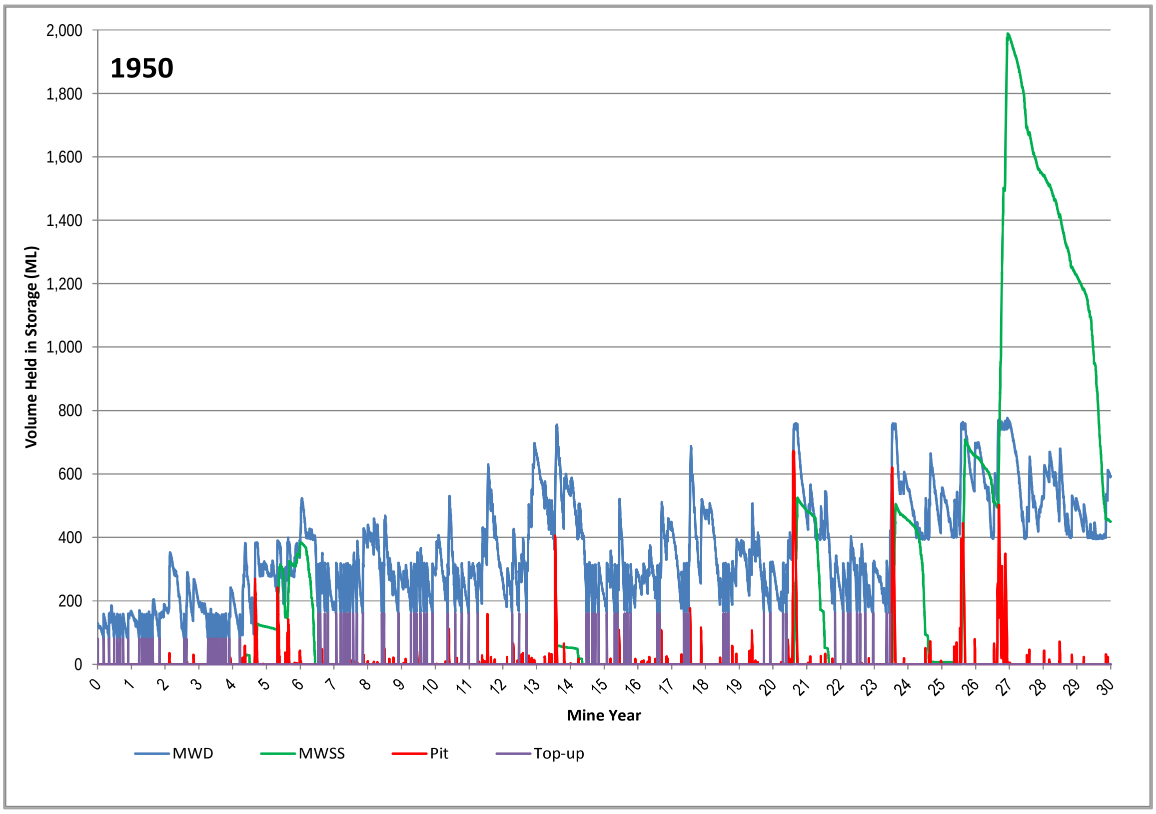


Figure 25: **Volume of Water Held in Various Storages and Top-up Water over the Life of the Mine for a Climate Sequence Starting in July 1950**

These sequences, starting a decade apart, have been selected to illustrate a number of key features of the behaviour of the mine water management system:

- The climate sequence starting in 1920 (**Figure 22**) represents conditions in which the water management system could be expected to perform as well as possible, but with frequent short periods when water would be retained in the open cut (red line) prior to transfer to the MWDs and subsequently on the MWSSs. In this scenario, the MWDs have sufficient capacity to retain mine runoff for the majority of the time and relatively little use would be made of the MWSSs (green line). Supplementary supply (purple line) would be required for a large proportion of the early years of the mine life. Notwithstanding the adequacy of available storage, water would be retained within the open cut (red line) for short periods because of the limitation placed on pumping from the open cut (20 ML/day).
- The climate sequence starting in 1930 (**Figure 23**) represents conditions in which the water management system could be expected to perform adequately, but the combination of the larger catchment area draining to the open cut and the very wet conditions in 1949 and 1950 (821 mm and 882 mm respectively) after Year 20 would lead to the MWSSs filling up and excess water being retained in the open cut for up to two years. The conditions illustrated in **Figure 23** represent the worst possible historic climate sequence which would lead to filling of the MWDs (800 ML), the MWSSs (2,000 ML) and retention of a maximum of up to about 1,000 ML within the open cut. Although extremely unlikely to occur, such conditions could be managed without the need for discharge of mine water by transferring excess water to a separate area of the open cut while operations occurred in other active areas.
- The climate sequences starting in 1940 (**Figure 24**) and 1950 (**Figure 25**) represent intermediate conditions in which the very heavy rainfall in 1949, 1950 and 1955 occur earlier in the mine life and do not lead to as much water in the open cut as shown in **Figure 23**, but do, however, lead to water being retained in the open cut for a number of short periods during the life of the mine.

9.4.2 Water Retention in the Open Cut

As noted previously, the water balance model assumes that any water from the open cut or the MIA would be retained within the water management system and would not be discharged off-site. The model includes transfer rules that ensure that any water in excess of the capacity of the MWDs and the MWSSs is retained within the open cut.

As illustrated in **Figure 22** to **Figure 25**, different climate sequences give rise to a requirement to retain water in the open cut at different stages in the mine life**.** **Figure 26** is a graph that has been prepared from the statistics of all 110 climate sequences. For each year of the mine life it shows the maximum volume of water that would need to be held in all the mine water storages and the open cut associated with different risks of occurrence in each year. For reference the graph also shows the proposed combined storage capacity of the MWDs and the MWSSs over the life of the mine (dashed black line).

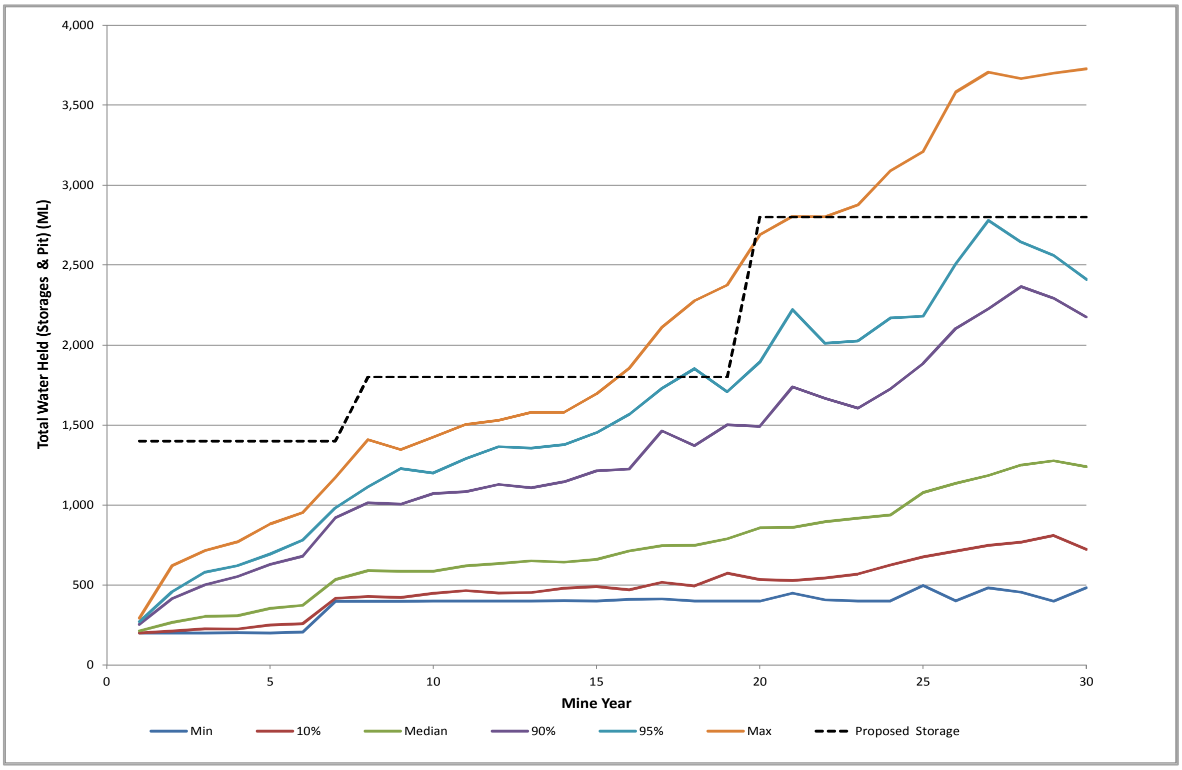


Figure 26: Probability of Total Volume of Water Held in the Mine Water Storages over the Life of the Mine

The overall conclusion to be drawn from **Figure 26** is that the proposed sequence of construction of MWDs and MWSSs would allow the mine to keep operating in the worst historic climate conditions up to Year 15 (total storage - dashed black line - is above the orange line which represents that maximum storage required in any of the historic climate sequences). Following Year 15 there would be a slightly increased risk (generally less than 5%) of needing to store excess water in the open cut for a period in order to avoid the need to discharge mine water.

It should be noted, however, that the proposed sequence for the commissioning of water storage capacity in the MWDs and MWSSs would provide for more than double the required storage capacity for 50% of the time (dashed black line compared to green line). It should also be noted that, for all climate sequences there would be short periods when there would be water held in the open cut (red lines). In most situations illustrated in **Figure 22** to **Figure 25,** the duration of water being held is governed by the assumed rate of pumping out of the open cut rather than the availability of storage in the MWDs or the MWSSs. The exception to this is shown in **Figure 23** which shows a combination of mine year and rainfall that would lead to all storages being full for a period of about two years coinciding with Year 27 and 28. However, as shown by **Figure 26**, the risk of such conditions is very low.

As noted in **Section 9.2.4**, runoff modelling has been based on current coal mining industry data and benchmarked against data from the adjacent Rocglen Coal Mine. However, the runoff characteristics of open cuts and waste emplacements exhibit significant variation depending on the local climate and geology as well as the particular characteristics of the mining operation. It is therefore recommended that sufficient monitoring of all the components of the mine water balance be conducted to permit periodic reviews of the mine water balance and to re-assess the operating rules and the required timing and volume for mine water storage dams.

9.4.3 Runoff, Transfers and Water Use

Table 22 summarises the statistics for runoff, transfers and water use from the 110 different climate sequences. Note that, apart from the last column, all values represent the total volume collected, transferred or used over the life of the mine.

Table 22: Summary Water Balance Statistics Over 30 Year Mine Life

	Total Volume (ML) over 30 Year Mine Life for Different Climate Scenarios						Annual Average
	Average rainfall	Minimum rainfall	10% low rainfall	50% median rainfall	90% high rainfall	Maximum rainfall	
Water reporting to:							
Open Cut	16,834	15,033	15,629	16,597	18,635	19,241	561
MIA	3,973	3,718	3,806	3,961	4,164	4,417	132
Western Emplacement	7,008	5,742	6,183	6,834	8,035	9,047	234
Eastern Emplacement	615	344	415	602	819	1,228	21
Rehabilitated Catchments	3,485	2,118	2,779	3,434	4,264	5,293	116
Transferred to MWD from:							
Open Cut	17,104	15,184	15,827	16,821	19,105	19,611	570
MIA	3,971	3,718	3,804	3,961	4,160	4,417	132
Western Emplacement	2,904	2,492	2,654	2,895	3,166	3,373	97
Eastern Emplacement	110	56	81	106	146	176	4
Rehabilitated Catchments	1,522	1,168	1,353	1,543	1,673	1,787	51
Water Use:							
Total Water Use	35,367	36,488	36,214	35,394	34,557	34,186	1,179
External Top-up	14,793	17,900	16,400	14,750	12,910	11,500	493
Years when Top-up Required	21	26	24	22	18	17	21

Key aspects of note relating to the water balance results in **Table 22** are:

- runoff reporting to the open cut (53%) and MIA (12%) account for the majority of the total runoff from the Project area. This occurs because of the higher runoff potential of the open cut itself and MIA, but is also affected by the relatively large active waste emplacement area that reports to the open cut from Year 17 onwards;
- over the life of the mine, the average water use for dust suppression, crushing and other operational purposes amounts to 1,179 ML/year;
- over the life of the mine, the average water transferred to the MWDs from all mine sources amounts to 854 ML/year (excluding external top-up in times of shortage); and
- an average top-up volume of 493 ML/year would be needed in those years in which top-up water is required because of a short term shortfall of water for mine operations.

9.4.4 Sediment Basin Discharge

Table 23 summarises the average annual performance of the sediment basins over the life of the project and shows that overall:

- about 40% of the runoff from the waste emplacements would be transferred to the MWDs (predominantly in the early years of the Project);
- about 45% of the runoff would be discharged from the sediment basins in accordance with the requirements to allow for settlement of suspended sediment prior to discharge;
- about 15% of runoff would overflow in storms that exceed the capacity of the sediment basins; and
- overflow would occur on 6 days per year on average.

Table 23: Average Performance of Sediment Basins

	Average
Runoff (ML/Year)	371
Transferred to MWDs (ML/Year)	152
Controlled discharge (ML/Year)	167
Overflow (ML/Year)	51
Overflow days	6

9.4.5 Water Sources

As shown in **Table 22**, the estimated average annual water use over the life of the Project is 1,179 ML/year. Actual water usage will vary significantly from year to year depending dust suppression requirements and rainfall.

The data in **Table 22** and **Table 23** indicates that averaged over the life of the mine, and after accounting for all historic climate sequences, the main sources of water would be:

▪ Groundwater (see **Figure 21**) and runoff reporting to the open cut	561 ML/year
▪ Runoff from the MIA	132 ML/year
▪ Runoff from emplacement areas (active and partially rehabilitated) – after allowing for controlled discharge and overflow from sediment basins	152 ML/year
▪ Top-up supply from licensed groundwater and surface water sources	493 ML/year

In relation to the sources of water for mine operations it should be noted that, as described in **Section 9.5.2**, runoff from the various different surfaces within the Project is expected to be significantly higher than runoff from the 'natural' landscape, largely because of the reduced loss of water by evapotranspiration as a result of removal of vegetation. Accordingly, much of the water to be used by the Project will be generated as a result of the operation rather than constituting a significant loss to catchments draining away from the Project area.

As indicated above, the Project would require ‘top-up’ water from licensed external sources in order to meet operational requirements for dust suppression. The volume of top-up water obtained from external sources will vary from year to year and will depend upon the mine water requirements and the water availability, particularly during droughts. Compared to irrigation farmers, however, the mine is likely to be much less reliant on external sources (due to the volume of water that would be captured and reused) and will have considerably greater flexibility to manage its ‘take’ of water from external sources by utilising the ‘carry over’ provisions of the Upper and Lower Namoi Regulated River Water Sources WSP.

As noted in **Section 9.2.7**, runoff collected in sediment basins would be used before relying on water from external sources. As shown in **Table 5**, the portfolio of water access licences currently held by Whitehaven includes (in order of decreasing reliability):

- 180 ML from groundwater sources;
- 1,076 unit shares of river general security water (equivalent to 1,076 ML when the available water determination is 100%, or 1 ML/share); and
- 79.2 unit shares of river supplementary water.

Various mechanisms have operated for sharing the available water from Keepit Dam, the most recent being the system of ‘Available Water Determinations’ (AWD) made in accordance with the Upper and Lower Namoi Regulated River Water Sources WSP. Prior to this, water was made available on the basis of ‘Announced Allocations’.

Figure 27 is a graph which summarises the history of ‘Announced Allocations’ and AWDs in the Namoi valley since 1977. For purposes of producing this summary it has been assumed that a previously announced allocation of 100% corresponds to an available water determination of 1 ML per unit share. While it is recognised that this analysis does not account for changes in the total volume of licensed general security water in the Namoi valley since 1977, it provides a more comprehensive indication of water availability in the Namoi valley than the relatively short record since the Upper and Lower Namoi Regulated River Water Sources WSP was implemented in 2004.

Figure 27 shows that:

- By the end of December, in 50% of years the AWD amounts to about 0.5 ML per unit share (equivalent to 538 ML for the 1,076 unit shares held by Whitehaven).
- By the end of the water year in June, in 50% of years the AWD amounts to about 0.68 ML per unit share (equivalent to 732 ML for the 1,076 unit shares held by Whitehaven).
- In 20% of years (wettest years) an AWD of 1 ML per unit share can be expected from the beginning of the water year.
- In 20% of years (driest years) an AWD of only 0.05 ML per unit share can be expected by December and 0.25 ML by the end of June.

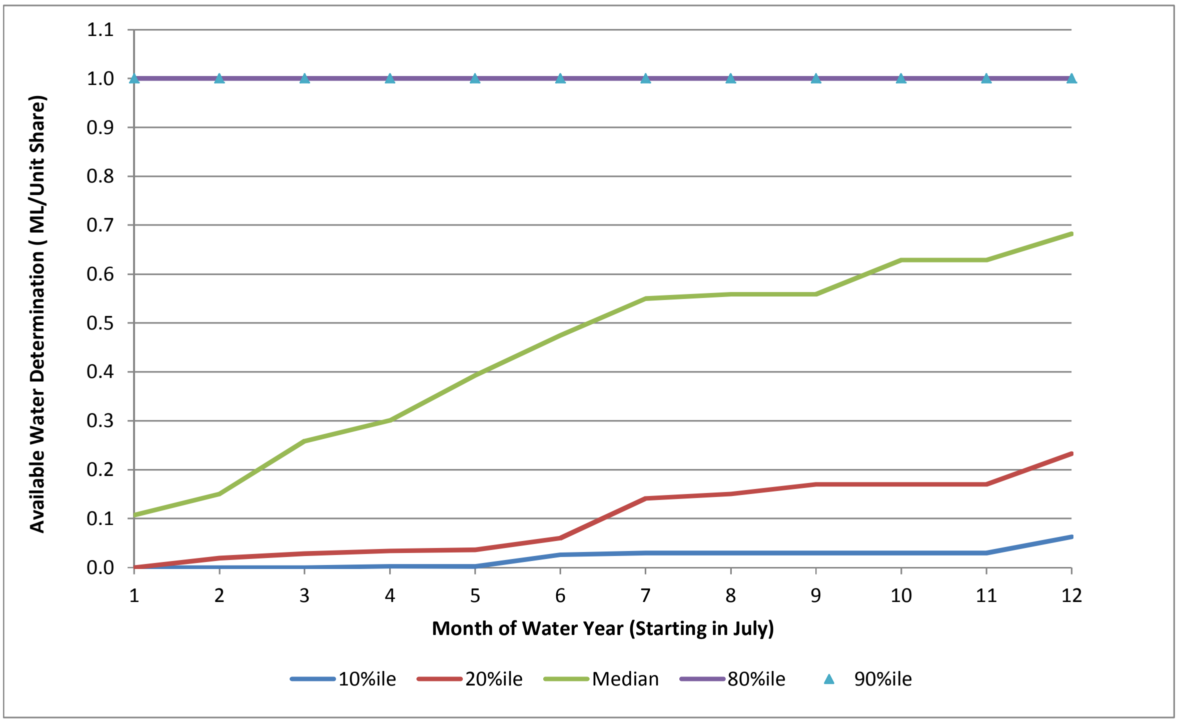


Figure 27: History of Namoi General Security Available Water Determinations

As shown in **Table 22,** the average 'external' water demand over the life of the Project is 493 ML/year. **Figure 28** provides further detail regarding the pattern of water demand over the life of the Project. **Figure 28**, which has been derived from the detailed water balance modelling using the 112 climate sequences represented by historic rainfall data, shows the median and 90%ile requirement for top-up water from external water sources. Key aspects of the data in **Figure 28** are:

- There is likely to be an initial requirement for external water during mine start-up which will reach a peak in about Year 7.
- Thereafter external demand can be expected to reduce progressively as the open cut and waste emplacements expand and additional runoff is contributed to the open cut and sediment basins.
- After about Year 25 there is likely to be minimal requirement for water from external sources.

By reference to both **Figure 27** and **Figure 28**, it can be seen that if median AWD are assumed, the current general security Namoi River WALs currently held by Whitehaven for the Project would be sufficient to meet the external water demand for the majority of the mine life. Should this volume not be sufficient to satisfy the external water demand at a particular stage of the Project (e.g. during peak demand during Year 7 of the Project, or during dry periods when AWD are lower), shortfalls in external water availability would be mitigated by:

- transferring any available allocation from WALs held for its other mining operations (in accordance with the relevant trading rules);
- purchasing additional WALs from the market if necessary to maintain operations;
- using the continuous water accounting 'carry over' provisions of the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003* to retain water in Keepit Dam for subsequent years;

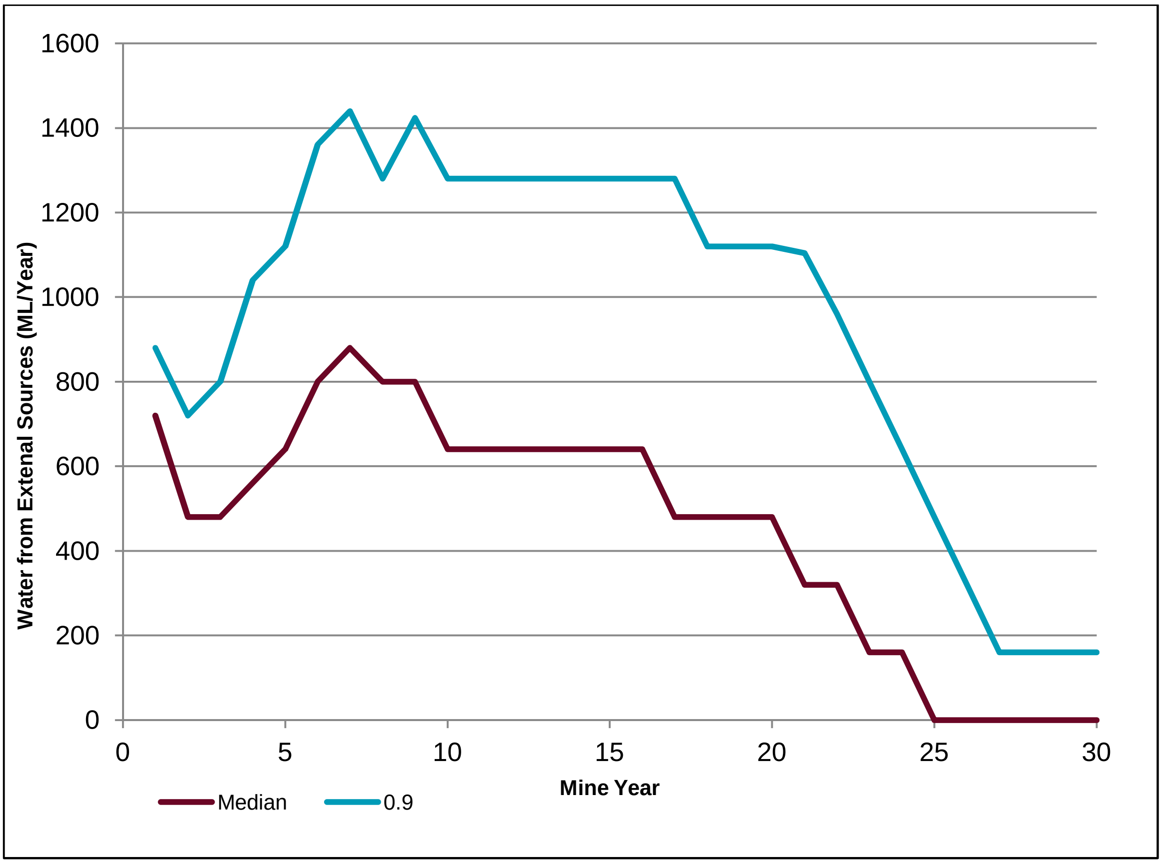


Figure 28: Median and 90%ile Top-up Water Requirements from External Water Sources

- using available storage capacity in the water management system to store water when it is available (particularly during the initial 15 years of the Project) such that the maximum water storage requirement would not be exceeded (**Figure 26**);
- using available allocation from groundwater WALs held for the Project; and
- adjusting operations to reduce water demand.

9.5 Model Sensitivity

9.5.1 Climate

As described previously, the water balance model has been run for a total of 110 climate sequences drawn from the historic record. These sequences include years which represent the extremes of likely rainfall to be experienced over the life of the mine, including sequences that are representative of possible climate change over the next 30 years (see **Section 11** for further discussion on this issue) and include sequences with the statistical characteristics over the medium and long term shown in **Table 24**. As would be expected, the table shows that the variability between maximum and minimum decreases over longer sequences. Over a 5 year period, the rainfall can vary from -25% to +20% of the long term average while for a 30 year sequence the variation is only ± 10%. It can be seen, therefore, that the modelling has taken account of a wide range of possible climate sequences that might occur in the future.

Table 24: Historic Rainfall Statistics over Different Durations

Rainfall Statistic	Duration of Climate Sequence			
	1 Year	5 Years	10 Years	30 Years
Average (mm)	583	583	583	582
Minimum (mm)	255	433	486	523
10^{th} Percentile (mm)	399	495	527	546
Median (mm)	563	584	579	581
90^{th} Percentile (mm)	769	665	642	628
Maximum	1,065	700	695	639

9.5.2 Runoff Sensitivity

An assessment of the sensitivity of the runoff generated from different surfaces was undertaken as part of the establishment of the setup of the runoff:rainfall model. Details of this assessment are provided in **Appendix E** and the effect on percentage runoff for each land surface type is summarised in **Table 25**.

Table 25: AWBM Model Parameter Sensitivity

Land Surface	Runoff as a Percentage of Rainfall		
	Minimum	Maximum	Adopted
Natural	4%	8%	4%
Rehabilitated	5%	20%	6%
Partially Rehabilitated	6%	18%	10%
Bare Spoil	12%	43%	12%
Open Cut	28%	59%	31%
Hardstand	42%	65%	58%

As set out in **Appendix E**, the sensitivity of AWBM to the adopted model parameters has been given careful consideration and the adopted parameters have been selected on the basis of monitored runoff from mine sites and natural catchments.

9.6 Water Management Implications

The water balance modelling indicates that:

- apart from the early years of the mine, on average adequate water available would be available to meet about 75% mine operational needs from collected runoff;
- all sediment basins would be set up in a manner that allows captured runoff to be transferred to the water management system if supply is low, or discharged off site (subject to meeting water quality requirements) if there is adequate supply (mine water storages greater than 50% full); and
- the timing and capacity of the proposed water storages would provide a very low risk that water would need to be stored in the open cut for any extended periods in order to avoid the need for discharge of mine water.

10 External Catchments

10.1 Driggle Draggle Creek

The main external catchments that flow into the Project area generally drain via the North-West Drainage Line. As outlined in **Section 8.1.2** two drainage diversions are proposed to divert the runoff from the North-West Drainage Line into the North Drainage Line, and thence to Driggle Draggle Creek, to minimise runoff from entering the open cut.

Two diversion dams (DD-1 and DD-2), shown on **Figure 12** to **Figure 15**, are proposed. DD-1 would collect runoff from the Vickery State Forest and divert it to a drainage line which would run parallel to the realigned Blue Vale Road to the east of the open cut and discharge into the North Drainage Line. The diversion would be constructed in conjunction with the realigned Blue Vale Road and would operate as a permanent structure.

DD-2 would be constructed at a location downstream of DD-1 on the North-West Drainage Line to divert local runoff to the North Drainage Line. DD-2 is designed to operate as a temporary structure, as the area occupied by DD-2 would be subsumed by the open cut sometime between Years 17 and 26.

10.1.1 Methodology

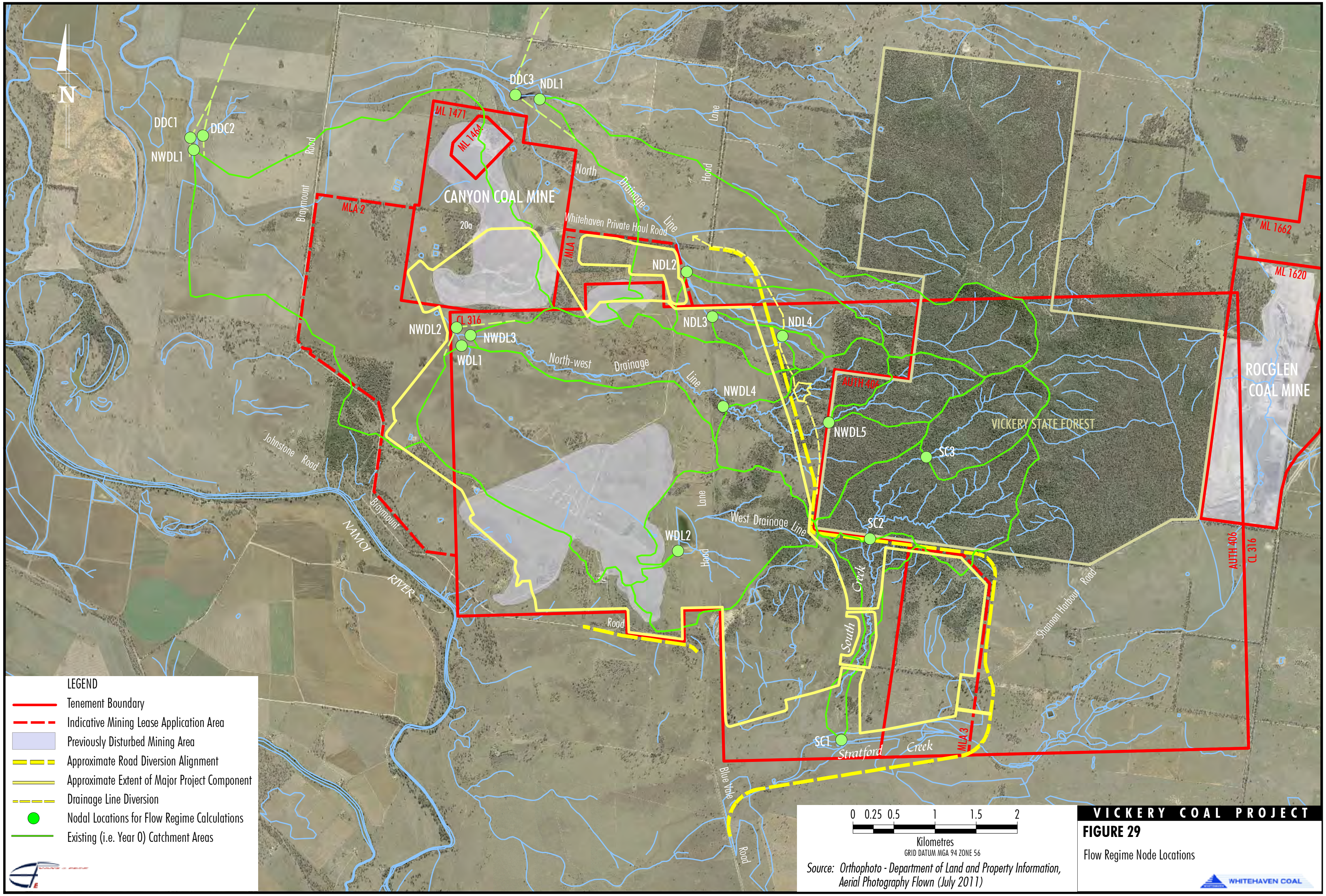
The diversions are not expected to cause any significant change to the flow regime in Driggle Draggle Creek. At the point where the DD-1 diversion discharges, the upstream catchment area of Driggle Draggle Creek is approximately 169.5 km^2. The contributing catchment area of DD-1 is approximately 2.5 km^2, which represents only a 1.5% increase to the contributing catchment area at this point.

Runoff modelling has been undertaken to assess the impact of the DD-1 diversion on the flow regime of Driggle Draggle Creek using the AWBM model, previously described in **Section 5.3** and detailed in **Appendix B.** Daily runoff volumes were calculated for Driggle Draggle Creek immediately downstream of the point where the diverted flow would enter the creek, the catchment draining to DD-1 and the diversion channel for both existing conditions and post-diversion conditions using a 112 year daily climate dataset.

In the case of DD-1 a separate daily water balance model was developed which accounted for the evaporation losses from the surface area of the dam and the detention effect of the storage. The relevant features of the dam for water balance modelling were:

- capacity = 80 ML; and
- surface area approximately 3.9 ha (when full).

A similar modelling procedure was used to assess the impact of the Project at a number of locations on Driggle Draggle Creek and its tributaries as mining progresses and the catchment areas draining to Driggle Draggle Creek change. **Figure 29** shows the locations at which daily flow modelling was undertaken to characterise the potential impacts of the mine.



VICKERY COAL PROJECT

FIGURE 29

Flow Regime Node Locations

WHC-10-03_AppSW_204C

10.1.2 Impact of Mining on the Flow Regime

In addition to modelling of the impact of DD-1 on the flow regime in Driggle Draggle Creek, flow modelling was undertaken to assess the effect of changes in catchment areas as the mine develops:

- Existing conditions (i.e. zero mine development);
- Year 2;
- Year 7;
- Year 17; and
- Year 26.

In addition to the 'nodes' at which the flow regime has been assessed, **Figure 29** also shows the catchment boundaries at each of the nodes.

Table 26 provides the upstream catchment areas at each node for each stage of the mine plan. For purposes of this analysis all runoff from mine overburden dumps is assumed to be retained within the water management system and not released to the environment (i.e. all mine areas have been subtracted from the total catchment area of each node). Catchment areas of 0 km^2 indicate that the associated node has been subsumed by the Project.

Table 26: Catchment Area at each Stage of the Mine Life

Drainage Line	Node	Existing Area (km^2)	Year 2 Area (km^2)	Year 7 Area (km^2)	Year 17 Area (km^2)	Year 26 Area (km^2)
South Creek	SC3	1.2	1.2	1.2	1.2	1.2
	SC2	3.6	3.6	3.5	3.5	3.5
	SC1	4.3	4.3	4.2	4.2	4.2
West Drainage Line	WDL2	2.8	2.2	0.9	0	0
	WDL1	5.9	4.9	0.7	0	0
North-West Drainage Line	NWDL5	0.9	0.9	0.9	0.9	0.9
	NWDL4	3.6	2.0	2.0	0.1	0
	NWDL3	6.1	4.5	0.3	0	0
	NWDL2	12.0	9.4	1.0	0	0
	NWDL1	22.6	20.0	11.6	9.0	9.0
North Drainage Line	NDL4	0.1	0.1	0.1	0.1	0.1
	NDL3	0.5	0.4	0.4	0.4	0.4
	NDL2	1.9	1.1	1.1	1.1	1.1
	NDL1	7.1	6.4	6.4	6.4	6.4
Driggle Draggle Creek	DDC3	170	169	169	169	169
	DDC2	188	187	187	187	187
	DDC1	205	202	193	191	191

At the completion of mining, runoff from the top of the Western Emplacement, and its western batter will be directed via swale drains and rock chutes to the Driggle Draggle Creek catchment. Runoff from the eastern batter of the Western Emplacement would flow south, across the infilled area of the open cut, and drain to the Stratford Creek catchment. Perimeter bunds would be constructed around the final voids to prevent runoff from the surrounding landform flowing into them.

The drainage design proposed above would result in changes to the Driggle Draggle Creek and Namoi River catchments as follows:

- a 4.3% reduction in the Driggle Draggle Creek catchment; and
- a 0.01% reduction in the Namoi River catchment.

Table 27 and **Table 28** contain flow statistics at nodes DDC3 and DDC1 which illustrate the overall impact of the Project on the flow regime in Driggle Draggle Creek throughout the mine life assuming all overburden runoff is retained on site.

Table 27: DDC3 Flow Regime Statistics

DDC3	Year 0	Year 2	Year 7	Year 17	Year 26
Area (km^2)	170	169	169	169	169
Average Runoff (ML/Year)	3,715	3,724	3,788	3,748	3,724
Minimum Year Runoff (ML/Year)	0	0	0	0	0
10^{th} Percentile Year Runoff (ML/Year)	0	0	0	0	0
Median Year Runoff (ML/Year)	15.5	15.5	15.8	15.6	15.5
90^{th} Percentile Year Runoff (ML/Year)	4,530	4,533	4,611	4,561	4,533
Maximum Year Runoff (ML/Year)	588,984	595,367	605,502	599,061	595,367

Table 28: DDC1 Flow Regime Statistics

DDC1	Year 0	Year 2	Year 7	Year 17	Year 26
Area (km^2)	205	202	193	191	191
Average Runoff (ML/Year)	4,498	4,449	4,329	4,230	4,207
Minimum Year (ML/Year)	0	0	0	0	0
10^{th} Percentile Year (ML/Year)	0	0	0	0	0
Median Year (ML/Year)	18.8	18.5	18.0	17.6	17.5
90^{th} Percentile Year (ML/Year)	5,484	5,417	5,270	5,149	5,121
Maximum Year (ML/Year)	712,959	710,310	691,243	675,507	671,813

The data in **Table 27** shows that at DDC3, the Project and its associated diversion dams would have minimal impact on the flow regime in Driggle Draggle Creek. On average, the annual runoff is expected to increase over the life of the mine by less than 0.25%. Even in the wettest year expected (over the past 112 years of records), the annual runoff is only expected to increase by just over 1%.

At DDC1, the Project and its associated diversion dams could have a greater impact on the flow regime in Driggle Draggle Creek. Average annual runoff is expected to decrease as a result of the mine subsuming about 14.5 km^2 of the area draining into DDC1. Assuming worst case conditions in which there is no discharge from the sediment basins, the average annual runoff is expected to decrease over the life of the mine by approximately 6.5%. In practice, however, the change in flow is expected to be negligible because the overburden dumps can be expected to generate more runoff than the natural land surface and 60% of the runoff to the sediment basins will discharge after treatment (see **Table 23**).

10.2 South Creek

The FMP identifies that in the vicinity of the Project, Stratford Creek, South Creek and the North-West Drainage Line have been designated as riparian zones. These areas were defined from interpretation of aerial photography for the Liverpool Plains Region (currently held by OEH) for purposes of defining the Riparian Zones within the *Liverpool Plains Regional Vegetation Management Plan* (DLWC, 2002b)

The FMP aims to maintain flood connectivity to these areas and recommends that riparian buffer zones be maintained to help maintain the integrity of the banks and the general health of the creeks and the adjacent cultivated land. The objectives of the FMP in relation to riparian zones are to:

- decrease the disturbance to creek and river banks in non-flood times;
- establish riparian buffer areas; and
- stabilise creek banks by artificial means in areas that are dangerous or place permanent infrastructure at risk.

Guidelines for the required widths for riparian corridors are set out in the guidelines *Controlled Activities: Guidelines for Riparian Corridors* (NOW, 2010).

Works within riparian zones require a “controlled activity approval” under the *Water Management Act 2000*, which is administered by NOW. Whilst Part 4.1 [Clause 89J(1)(g)] of the *Environmental Planning and Assessment Act 1979* provides exemption for separate approval relating to works within riparian corridors for works assessed as State Significant Development, the requirements for works within or adjacent to riparian zones have been taken into account in providing setbacks from South Creek through the Project area.

South Creek flows south through the Project area from the north and drains into Stratford Creek, as shown on **Figure 12** to **Figure 16.** The Eastern Emplacement would be constructed on the eastern side of South Creek, while the open cut would be constructed to the west of South Creek.

In accordance with the *Controlled Activities: Guidelines for Riparian Corridors* (NOW, 2010), riparian protection of South Creek would be provided by considering:

1. **Core Riparian Zone (CRZ)** – as South Creek is a 4th order Strahler watercourse, this width should be between 20 to 40 m wide, or taken conservatively as 40 m (refer page 2 of guidelines).
2. **Vegetated Buffer (VB)** – recommended width is 10 m.
3. **Asset Protection Zone (APZ)** – no assets, therefore not applicable.

In addition to the total width of 50 m (CRZ + VB), the design of the Eastern Emplacement has made provision for the construction of a bund and drainage line to convey runoff from Eastern Emplacement into the relevant sediment basin.

An **indicative** cross-section of South Creek (looking upstream) is provided in **Figure 30**.

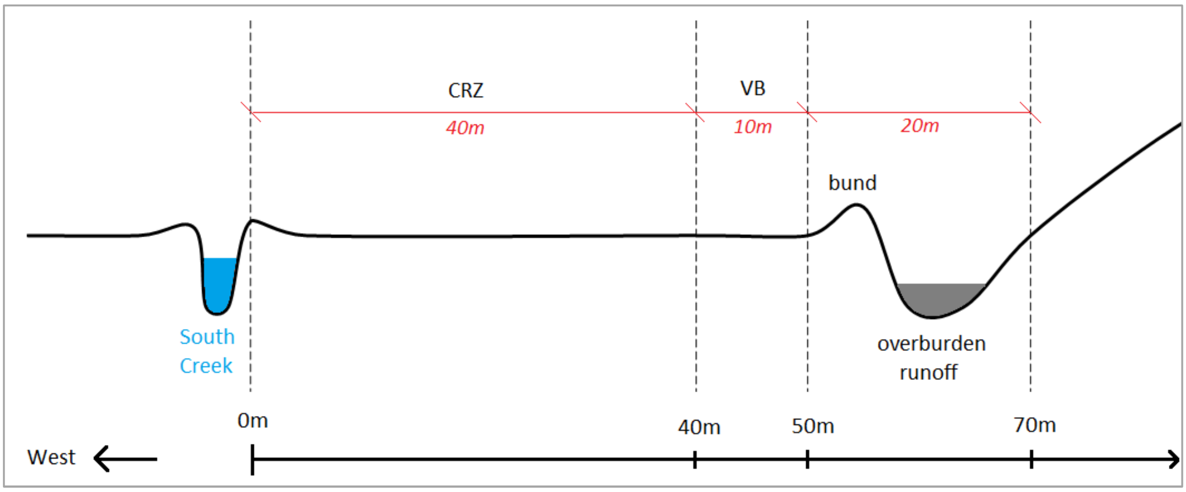


Figure 30: Indicative Cross-Section for South Creek

11 Effects of Climate Change on Surface Water

11.1 Future Rainfall and Evapotranspiration

Estimates of the impact of climate change on rainfall and evaporation are progressively being updated as climate science evolves. **Table 29** summarises data from two publications which specifically address potential climate change impacts in the Project area:

- *Climate Change in the Namoi Catchment* (Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2006) which provides estimates of annual average changes in 2030 and 2070; and
- *NSW Climate Impact Profile* (NSW Department of Environment, Climate Change and Water [DECCW], 2010) which provides a summary of the projected seasonal changes in 2050.

These two reports provide different perspectives and use different timescales, but indicate a general trend of reduced rainfall and increased evaporation. The general trends outlined in **Table 29** have been combined with the historic rainfall data and open water evaporation (assuming a 'pan factor' of 0.85) to produce the climate change estimates in **Table 30**.

Table 29: Predicted Rainfall and Evaporation Changes for 2030, 2050 and 2070

Year	Season	Precipitation	Evaporation	Extreme Rainfall	Source
2030	Year	-13% to +7%	+2% to +13%	+3%	CSIRO, 2006
2050	Spring	+10% to +20%	+20% to +50%	-	DECCW, 2010
2050	Summer	+10% to +20%	+10% to +20%	-	DECCW, 2010
2050	Autumn	+5% to +10%	+10% to +20%	-	DECCW, 2010
2050	Winter	-10% to -20%	+10% to +20%	-	DECCW, 2010
2070	Year	-40% to + 20%	+4% to +40%	+10%	CSIRO, 2006

Table 30: Indicative Effects of Climate Change on Average Rainfall and Open Water Evaporation

	Year	Spring		Summer		Autumn		Winter		Year		Average
		Low	High	Low	High	Low	High	Low	High	Low	High	
Rainfall	Historic	147		197		116		123		583		583
	2030	-	-	-	-	-	-	-	-	507	624	566
	2050	162	177	216	236	122	128	98	111	599	651	625
	2070	-	-	-	-	-	-	-	-	350	700	525
Evaporation	Historic	411		572		341		173		1,489		1,489
	2030	-	-	-	-	-	-	-	-	1,519	1,683	1,601
	2050	493	616	630	687	375	410	190	207	1,688	1,919	1,804
	2070	-	-	-	-	-	-	-	-	1,549	2,085	1,817

Although the different estimates are not entirely consistent, they indicate the following trends of relevance to the Project:

- By 2045 (at the end of active mining):
  - increase of about 5% in average annual rainfall; and
  - increase of about 20% in average annual open water evaporation.
- By 2070 (the last available estimates – which are taken to be representative of post-mine conditions):
  - decrease of about 10% in average annual rainfall; and
  - increase of about 20% in average annual open water evaporation.

11.2 Water Management Impacts of Climate Change

11.2.1 Water Balance during Mine Operations

The climate change estimates for 2045 indicate an increase in rainfall (approximately 5%) and an increase in evaporation (approximately 20%). These changes are predicted to occur progressively over time and would be difficult to distinguish from the variability in the long term climate record as illustrated by the variability shown in **Figure 4**. In addition, any progressive change in climate would occur as the mine expands and would have most impact late in the mine life when the water balance analysis indicates that there is likely to be an excess of water within the water management system. Accordingly, a separate analysis that attempts to take account of the progressive effects of climate change over the life of the mine is not warranted.

11.2.2 Long Term Void Water Balance

Following completion of mining the open cut area would be rehabilitated to produce:

- a northern void with a total contributing catchment area of about 244 ha; and
- a southern void with a total contributing catchment area of about 247 ha

The 'recovery' run of the groundwater model indicates that both voids would remain 'sinks' and that, depending on the water level established within the void, the inflow would progressively decline from about 1.1 to 0.8 ML/day in the northern void and from about 1.7 to 0.6 ML/day in the southern void.

A water balance analysis has been undertaken to establish the water surface areas that would achieve a balance between inputs (runoff, groundwater inflow and direct rainfall) and losses (evaporation) using the following assumptions:

- for existing climate conditions, average rainfall (583 mm/year) and open water evaporation (1,489 mm/year) remain constant;
- future climate change effects would lead to:
  - 10% reduction in rainfall;
  - 30% reduction in runoff (to account for the rainfall elasticity of streamflow (Chiew, 2006); and
  - 12% increase in evaporation;

- the contributing catchment above the pit lake water level would be rehabilitated to woodland vegetation;
- based on the monitoring reported in ACARP (2001), an 'pan factor' of 0.7 has been adopted to account for the fact that the lake within each void would be partially shaded and sheltered, leading to lower evaporation loss than if the water was fully exposed at the land surface; and
- the permeable overburden backfill between the final voids would allow water to flow from the void with the higher water level to the other. For purposes of this analysis a permeability of 1 metre per day has been assumed.

The modelling accounts for the geometry of each void (depth, area, volume) as determined from the mine plans. For purposes of this analysis a synthetic 1,000 year climate sequence was generated by random selection of years taken from the historic record. **Figure 31** and **Figure 32** show the modelled variation of water level in each void for the existing climate. For the climate change scenario, the water levels show similar fluctuation, but of the order of 4 to 5 m lower level as a result of the reduction in rainfall and runoff and the increase in evaporation. **Table 31** summarises the average and maximum water levels and depths for each void for the two climate scenarios while **Table 32** provides the corresponding water surface areas. The model results show that, because of the flow of water from the Northern Void to the Southern Void, the Southern Void water level can be expected to stabilise at about 10 m deeper, but maintain a difference between the water levels of about 20 m.

Table 31: Water Level Variation in Voids for Current Climate and Climate Change Scenarios

Void	Climate	Level (m AHD)		Depth (m)	
		Average	Maximum	Average	Maximum
Northern	Current Climate	166.8	172.7	46.8	52.7
	Climate Change	161.7	166.8	41.7	46.8
Southern	Current Climate	146.7	150.9	56.7	60.9
	Climate Change	142.6	146.4	52.6	56.4

Table 32: Water Surface Area Variation in Voids for Current Climate and Climate Change Scenarios

Void	Climate	Average Area (ha)	Maximum Area (ha)
Northern	Current Climate	27.3	35.6
	Climate Change	21.1	27.1
Southern	Current Climate	49.0	54.3
	Climate Change	44.5	48.5

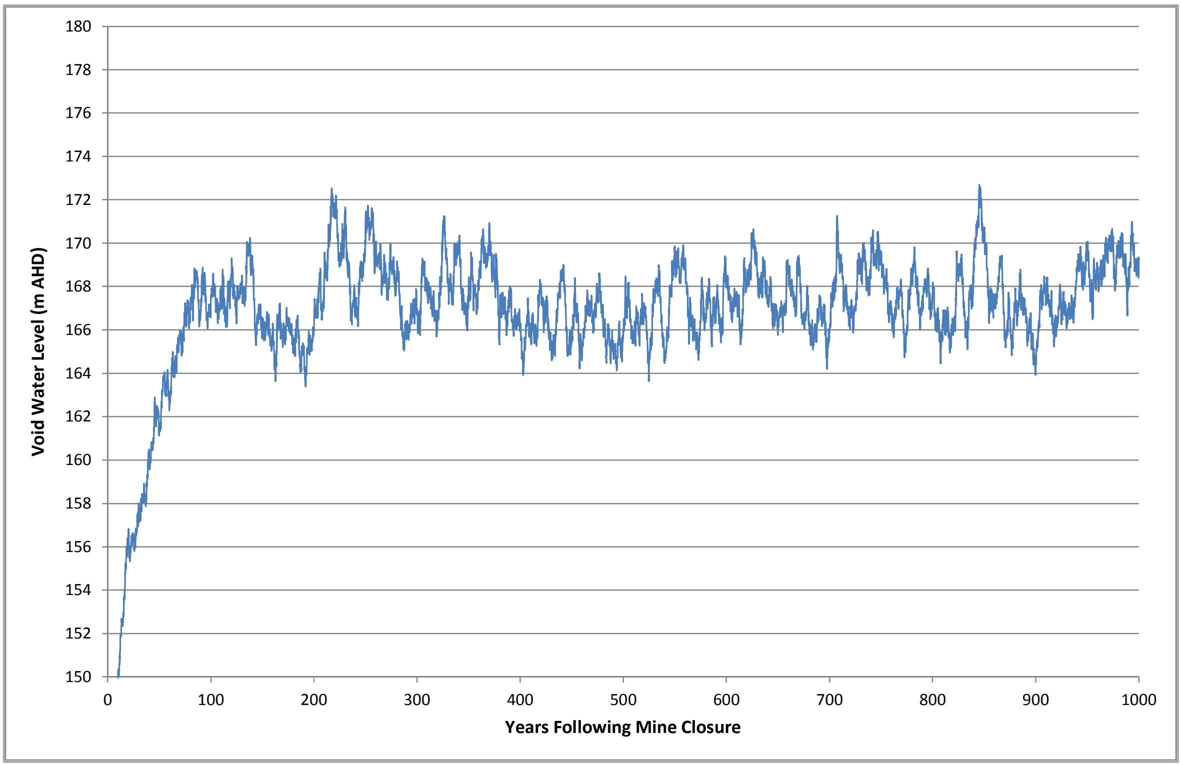


Figure 31: Modelled Water Level Variation in the Northern Void Following Mine Closure

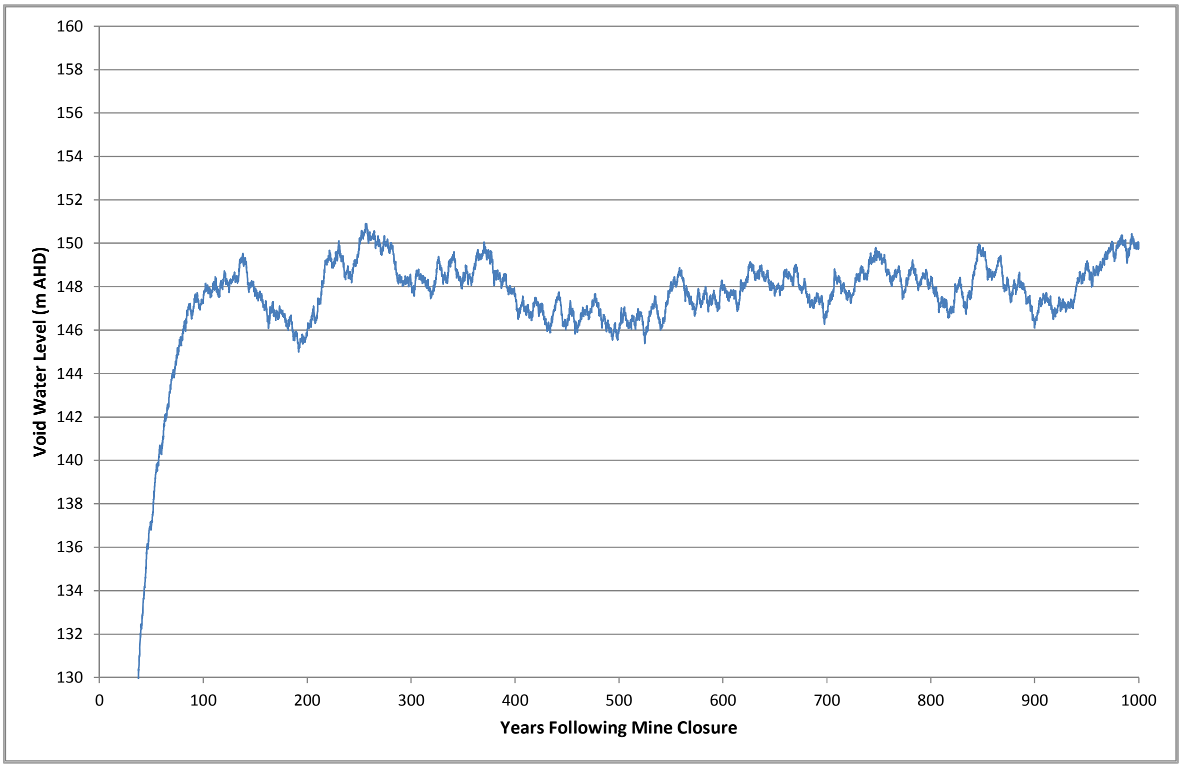


Figure 32: Modelled Water Level Variation in the Southern Void Following Mine Closure

11.3 Long Term Salinity in the Void Lakes

The steady state water balance has also been used to assess the progressive increase in salinity that could be expected as a result of the voids remaining ‘sinks’ for groundwater, leading to a progressive accumulation of salt. The salinity predictions are based on the following salt loads:

- median groundwater salinity in the area is 2,400 mg/L (pers. com. Merrick, 2012);
- average salinity of surface runoff is assumed to be 100 mg/L (160 µS/cm) based on typical water quality in the creek systems in the area (see **Table 15**); and
- the salt load associated with the flow of water through the overburden between the pits was accounted for, with a delay of 35 years based on an average flow velocity through the overburden and the width of the intervening barrier.

The results of the salinity analysis for the first 100 years are shown in **Figure 33** and **Figure 34**. **Figure 33** shows that under either climate scenario salinity in the Northern Void could be expected to increase in an almost linear manner to about 5,000 mg/L in 100 years. The longer term results show that the salinity in the Northern Void would stabilise in the range of in the rage of 5,500 to 6,000 mg/L for either climate scenario.

Figure 33: Progressive Increase in Salinity in the Northern Void under Different Climate Scenarios

As a result of the drainage of water from the Northern Void towards the Southern Void, the salinity in the Southern Void can be expected to show a different trend to that in the Northern Void. As shown in **Figure 34**, under the current climate scenario, the salinity in the Southern Void would increase to about 6,000 mg/L after 35 years followed by a decrease over the next 10 years as relatively fresh water that left the Northern Void 35 years earlier contributes to the Southern Void. Thereafter, the salinity could be expected to increase to about 7,000 mg/L after 100 years. For the climate change scenario, the salinity could be expected to be of the order of 10,000 mg/L after 100 years. In the longer term, because it represents the final 'sink' for water in the landscape, the salinity in the Southern Void can be expected to continue to progressively increase over time and reach concentrations of the order of 85,000 mg/L under the existing climate scenario or 100,000 mg/L under climate change conditions after 1,000 years.

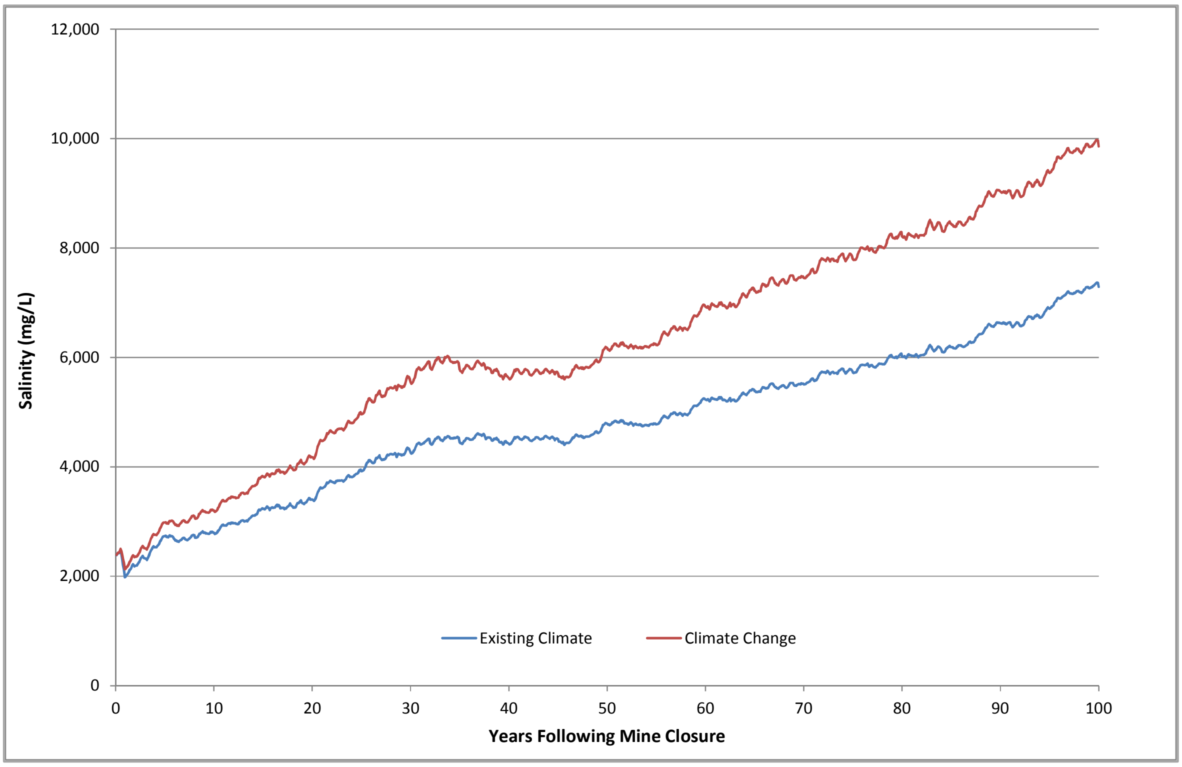


Figure 34: Progressive Increase in Salinity in the Southern Void under Different Climate Scenarios

An inspection of the details of the analysis that underpins the trends shown in **Figure 31** and **Figure 34** indicates that the primary source of salt is the estimated groundwater inflow which contributes about 85% of the water and over 99.5% of the salt load.

12 Water Management Plan

Prior to the commencement of operation, a WMP would be developed for the Project. The WMP would include full description of monitoring and management measures, which are summarised below.

12.1 Climate Monitoring

From a surface water management perspective, the key factors to be monitored are rainfall and evaporation.

A meteorological monitoring station has been installed at the Canyon Coal Mine to the immediate north of the Project to obtain ongoing meteorological monitoring. Parameters measured at the station include temperature, humidity, barometric pressure, wind speed and direction, rainfall (depth and rate), solar radiation and dew point.

These parameters can be used to calculate evaporation using the Penman-Monteith equation, which is considered more representative of evapotranspiration conditions than the traditional Class A evaporation pan, and can be adapted to estimate open water evaporation.

12.2 Surface Water Discharge

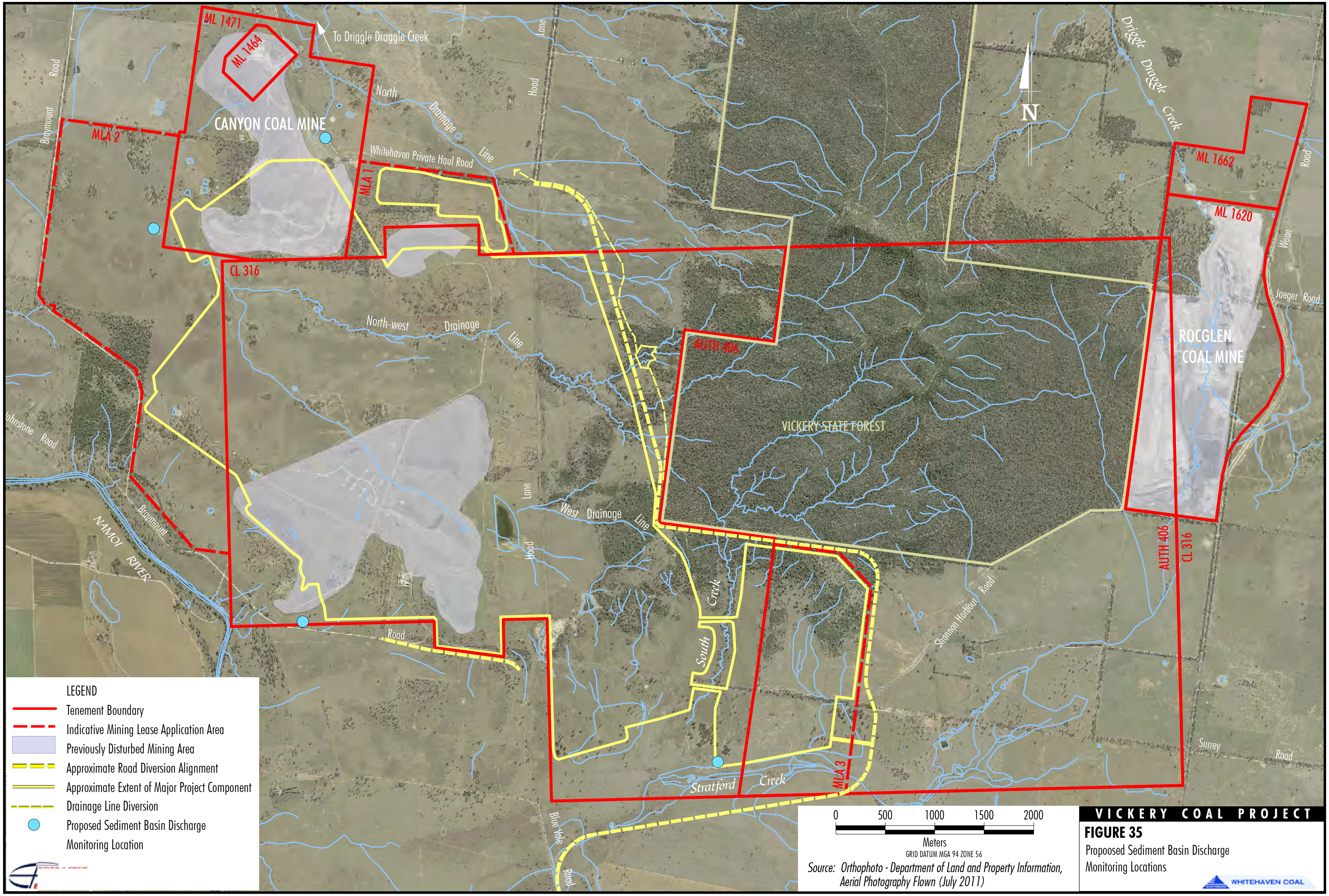
Figure 35 shows the location of four proposed locations at which monitoring is proposed for any discharge from the sediment basins around the periphery of the waste rock emplacements and the MIA:

- at the outlet from sediment basins SB-4 and SB-5 near the MIA;
- at the outlet from sediment basin SB-1;
- at a location on the West Drainage Line downstream of any discharge from sediment basin SB-8; and
- downstream of the outlets from sediment basins SB-9 and SB-10.

Consistent with the EPL conditions for other mines in the vicinity of the Project, it is proposed that water quality monitoring be undertaken by means of a grab sample taken during each overflow event and analysed for the following parameters:

- conductivity;
- TDS;
- TSS;
- turbidity;
- pH; and
- oil and grease.

A grab sample would also be taken prior to any controlled discharge that was undertaken once water in the sediment basin had sufficiently low TSS (50 mg/L) to permit discharge.



VICKERY COAL PROJECT

FIGURE 35

Proposed Sediment Basin Discharge Monitoring Locations

WHC-10-03_AppSW_205F

In accordance with the recommendations of the *Geochemistry Assessment* (Geo-Environmental Management, 2012) (Appendix L to the EIS) the water quality monitoring for water held in sediment basins would include quarterly sample collection and analysis for the parameters listed above as well as:

- Total alkalinity/acidity;
- SO4;
- Al;
- As;
- Mo; and
- Se.

The *Geochemistry Assessment* recommends that the quarterly monitoring data be reviewed annually. The reviews should be able to identify if exposure of sodic or potentially acid forming materials within the waste emplacements or pit walls is impacting water quality and would also indicate if the release of any of the enriched or soluble elements were present at sufficient concentrations to potentially adversely impact the quality of water in the receiving environment. The annual review should also include a review of the recommended parameter list for the quarterly monitoring and, if relatively low pH conditions are identified (i.e. pH < 6), the parameter list should be expanded to include Co, Ni, Pb, and Zn.

12.3 Ambient Surface Water Quality

Ambient surface water quality monitoring should continue to be undertaken at the existing sites shown on **Figure 6**. In addition, it is recommended that additional monitoring points be established at the following sites on watercourses that drain away from the mine area:

- Stratford Creek upstream of the MIA;
- Stratford Creek at Blue Vale Road (Site 12 on **Figure 6**);
- Driggle Draggle Creek upstream of any mine influence (Site WW1 on **Figure 6**); and
- Driggle Draggle Creek downstream of the Project (Site 5 or 14 on **Figure 6**).

Monitoring at these locations should continue to be on an opportunistic basis – whenever sufficient rainfall occurs to cause flow. Water quality monitoring at these locations should include the same suite of parameters specified in the EPL conditions for other mines in the vicinity:

- conductivity;
- TDS;
- TSS;
- turbidity;
- pH;
- oil and grease; and
- total organic carbon.

The monitoring locations, monitoring parameters and monitoring frequency would be described in detail in the WMP for the Project.

12.4 Water Balance Monitoring and Management

The water balance assessment provided in **Section 9** of this report is based on the best currently available science in relation to runoff characteristics of the various types of mine surfaces within a mine site and benchmarked against data from the adjacent Rocglen Coal Mine.

The water balance analysis provides the basis for the assessment of water security for operational purposes and the proposed staging of construction of various water storages.

However, the runoff characteristics of open cuts and waste emplacements exhibit significant variation depending on the local climate and geology as well as the particular characteristics of the mining operation. It is therefore proposed that sufficient monitoring of all the components of the mine water balance be conducted to permit periodic reviews of the mine water balance modelling in re-assess the required volume and timing for construction of future mine water storage dams.

Following Project Approval a site WMP would be prepared that reflects details of the detailed design of the mine and its water management facilities. The operating rules for the water management system would be further developed at that time and would be reviewed as part of the periodic review of the WMP to reflect operating experience and improved data relating to the runoff characteristics of the various land surfaces within the mine.

13 References

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Australian Coal Association Research Program (2001), *Water Quality and Discharge Predictions for Final Void and Spoil Catchments*, ACARP Project No. C7007, prepared by PPK Environment & Infrastructure.

Boughton, W.C. (2010). *Rainfall-Runoff Modelling with the AWBM*. Engineers Media, Crows Nest.

Boughton, W.C. (1984). *A simple model for estimating the water yield of ungauged catchments*. Civ Eng Trans, Institution of Engineers Australia, CE26(2), 83-88.

Boughton, W.C. and Chiew, F. (2003). *Calibrations of the AWBM for use on ungauged catchments,* CRC for Catchment Hydrology, Monash University, Tech Rep 03/15.

Bureau of Meteorology, CDIRS database (accessed 25/4/2012).

Bureau of Meteorology (2002), *Climate Atlas of Australia: Maps of Evapotranspiration* (Version 1.0).

Bureau of Meteorology (2003), *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method.*

Chiew, F.H.S. (2006). *Estimation of rainfall elasticity of streamflow in Australia.* Hydrological Sciences Journal, 51, 613-625.

Coast Ecology (2012), *Vickery Coal Mine – Aquatic Assessment*, Report prepared for Whitehaven Coal Limited.

Commonwealth Scientific and Industrial Research Organisation (2006), *Climate Change in the Namoi Catchment,* Report prepared for the NSW Government.

Department of Environment and Climate Change (2008), *Managing Urban Stormwater: Soils & Construction – Volume 2E: Mines and Quarries.*

Department of Environment and Conservation (2004), *Environmental Guidelines: Use of Effluent by Irrigation.*

Department of Environment and Conservation (2006), *Using the ANZECC Guidelines and Water Quality Objectives in NSW*

Department of Environment Climate Change and Water (2010), *NSW Climate Impact Profile.*

Department of Land and Water Conservation (1999), *Farm Dams Assessment Guide*, Report HO/13/99. Sydney.

Department of Land and Water Conservation (2002a), *Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Mine Sites in the Hunter Coalfields*

Department of Land and Water Conservation (2002b), *Liverpool Plains Regional Vegetation Management Plan,* (draft, June 2002)

Fluvial Systems Pty Ltd (2012), *Fluvial Geomorphological Assessment for Vickery Coal Project*, Report prepared for Whitehaven Coal Limited.

Geo-Environmental Management Pty Ltd (2012), *Vickery Coal Project – Geochemistry Assessment of Overburden, Interburden and Coal Rejects*, Report prepared for Whitehaven Coal Limited.

Gilbert & Associates Pty Ltd (2011), *Surface Water Assessment – Tarrawonga Coal Project*, Report prepared for Whitehaven Coal Pty Limited.

Heritage Computing (2013), *Vickery Coal Project: Groundwater Assessment,* Report prepared for Whitehaven Coal Pty Limited.

Institution of Engineers Australia (1998*).* *Australian Rainfall & Runoff: A Guide to Flood Estimation, Volume 1* (electronic version 2003).

Landcom (2004), *Managing Urban Stormwater: Soils & Construction,* Volume 1.

Mawhinney (2011), *Namoi Water Quality Project 2002-2007*, Report prepared for NSW Office of Water.

McKenzie Soil Management (2012), *Vickery Coal Project*: *Agricultural Resources Assessment,* Report prepared for Whitehaven Coal Limited.

Namoi Catchment Management Authority (2011), *Namoi Catchment Action Plan 2010-2020*.

National Health and Medical Research Council (2011), *Australian Drinking Water Guidelines.*

Niche Environment and Heritage (2012), *Vickery Coal Project: Ecological Assessment,* Report prepared for Whitehaven Coal Limited.

NSW Government (2002), *State Water Management Outcomes Plan Order 2002*.

NSW Government (2003), *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003.*

NSW Government (2012), *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012.*

NSW Office of Environment and Heritage (undated), *NSW Water Quality and River Flow Objectives,* web: http://www.environment.nsw.gov.au/ieo/

NSW Office of Water (2010), *Guidelines for Controlled Activities: Riparian Corridors*.

Schlumberger Water Services (Australia) Pty Ltd (2011/12), *Namoi Catchment Water Study – Independent Expert*, Reports prepared for Department of Trade and Investment, Regional Infrastructure and Services:

- *Phase 1 Report* (November 2010)
- *Phase 2 Report* (August 2011)
- *Phase 3 Report* (April 2012)
- *Final Report* (July 2012)

SMEC (2003), *Carroll to Boggabri Flood Study and Compendium of Data*, Report prepared for the NSW Department of Land and Water Conservation.

SP Solutions (2012), *Vickery Coal Project – Environmental Risk Assessment,* report prepared for Whitehaven Coal Limited.

Tarrawonga Coal Pty Ltd (2011), *Environmental Assessment for Tarrawonga Coal Mine Modification*.

Thompson and Visser (2002), *Benchmarking and management of fugitive dust emissions from surface mine haul roads,* Trans. Inst. Min. Metal. V110, SA, A28 –A34.

Thoms, M. Norris, R. Harris, J. Williams, D. and Cottingham, P. (1999), *Environmental Scan of the Namoi River Valley*, report prepared for the Department of Land & Water Conservation and the Namoi River Management Committee.

Vickery Joint Venture (1986), *Namoi Valley Coal Environmental Impact Statement*.

Webb McKeown & Associates (2005), *Carroll to Boggabri Floodplain Management Study (draft)*, Report prepared for the NSW Department of Infrastructure, Planning & Natural Resources.

Webb McKeown & Associates (2006), *Carroll to Boggabri Floodplain Management Plan*, Report prepared for the NSW Department of Natural Resources.

Worley Parsons Pty Ltd (2013), *Vickery Mine Project – Flood Assessment*, Report prepared for Whitehaven Coal Limited.

WRM (2011), *Surface Water Import Assessment for the Maules Creek Coal Project,* Report prepared for Aston Resources Pty Ltd.