

Surface Water Study for Rixs Creek Continuation of Mining

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Client: Rix's Creek Mine

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28/11/2014

Job No.: 14005

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Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	17-Nov-14	Draft	John Pola Principal	
B	28-Dec-14	Final	John Pola Principal	
C	20-Oct-15	Review of Adequacy	John Pola Principal	

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GLOSSARY OF TERMS

Term	Definition
Active workings	Any place in a mine where miners are normally required to work or travel.
Annual recurrence interval (ARI)	Used to describe the frequency or probability of floods occurring (e.g. a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years).
Anticline	Upwards-arched fold in the rock strata where the beds dip outwards in two or more directions from the crest.
Aquifer	Geologic formation, group of formations, or part of a formation capable of transmitting and yielding quantities of water.
Bed	Stratum of coal or other sedimentary deposit.
Bin	Coal storage structure, either underground or surface structure.
Blast	A controlled explosion which is used to loosen the substance being mined.
Bloomfield	Bloomfield Collieries Pty Ltd – Parent Company of the Bloomfield Colliery and Rix's Creek Mine
Bore	Normally refers to a cylindrical drill hole sunk into the ground from which water is pumped for use or monitoring. Also, under the Water Act 1912 an open cut mining excavations is licenced as a bore.
Borehole	Normally, a hole produced in the ground by drilling for the investigation and assessment of soil and rock profiles or for water supply.
Catchment	The area from which a surface watercourse or a groundwater system derives its water.
Clearing	The removal of vegetation or other obstacles at or above ground level.
Coal Handling and Preparation Plant	Treatment by screening coal into various sizes to meet a purchasers requirements and treatment by one or more processes to reduce the amount of waste (ash) present in the coal.
Coking coal	Coal suitable for the manufacture of coke.
Coarse reject	Waste rock from the ash removal process, normally less than 20mm but does not include finer particles of silts and clays.
Compressive strain	Compressive strains decrease in the distance between two points and may cause shear cracking, steps, or concave curvatures at the ground surface.
Conveyor	A means of transporting coal. It consists of a belt being driven by a motor drum system over a structure roller assembly.
Cover	The overburden above the coal resource.
Cumulative impacts	Combination of individual effects of the same kind due to multiple actions from various sources over time.
Cut	Mechanically slice a coal seam to extract the coal resource.
Discharge	A release of water from a particular source.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Earthworks	Operations involved in loosening, excavating, placing, shaping and compacting soil or rock.

Term	Definition
Ecologically sustainable development	As defined by the <i>Protection of the Environment Administration Act 1991</i>, requires the effective integration of economic and environmental considerations in decision making processes including: • The precautionary principle. • Inter-generational equity. • Conservation of biological diversity and ecological integrity. • Improved valuation, pricing and incentive mechanisms (includes polluter pays, full life cycle costs, cost effective pursuit of environmental goals).
Ecosystem	As defined in the <i>Environment Protection and Biodiversity Conservation Act 1999</i> , an ecosystem is a 'dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.'
Emission	The discharge of a substance into the environment.
Environmental management plan	A plan used to manage environmental impacts during each phase of project development. It is a synthesis of proposed mitigation, management and monitoring actions, set to a timeline with defined responsibilities and follow up actions. The purpose is to ensure all parties comply with the environmental conditions of approval for the project and that identified environmental risks are properly managed.
Environmental management system (EMS)	An environmental management system (EMS) is a quality system that enables an organisation to identify, monitor and control its environmental aspects. An EMS is part of an overall management system, which includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy.
Environment	As defined within the <i>Environmental Protection & Assessment Act, 1979</i> , all aspects of the surroundings of humans, whether affecting any human as an individual or in his or her social groupings.
Ephemeral	Existing for a short duration of time.
Environment Protection Licence	Environment Protection Licence, or EPL is issued by the EPA under the <i>Protection of the Environment Operations Act 1997</i> . EPLs with respect to scheduled development work or scheduled activities or non-scheduled activities may regulate all forms of pollution (including water pollution) resulting from that work or those activities. EPLs authorising or controlling an activity carried on at any premises may also regulate pollution resulting from any other activity carried on at the premises to which the licence applies.
Extraction height	The heights at which the seam is extracted.
Exploration	The work done to prove or establish the extent of the coal resource.
Fault	Break in the continuity of a coal seam or rock strata.
Groundwater	Water located within an aquifer, i.e. it is contained in the rocks and soil beneath the earth's surface.
Hydrocarbon	Any organic compound — gaseous, liquid or solid — consisting only of carbon and hydrogen.
Hydrogeology	The study of subsurface water in its geological context.
Hydrology	The study of rainfall and surface water runoff processes.

Term	Definition
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Interburden	The rock between two geological features.
Local road	A council controlled road which provides for local circulation and access.
Overburden	The geological units and material above the coal seam proposed or being mined.
Pollutant	Any matter that is not naturally present in the environment.
Preparation plant	A place where coal is sized, treated by one or more processes, including washing, to reduce the amount of waste (ash) present and prepared for market.
Product coal	Coal that has been processed within the processing plant to remove unwanted waste rock and prepared to customers specifications.
Proposed development	Extension of open cut coal mining and associated activities at Rix's Creek Mine within the Project Area. Referred to as The Rix's Creek Continuation of Mining Project (The Project).
Rehabilitation	The return of disturbed land to a stable, self-sustaining condition, after taking into account beneficial uses of the site and surrounding land.
Revegetation	Direct seeding or planting (generally with native species) within an area in order to re-establish vegetation that was previously removed from that area.
Riparian	Relating to the banks of a natural waterway.
Rixs Creek	The creek running through the Rix's Creek Mine.
Runoff	The portion of water that drains away as surface flow.
Run of mine	Raw coal production that contains coal and rock.
Seam	Layer or bed of coal.
Stockpile	Stored materials such as product coal, soil, sand, gravel and spoil/waste.
Strain	The change in horizontal distance between two points at the surface after mining, divided by the pre-mining distance between the points and usually expressed in mm/m.
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
Syncline	A trough-like fold in rocks.
Tailings	A component of waste rock and soil from the ash removal process consisting of fine particles of silts and clays. It can be handled as liquid slurry or dewatered to a cake for disposal.
Tributary	A river or stream flowing into a larger river or lake.
Water table	The surface of saturation in an unconfined aquifer at which the pressure of the water is equal to that of the atmosphere.
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).

ACRONYMS

Acronym	Term/ Definition
AHD	Australian Height Datum
CL	Coal Lease
CHPP	Coal Handling & Preparation Plant
CWD	Clean water dam. The purpose of the dam normally is to hold and convey runoff water from land undisturbed by mining activity.
DGRs	Director-General's requirements
DoE	Department of Environment (Commonwealth)
DoP	Department of Planning and Environment
DPI	Department of Primary Industry
DRE	DTIRIS Division of Resources and Energy
DTIRIS	NSW Department of Trade and Investment, Regional Infrastructure and Services
DWD	Dirty water dam. The purpose of the dam normally is to hold runoff water that has been in contact with coal for re-use or release. In a coal mine, a DWD must be able to contain runoff from a 1% AEP 1 day duration storm without overflowing.
EC	Electrical conductivity, expressed as microsiemens per centimetre in this report. EC is an analogue for dissolved solids (salts).
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979 (NSW)</i>
EPL	Environment Protection Licence
ha	Hectare/s
LEP	Local Environment Plan
LGA	Local Government Area
mAHD	Metres, Australian height datum
mg/L	milligrams per litre
micron	One millionth of a metre (abbreviation μ)
Mining SEPP	<i>State Environment Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007</i>

Acronym	Term/ Definition
mL	millilitre
ML	megalitre, one million litres
mtpa	million tonnes per annum
OEH	Office of Environment and Heritage
PEA	Preliminary Environmental Assessment
POEO Act	<i>Protection of the Environment Operations Act 1997</i> (NSW)
ppm	Parts per million. Equivalent of milligrams per litre.
pH	A measure of acidity or alkalinity of a solution. The potential of hydrogen.
PRP	Pollution Reduction Program
REA	Rejects emplacement area. Can also be called refuse emplacement area.
ROM	Run of mine
SEE	Statement of Environmental Effects
SEPP	State Environmental Planning Policy
SD	Sediment Dam.
SSC	Singleton Shire Council
TPH	Total petroleum hydrocarbons
VOC	Volatile organic compounds
WAL	Water access licence.

Executive Summary

The Project is a planned continuation of the existing Rixs Creek Mine to continue the existing mining operation at the Mine and to mine up to 4.5Mtpa ROM coal per year over 28 years. The Mine is located approximately 5km north-west of Singleton in the Hunter Coalfields. A water management system has been developed for the Project that includes:

- A mine water management system (water that has come in contact with coal) to collect and use water that may contain high TDS (salt) concentrations.
- A tailings water management system to dewater tailings to a dry cake at the CHPP eliminating the need for a permanent tailings disposal facility.
- A sediment and erosion management system to ensure runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment and release.
- A clean water management system to divert water undisturbed by mining around the Rixs Creek disturbance footprint; and
- A contaminated water management system for water that has come in contact with chemicals of various types used in the mining operations.

Water Balance Modelling

Water balance modelling was undertaken to assess the performance of the proposed water management system. The results of the water balance modelling are as follows:

Overall Performance of the System:

- Under the proposed water management system, runoff from the Rixs Creek Mine catchments and dewatered groundwater can supply all water requirements up to 50th percentile dry conditions at Rixs Creek South over the life of the Project. For drier than 50th percentile conditions, the peak annual demand for imported water gradually increases to a maximum of 224 ML for the 99th percentile climate regime (extreme dry). The majority of the offsite demand occurs in the first half of the project life. The overall site water demand generally rises as ROM production rises. Even in the most extreme climate cycle, imported water is required for only 10 out of the 28 years of the project life, with an average use of 36 ML p.a..
- The water management system can contain saline water on site without off site discharges for most foreseeable climatic conditions. This comes with a risk of impaired mining production for conditions wetter than 10th percentile climate regime.

Performance of West Pit:

- Under 50th percentile conditions i.e. “average” conditions, no water will accumulate in West Pit over the life of the Project. Under the 20th percentile conditions, or wet conditions, up to 1,300

ML of water may accumulate in West Pit before coal in the pit is exhausted, but for almost 70% of the time West Pit is dry under this climatic regime.

- Pit workability would normally be adversely impacted by more than 500 ML of water held in West Pit due to out of pit storages being full and unable to accept water. This scenario is not likely to occur until late in the third quarter of the mine life under the 10th percentile climatic conditions, and if an adaptive approach is taken to water management there should be adequate lead time to provide more out of pit storage or to initiate operations under the HRSTS, however the prevailing risk regime is slanted towards water shortage.

Sensitivity Analysis

- The results of the water cart usage sensitivity analysis are indicative of the climate variability of the region. When the water balance is in equilibrium, there could potentially be both shortfalls in demand, requiring offsite make-up water, or a build-up of water that impacts on operational workability depending upon whether wet or dry conditions are experienced over the Project life. Given that current storage inventory will reduce over the early part of the Project life, there is merit in investigating minimising water use via strategies such as dust suppressants, and also considering the impact of installing an out of pit storage with an HRSTS discharge point to balance out the extremes in the water balance. Minimising, or eliminating, the requirement for offsite supplies is the preferred approach from both an operational and environmental perspective.
- Water cart usage has a significant impact on the water balance. The sensitivity analysis found that with a 30% increase in water cart dust suppression, there is a significant increase in imported water volumes over the life of the project with more frequent peak demands as high as 1,221 ML per year, a fivefold increase over base case conditions.

Water Quality

The Project will not impact on off site water quality due to spillages from the mine water dams:

- The North Pit Void, CHPP Dams, Old North Pit, Dirty Water Dam 3 or the Old Underground Workings do not spill over the Project life. The 1% confidence plot indicates Dirty Water Dam 2 may spill up to 0.6 ML over the life of the project
- Current water management and planning systems are effectively preventing spills

Water Licencing Requirements

Water Access Licences currently owned by Rixs Creek Mine are likely to satisfy any water supply shortfall under this scenario, even with increased water cart usage rates used in the sensitivity

analysis. If more water is required, Rixs Creek Mine could either purchase additional units on the open market or approach other Water Access Licence holders for a term transfer, which may require an application to change the zone. Rixs Creek may have to obtain a Works Approval to pump from the Hunter River, and install a supply pipeline at least as far as West Pit. The Mine holds a current Works Approval but the existing works are unlikely to be of sufficient capacity to convey water the distance required.

A section of Stonequarry Gully will be consumed by open cut mining around 2035 and about 680 metres of the stream will need to be diverted. The proposed stream diversion will require a Works Approval. A design that addresses appropriate hydraulic and geomorphological aspects of the proposed diverted stream will adequately mitigate any potential erosion, deposition and stream stability risks.

Catchment Loss

The Project will reduce the Rixs Creek catchment by a maximum of 22%, and is currently at this maximum, reducing to 5% at the completion of mining. The Project will add about 1% to the original size of Station Creek; however the major impact on this catchment will remain to be Integra Coal. An Un-named Tributary of the Hunter River to the west of West Pit will lose 10% of its original size at the completion of mining. Overall, 243 ha will be permanently lost to the final void and underground portal.

The Project will have an insignificant impact on the Hunter River flows. Under mining conditions, the Project will reduce the catchment draining to the Hunter River at Singleton by less than 0.1% and the catchment loss at completion of mining equates to 0.015%

Rixs Creek holds WAL's that can be surrendered to compensate for the permanent loss of catchment in Rixs Creek and the Un-named Tributary at the completion of mining.

Flooding

The Rixs Creek West Pit disturbance footprint is located outside of the 100 year ARI flood extent of both the Hunter River and Rixs Creek.

1.0 Introduction

1.1 Rix's Creek Continuation of Mining Project

This section provides an introduction to the Rix's Creek Mine, the proposed Rix's Creek Continuation of Mining Project (the Project), and the purpose and content of this report.

1.1.1 Overview

Rix's Creek Mine (the Mine) of Rix's Creek Pty Limited, is owned and operated by Bloomfield Collieries Pty Limited (Bloomfield). The Mine is an open cut coal mine approximately 5 km north-west of Singleton in the Hunter Valley Coalfields of NSW. Refer Figure 1: Regional Context. The Mine currently produces approximately 1.5mtpa of product coal from its existing operations.

Bloomfield is seeking approval for the Project, which relates to the continued operation of the existing open cut coal mine. The Project would allow the Mine to continue to operate as an open cut mine, accessed via its existing infrastructure facilities.

The Project seeks to extend the life of the existing open cut mining operation at Rix's Creek until approximately 2037. The continuation of mining operations will extend in a north-westerly direction and require a modification to Mine Lease 1432 for an out of pit dump. The continuation of operations will utilise the existing mine access, Coal Handling and Preparation Plant, coal stockpiling and rail facilities.

1.1.2 Proposed development

The Project seeks to continue the existing mining operation at the Mine and to mine up to 4.5mtpa ROM coal per year. Mining methods will be the same as those currently employed at the Mine, being multi-seam bench open cut techniques. ROM coal will continue to be processed onsite at the existing CHPP which has capacity to accept the proposed increase in throughput. Product coal will then be transported by rail to the Port of Newcastle. It is estimated that the Mine could yield a total of 32 million saleable tonnes of coal at an overburden ratio of approximately 10.5:1 before coal seams are exhausted.

The components of the proposed development comprise:

- The ongoing use of, and future additions to, the existing mine fleet.

- Use of the existing mine infrastructure facilities including the CHPP.
- Continuation of operating hours - 24 hours a day 7 days a week.
- Use of existing and new rejects and tailings emplacements.
- Rail transport of product coal to the Port of Newcastle.
- Mine closure and rehabilitation; and
- Environmental management.

Refer **Figure 2: Project Area**

1.2 Proposed Operations Relevant to the Surface Water Impact Assessment

The Project seeks to continue the existing mining operation at the Mine

The following issues will be considered in assessing the surface water impacts impact of the Project:

- Catchment and drainage modifications associated with the continuation of the Mine.
- Changes to the existing site water balance, including water use, the management of mine water, potential increases and potential need for operational discharge to the environment, and the likelihood of uncontrolled flows to adjacent watercourses from site drainage.
- Management of retained site water inventories to maintain water supplies for mining and minimise demands on external water resources.
- Erosion, sedimentation or contamination resulting from ground disturbance; and
- Changes to the existing management systems that may be required to manage the above issues. The mine implements and maintains a Water Management Plan and an Erosion and Sediment Control Plan approved by the Department of Planning and Environment.

The extent of the area considered in this study is shown on **Figure 3: Study Area**. It should be noted that in the vicinity of the overburden emplacements, a minimal width allowance for drainage structures has been assumed for preparation of figures in this report. Detailed drainage design at the time of installation may place structures partly or wholly outside these lines.

The reconstruction of landforms at the mined out areas of North Pit and South Pit; and the ongoing operation of West Pit will require progressive installation of surface drainage and catchment dams to direct surface runoff to sediment settling structures before the water is released from site. The

drainage should be designed and installed to maintain water velocities within a range that minimises both erosion and deposition. The drainage and sediment settling structures will require ongoing maintenance until monitoring indicates that runoff quality is within acceptable parameters and that the landform can be considered stable.

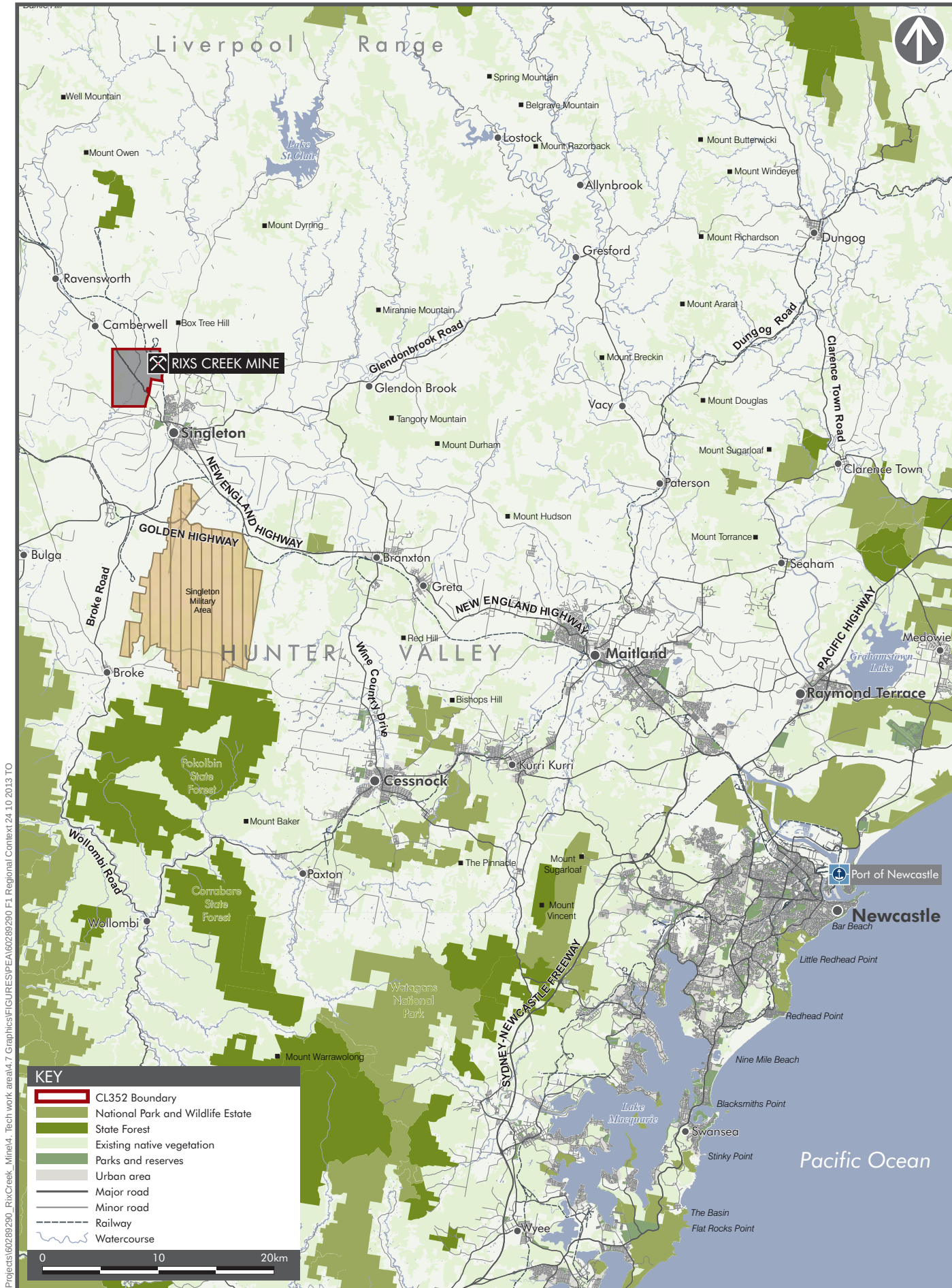
Adequate provision of sufficient mine water storage over the life of the Mine will be required to maintain water supply for ongoing operation; minimise inundation risks to operational areas and prevent uncontrolled releases off site. Traditionally the Mine has maintained a series of large open voids in mined out areas to store water, and also utilised void space in the abandoned underground workings remaining after coal mining in the 19th century. These voids have proved successful in maintaining water supply in both extreme wet and dry climatic conditions experienced since the Mine commenced operations in 1991. The ability to maintain large inventories on site means that Rixs Creek has to date not needed to install a discharge facility under the Hunter River Salinity Trading Scheme.

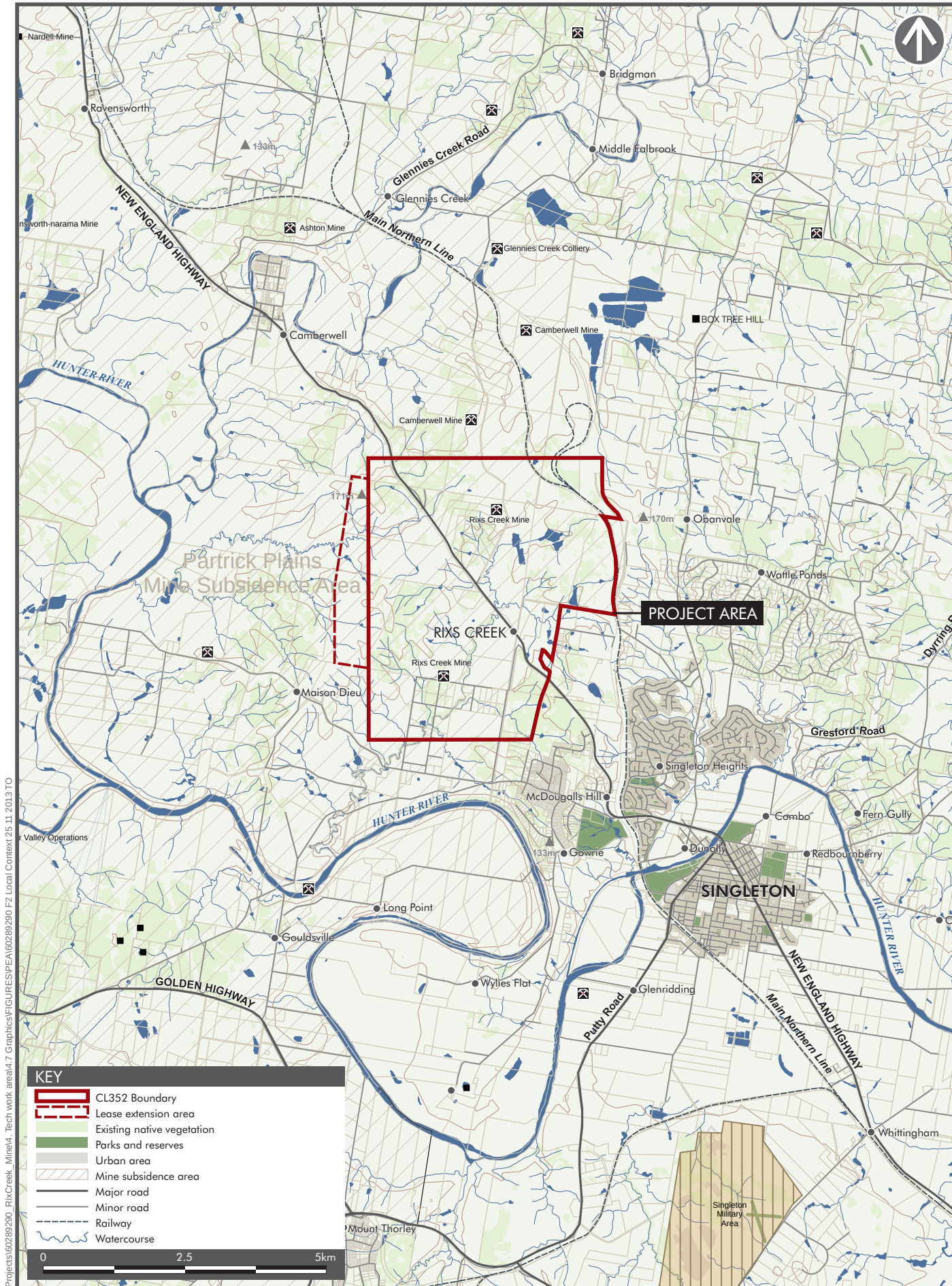
As West Pit (Pit 3) progresses, most current mine water storage voids will be consumed by disposal of mined overburden. In response, the proposed strategy is to store water in void space in the backfilled excavations beneath the reconstructed landform at North Pit only constructing out of pit storage when there is a measureable risk of water shortage or inundation. The effects of this strategy are modelled as part of this study.

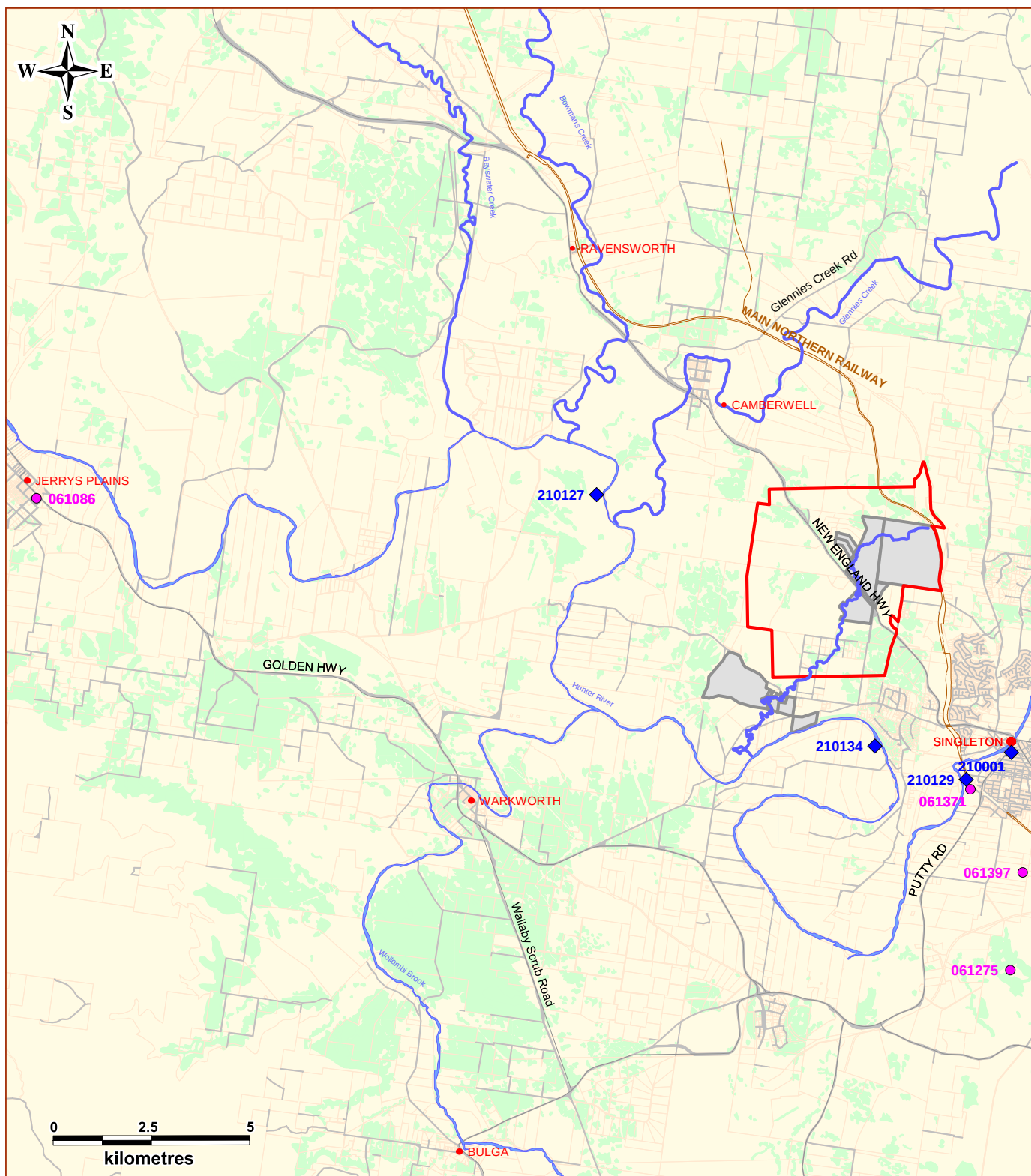
The Rixs Creek channel and associated waterfront land south of the New England Highway, apart from two culvert channel crossings, is relatively unaffected by current or past mining activities. There is no evidence of appreciable erosion, sediment transport or deposition due to mining activity and water quality trends appear stable. Overburden emplacements in the vicinity of South Pit will move closer to the creek channel, but will not encroach on the waterfront land. The Project is not expected to impact this reach of Rixs Creek.

Diversions of Rixs Creek are currently in place on the north side of the New England Highway. Development of the underground portal, commencing about two years prior to the cessation of open cut mining will require a diversion of Stonequarry Gully, the subject reach being classified a third order stream under the Strahler stream order system (1952).

Flooding is not expected to be a key issue for the project as the Mine is not located within an active floodplain or flood prone area.







- Study/Project Area
- ◆ HITS Station and Number
- BOM Daily Rainfall Station & Number
- NOW Works Approval

JP Environmental

**Surface Water Study for Rixs Creek
Continuation of Mining**

Figure 3: Study Area

1.3 Purpose of the Report

1.3.1 Director-General's Requirements

The Rix's Creek Continuation of Mining Project Environmental Impact Statement has been prepared in accordance with Division 4.1, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) which ensures that the potential environmental effects of a proposal are properly assessed and considered in the decision-making process.

In preparing this Surface Water Impact Assessment "Surface Water Study for Rixs Creek Continuation of Mining, the Director - General's Requirements (DGRs) issued for the Rix's Creek Continuation of Mining Project (SSD 13_6300) on 3 March 2014 have been addressed as required by Clause 75F of the EP&A Act. The key matters raised by the Director-General for consideration in the Surface Water Impact Assessment are outlined in Table 1 along with a reference to where the requirements are addressed in the report.

Table 1: Director General Requirements Applicable to the Surface Water Impact Assessment

Director Generals Requirement	Section Addressed
In addition, the EIS must include a: • detailed assessment of the key issues specified below, and any other significant issues including: – a description of the existing environment, using sufficient baseline data – an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant guidelines and policies; and ; – 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.	Section 3.0 Existing Environment Section 5 Water Balance; Section 6 Impact Assessment Section 7 Mitigation Management and Monitoring Measures.
Water resources including: • detailed assessment of potential impacts (including cumulative impacts) on the quality and quantity of existing surface water resources, including: • impacts on affected licensed water users and basic landholder rights. • impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows; and • a flood assessment including identification of any necessary flood impact mitigation measures.	Section 6.2.3 Water Quality Section 6.2.2 Loss of Catchment Flows Section 6.2.1 Flooding

Director Generals Requirement	Section Addressed
a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume, salinity and frequency of any water discharges), water supply infrastructure and water storage structures.	Section 5.0 Water Balance Section 4.0 Water Management System
an assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives.	Not applicable
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 3.8 Mine Water Management System Section 6.2.3 Water Quality
identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000.	Sections 2.2, 2.3 and 2.4; and Section 6.2.4 Water Licensing
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).	Sections 2.2, 2.3 and 2.4; and Section 6.2.4 Water Licensing; Section 5.5.3 Imported Water Requirements
a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo.	Section 7 Mitigation Management and Monitoring Measures.
a detailed description of the proposed water management system (including sewage), water monitoring program and measures to mitigate surface and groundwater impacts; and	Section 4.0 Water Management System Section 7 Mitigation Management and Monitoring Measures.
compliance with the Hunter River Salinity Trading Scheme.	No Applicable

1.3.2 Surface Water Impact Assessment Objectives

JP Environmental (JPE) has been engaged by Rixs Creek Coal to complete a surface water impact assessment for the Project. The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by AECOM to support an application for Project Approval under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) to facilitate the continuation of the existing Rixs Creek Mine West Pit (Pit 3) by the ongoing development of an open cut mining operation and associated infrastructure within the Rixs Creek Mine Project Area.

The scope of work completed by JPE for this assessment included:

- Addressing the Director-General's Environmental Assessment Requirements (EARs) relating to surface water, issued on 3 August 2011.
- Identification of surface water values:
- Identification of potential surface water impacts:
- Identification and development of surface water control measures:
- Development and analysis of a site water balance; and
- Development of a surface water monitoring plan

1.3.3 Report Structure

This report is structured as follows:

Section 1.0 Introduction – outlines the Project and presents the purpose of the report.

Section 2.0 Methodology – describes the methodology employed for the Surface Water Impact Assessment.

Section 3.0 Describes the existing environment.

Section 4.0 Describes the water management system and the interactions with the mine plan.

Section 5.0 Describes the site water balance and the methodology and outcomes of water balance modelling for the Project.

Section 6.0 Provides a detailed assessment of potential impacts (including cumulative impacts) on the quality and quantity of existing surface water resources

Section 7.0 Describes mitigation measures for impacts and monitoring requirements to check the performance of the ongoing Project

Appendix A: Water Balance Model Development and Calibration

Appendix B: Water Quality Monitoring Data

Appendix C: Reference Cross Sections for Rixs Creek

Appendix D: Dam Stage-Storage-Area Curves

Appendix E: Catchment Areas for OPSIM Model

1.3.4 Related Studies

The studies which are to be read in conjunction with this assessment include the following:

- The EA groundwater impact assessment.
- The EA ecology impact assessment; and
- The EA agricultural impact statement

2.0 Methodology

2.1 Legislation, Policy, Guidelines and/or Criteria

The following legislation, plans, policies and regulations are relevant to the Project for surface water management:

- The Water Management Act 2000, Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002, Water Sharing Plan for the Hunter Regulated River Water Source 2003 (H RRWSP) and Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (HUAWSP) with respect to the:
 - Taking of waters from the Hunter River Regulated Water Source.
 - Taking of waters from the Hunter River Unregulated and Alluvial Water Source.
 - Capture of clean water runoff.
 - Use of the final voids at Rixs Creek Mine as a water storage:
 - Construction and use of a pump station on the Hunter River and
 - The objectives of the State Water Management Outcomes Plan (SWMOP) and Hunter-Central Rivers Catchment Action Plan (CAP).
- The Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 with respect to the release point for Hunter River Salinity Trading Scheme (HRSTS) discharges into the Hunter River. . These discharges will be required to be authorised as part of the Environment Protection Licence.
- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ. 2000) and the ANZECC Guidelines and Water Quality Objectives in NSW (DEC, 2006) with respect to defining the environmental values of receiving waters and the definition of protection level based on ecosystem condition.
- NSW Office of Water (NOW) Water Reporting Requirements for Mining Operations 2009.
- Dams Safety Act 1978 (Dams Safety Act) with respect to the design, construction, monitoring and management requirements of any prescribed dams on the site or in the surrounding area.
- Managing Urban Stormwater Soils and Construction - Volume 2E Mines and Quarries, (DECC, 2008) and Managing Urban Storm water, Soils and Construction, (Landcom, 2004) with respect to the design of erosion and sediment control measures, colloquially described as the Blue Book; and

- Water Act 1912 (Water Act) with respect of any water contained in fractured rock aquifers and basement rocks; and for diverting the course of Stonequarry Gully.

2.2 Water Licences

A Water Access Licence (WAL) is required for any water to be taken from the Hunter River and tributaries and used for the Project. Additionally, any water occurring naturally on or below the surface of the ground which is taken by the Project will be required to be the subject of a Water Access Licence unless it is subject to an exemption.

2.3 Water Supply Works Approvals

All dams pipes, pumping stations and other water supply works which would ordinarily require water supply works approvals under the Water Management Act 2000 (Sections 89, 90 or 91) will be exempt if a project approval is granted under Part 4 of the EP&A Act (see section 89J EP&A Act). The impact and environmental issues relating to these elements are included in this assessment.

The Mine holds five Works Approvals and linked WAL's as set out in **Table 2**. Works Approvals 20WA201037 and 20WA201499 have linked WAL's granting access to up to 259 ML water (general security) annually from the Hunter Regulated River Water Source. Works Approvals 20WA209900 and 20WA209902 have linked WAL's granting access to up to 450 ML annually from the Singleton water source under the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (WSP). The rail loading point has access to 5 ML from the Glennies water source under the Hunter Unregulated and Alluvial Water Sources WSP via 20WA207389 and a linked WAL.

2.4 Excluded Works

Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice, or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, and which are located on a minor stream, are excluded works. Accordingly these dams are not required to be the subject of water supply works approval and there is no requirement for a WAL to take water and use water from them.

Table 2: Water Supply Approvals and Licences

Works Approval	Usage Approval	Water Access Licence	Works	Use	Water Sharing Plan and Source	Category	Share Component
20WA201037	20UA201038	11917	Diversion Works - Pumps	Irrigation	Hunter Regulated Water Sharing Plan - Hunter Regulated River	General	49.5
	20UA201039	11918					49.5
	20UA201040	11919					159
20WA201499	-	11084	Diversion Works - Pumps	Water Supply Works	Hunter Regulated Water Sharing Plan - Hunter Regulated River	General	1
20WA207389	-	17992	Diversion Works - Pumps	Water Supply Works	Hunter Unregulated and Alluvial Water Sources - Glennies	Unregulated River	5
20WA209900	-	19024	Diversion Works - Pumps	Water Supply Works	Hunter Unregulated and Alluvial Water Sources - Singleton	Unregulated River	150
20WA209902	-	19027	Diversion Works - Pumps	Water Supply Works	Hunter Unregulated and Alluvial Water Sources - Singleton	Unregulated River	300

2.5 Study Area

The study area consists of the proposed West Pit disturbance footprint and the existing areas of Rixs Creek Mine, essentially the same footprint as the Project Area – Refer **Figure 2**. Areas external to the study area are a potential pipeline route from the Hunter River to the Mine and the incorporation of an existing water supply work into the mining operation.

2.6 Background Information Review

2.6.1 Database Searches

The NSW Water Register maintained by NOW was searched to confirm currency, status and conditions for water licences and approvals issued to the Mine under the Water Management Act 2000 and the Water Act 1912.

2.6.2 Review of Surrounding Developments

The Integra Coal Mine open cut occupies the northern boundary of the Mine lease (CL 755). There are two aspects relating to Integra that are relevant to this study. Integra operates predominantly in the same coal seams as Rixs Creek and both mines have removed the coal along the northern boundary. Subsequently, there is a void immediately to the north of Rixs Creek boundary that must be accounted for in design and placement of surface water management structures. The removal of coal and overburden along the common boundary has left a competent barrier as high as 40mAHD. This is the practical limit to the height that which water can be stored in the sub-surface overburden inside the Rixs Creek lease.

The Integra Mine is under care and maintenance and it is uncertain what future developments of the landform in this area will be. This study assumes that there will be no change to conditions along the northern boundary.

2.6.3 Review of Baseline Data

Baseline data:

- Water quality monitoring data for the Rixs Creek Mine for the period January 1999 to March 2014 was sourced from Mr John Hindmarsh of Rixs Creek Mine in June 2014.
- Daily rainfall data for the Rixs Creek Mine for the period January 1999 to June 2014 was sourced from Mr John Hindmarsh of Rixs Creek Mine in June 2014.
- Water cart usage for Rixs Creek Mine for the period January 1999 to June 2014 was sourced from Mr Jason Desmond of Rixs Creek Mine in June 2014 in June 2014.
- Electronic copies of the mine plans (dxf format, 2014 to 2036), aerial photographs (2014 and historic), mine schedules were downloaded from the data room 'Project Rix's Creek Continuation of Mining' at www.ansarada.com (Ansarada Pty Ltd).
- Digital terrain models of the mine plans (DAT files) were provided by Mr Chris Moy of Rixs Creek Mine in May 2014

2.6.4 Preliminary Field Work

The following site inspections relevant to this study were performed at the Mine by staff from JP Environmental:

- An inspection and survey of the route of Rixs Creek and Stonequarry Gully for the purpose of a stream impact assessment.
- A site inspection of West Pit and the CHPP tailings dewatering system.

2.7 Method of Impact Assessment

2.7.1 Modelling

OPSIM Model

A computer based simulation model has been used to assess the dynamics of the mine water management system under conditions of varying rainfall and groundwater seepage rather than a simple wet and dry year water balance. The adopted approach provides a probabilistic outcome and is preferred to a simpler spread sheet based model as the latter cannot easily address varying catchment areas, varying groundwater seepage or rainfall runoff accumulations attributed to increasing soil moisture.

The OPSIM model develops a daily water balance for the mine site for wide ranging climatic conditions by utilising evaporation data and rainfall records to generate catchment runoff estimates. For the purposes of this study, synthetic daily rainfall and evaporation data for 125 years from 1 January 1889 to 31 December 2013 were used. A slightly smaller rainfall data set (1892 – 2013) is used when modelling discharges under the HRSTS because the available stream flow data for Singleton available for HRSTS modelling only extends from 1892 to date. The model provides for pumping and accumulation of mine water, transfer of mine water between dams, losses related to the CPP, dust suppression, HRSTS discharges etc.

Runoff from each of the catchments is calculated on a daily basis and distributed around the mine site according to the water management system described above. Daily water demands (including evaporation and losses to tailings) are then applied to the water storage facilities and a water balance calculated.

The OPSIM Model accepts multiple scenarios that describe different layouts of the water management system and can model these scenarios sequentially. Thus the configuration of the water management system can be varied to reflect changes to the water management system over time, modelling different sizes and layouts of catchments, pipelines, storages, tailings emplacements and ore processing plants, reflecting the progress of the mine plan.

The probabilistic inventory estimates calculated by the model can be compared to the water storage capacity available storage for each stage of the mine plan, allowing assessment of the overall mine water balance and, if required, the performance of individual elements of the site water management system.

Modelling Scenarios

The modelling assumed that there was no discharge of surplus water off site, i.e. no HRSTS discharge point was considered. Under this assumption, water is no longer pumped from the active mining area once the site water management system reaches its capacity. Consequently, mining operations may be impaired as water levels rise in the pit.

The OPSIM model was organised into 8 scenarios reflecting the mine configuration at 2014, 2017, 2020, 2023, 2026 and 2036, and two interpolated configurations at 2031 and 2033.

The scenarios for 2031 and 2033 model the catchment variation as mining transitions from open cut to underground mining and incorporate elements of the 2026 and 2036 mine plans. The 2031 and 2035 configurations were simple to construct without reference to a specific mine plan. It is understood that the underground portal does not form part of the Project; however it is included in the modelling scenarios to reflect the most likely scenario of continued mining after open cut reserves are exhausted. The model extends over 28 years from 2014 to 2041.

2.7.2 Assumptions

There are two assumptions made for the water balance modelling:

1. Past climatic conditions are representative of future climatic conditions.
2. The Project was modelled using synthesised climatic data from the SILO Data Drill service (Jeffrey et al. 2001). It is assumed that the synthetic rainfall records sourced from SILO are representative of conditions at the site. Refer **Appendix A Section A.3** for a justification of this assumption.

3.0 Existing Environment

3.1 Study Area

The Mine is located approximately 5km north-west of Singleton in the Hunter Coalfields (refer to **Figure 1: Regional Context** and **Figure 2: Project Area**).

The local landscape has been modified by mining of Permian coal measures at Rixs Creek Mine and at other mines to the north, including Integra Coal, Ashton Coal, and the Glencore Mt Owen Complex. These mines operate predominantly in the Vane Subgroup of coal measures that form the Wittingham Coal Measures. The regional landscape comprises undulating hills and sediment filled valleys.

The Mine uses open cut methods to mine coal in the Vane Subgroup at current depths of 40 to 90 m below surface in the area known as Pit 3 (West Pit). The mined coal seams include, in ascending order from the base of the coal measures the Hebden, Barrett, Liddell, Arties, Pikes Gully and Lemington Seams.

Extraction of coal was completed in South Pit (Pit 2) in 2003 and in North Pit (Pit 1) in early 2014. North Pit will be progressively backfilled and rehabilitated except for a dewatering sump to allow recovery of water that is proposed to be stored in a sump below the reconstructed landform. South Pit was used as a tailings emplacement from 2003 until mid-2014. Since then tailings placement has switched to a void in North Pit and South Pit is expected to be rehabilitated by 2017.

3.2 Regional Drainage Network

The regional drainage network in the area of interest is shown on **Figure 2**. The project area is located off the northern floodplain of the Hunter River, straddling the New England Highway. The Mine is situated predominantly in the Rixs Creek catchment which joins the Hunter River some 23 km upstream of the Singleton Gauge. The Hunter River has a catchment area of approximately 16,250 km to Rixs Creek. Two major tributaries, Glennies Creek and Wollombi Brook, drain into the Hunter River some 12.1 km and 5.4 km upstream of the Mine respectively. The total catchment area of the Hunter River at Singleton gauge, downstream, is 16,400km

The Hunter catchment extends some 100km to the north and 140km to the west and includes the major tributaries of the Pages River, Dart Brook and the Goulburn River. The Hunter River is a regulated river supplying water from Glenbawn Dam and Glennies Creek Dam to a range of industrial

and agricultural users as well as town water supplies. Glenbawn Dam is located on the upper headwaters of the Hunter River, approximately 46 km north north-west of the Mine, and Glennies Creek is about 21 km to the north east.

3.3 Local Drainage Network

The Mine lies off the Hunter River flood plain, mainly within the upper catchment of Rixs Creek. Smaller areas of land in the headwaters of Station Creek flowing to the north and an unnamed tributary of the Hunter River flowing to the west are also affected. The mine site is bounded by ridges on the north, east and western sides. These ridges define the catchment of Rixs Creek which flows southwards to the Hunter River. The local regional setting for the Mine is shown on **Figure 2**.

The majority of the Project Area (1355 ha or 67%) falls within the Rixs Creek catchment and drains south-west to the Hunter River. At the start of 2014 Rixs Creek catchment drained 1,986 ha of land. Prior to mining the Rixs Creek catchment drained some 2,562 ha of land. An unnamed tributary of the Hunter River occupies 498 ha (or 25%) of the Project Area and drains to the west. This unnamed catchment was originally 1,402 ha, and some 95 ha of this catchment is currently affected by mining. Station Creek catchment (2,413 ha) covers some 156 ha or 8% of the project Area. About 102 ha of the Station Creek catchment is affected by the existing Mine. A small 10 ha area at the north-west corner of the Project Area will not be affected by this mining proposal and it drains west into an unnamed tributary of the Hunter River. The watershed boundaries are shown on **Figure 4**

Rixs Creek is a 4th order stream where it joins the Hunter River, based on the Strahler system of stream order classification - **Figure 5**. The original channel of Rixs Creek was 4th order for 86% of its original length of 14.4 km, including at the point it crosses the southern Project Boundary. However the stream is ephemeral, effectively functioning as a lower order stream. Upstream of the New England Highway, the uppermost 4.4 km of Rixs Creek has been consumed by mining under the terms of the current Development Consent. The Unnamed Tributary draining to the West is a 3rd order stream where it crosses the Project Boundary and 4th order at the confluence with the Hunter River. This stream is also ephemeral, effectively functioning as a lower order stream. The streamlines crossing the northern boundary of the Project Area to join Station Creek are all 1st order streams.

Downstream of the New England Highway Rixs Creek is well defined and mostly unaffected by mining activity, except for two haul road culvert crossings. The stream has a well vegetated forest corridor from the New England Highway to the southern Project boundary, ranging from 50 to 180 metres wide. From the southern Project Boundary, south to the Maison Dieu Road the vegetative corridor narrows, with mostly scattered trees or pasture along the remaining reach to the Hunter River. The Unnamed

tributary passes through mostly scattered trees, except for a 2km section of the southern arm which passes through a light density timber regrowth area.

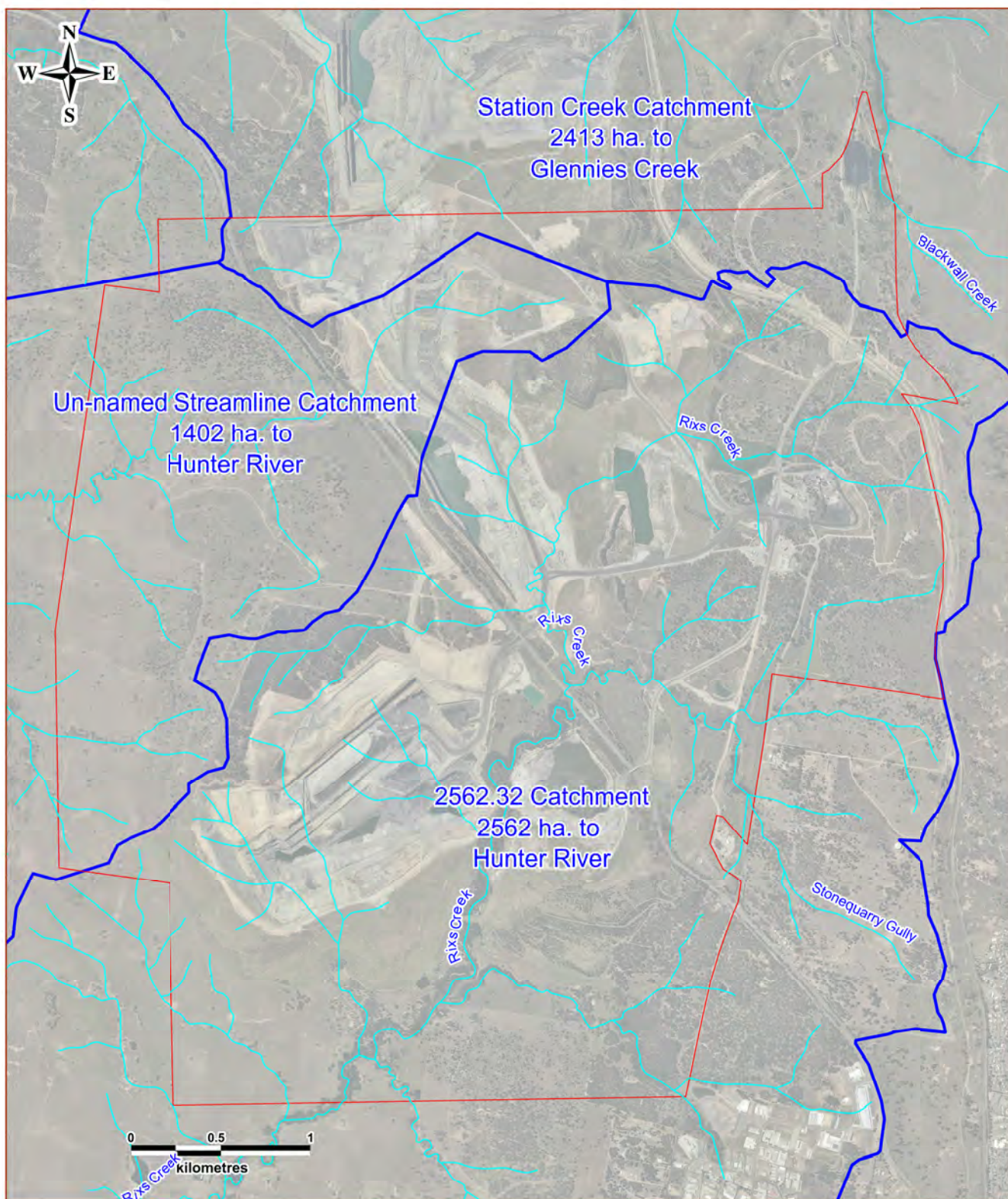
The existing Mine is not affected by Hunter River flooding. The toe of the lowest overburden emplacement is 17 metres above the top of the Hunter River bank where Rixs Creek joins the Hunter River, and the lowest point on the pit shell is 20 metres above the top of bank.

3.4 Climate

The regional climate is temperate. Rainfall occurs predominately in the summer months and, based on site records, averages about 697mm per annum. Regional rainfall gauging stations at Singleton Army Base and Jerrys Plains display similar seasonal patterns. Jerrys Plains is the nearest station with the most complete most complete long term record.

Evaporation data is available with the nearest monitoring location being Cessnock. However this location is influenced by coastal climate. A more representative site with an extensive record is Scone Research Station, 54km NNW of the Project. Monthly pan evaporation losses typically range from about 220mm in January to less than 50mm in July. Jerrys Plains, 20km to the west displays similar trends to Scone, however only a short period of data is available.

The last two and a half decades have witnessed variable but often below average annual rainfalls in the Upper Hunter region with mostly dry years occurring from 1991 to 1997 and 2002 to 2006. These periods equated to a persistent El Nino type climate that affected much of the south-eastern Pacific and east Australian region. Highly variable and sometimes extreme rainfalls can be attributed to the emergence of a La Nina period in late 1998, 2007 and again in 2010 to 2012. Each of these periods has led to local mines carrying excess stocks of stored water, and recharge of local shallow aquifer systems. The cyclic nature of these events is of the order of 3 to 5 years and current climate predictions support the re-emergence of an El Nino phase of generally below average rainfalls.

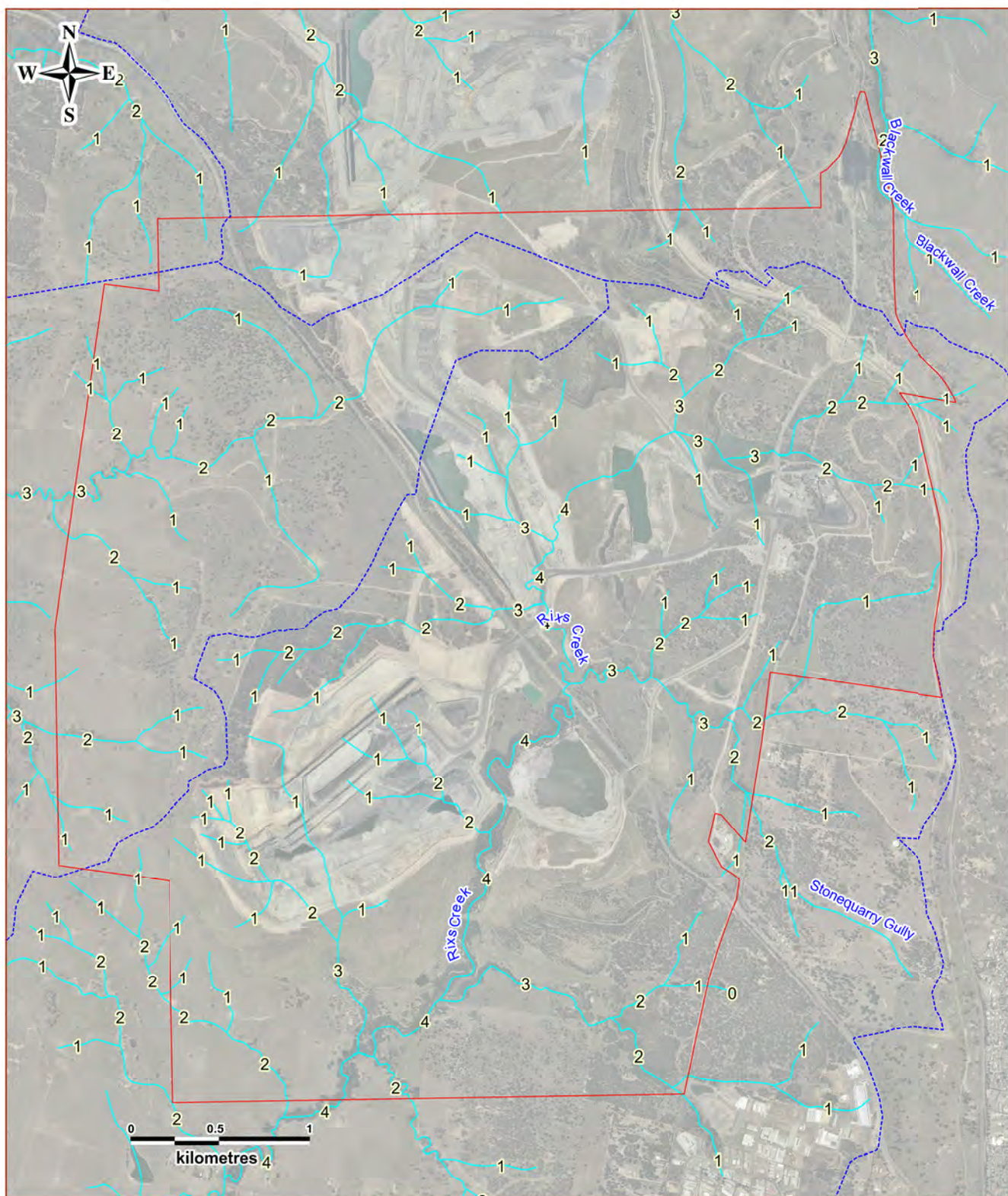


- Watershed Boundary
- Streamline
- Project Boundary

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**Surface Water Study for Rixs Creek
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Figure 4: Affected Watersheds: Pre-mining



- 4 Streamline and Ranking
- Watershed Boundary
- Project Boundary

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**Surface Water Study for Rixs Creek
Continuation of Mining**

Figure 5: Stream Rankings - Strahler

3.5 Rainfall and Evaporation

Table 3 shows summary details of Bureau of Meteorology (BOM) rainfall recording stations in the vicinity of the Mine, and the Rixs Creek Mine weather station. The locations of the various stations are shown in **Figure 3: Study Area**.

Table 3: Local Weather Stations

BOM Station Number	Name	Distance (km)	Elevation (m)	Easting (m)	Northing (m)
061086	Jerrys Plains Post Office	21	87	303,568	6,402,526
061371	Singleton Water Board	6	40	327,323	6,394,872
061397	Singleton STP	9	45	328,654	6,392,693
061275	Singleton Army Base	11	73	328,341	6,390,137
061089	Scone SCS	54	216	304,325	6,450,739
Not Applicable	Rixs Creek Mine	0	120	324,220	6,400,410

Table 4 shows mean monthly rainfalls for six nearby rainfall stations identified in **Table 3**. Note that the mean monthly values are based on different observation periods. The mean annual rainfall in the area of interest ranges from 645 to 720 mm. Maximum monthly rainfalls occur during the summer months. The maximum monthly rainfall occurs in February for stations that commenced operations after 1980 and in January at the other stations with longer observation records. **Table 4** also shows mean daily evaporation (Class A evaporation pan) recorded at Jerrys Plains Post Office (BOM Station No. 061086), and Scone Soil Conservation Service (BOM 061090). Mean annual evaporation at Jerrys Plains is 1643 mm, which is more than double mean annual rainfall at that station. Jerry Plains Post Office, the station with the longest record, has been adopted as the representative daily rainfall station for basic hydrologic calculations.

Figure 6 shows the annual distribution of average monthly rainfall and evaporation at Rixs Creek compared to the station with the longest period of records in the local area, Jerry Plains Post Office. Average monthly rainfall for Singleton Sewage Treatment Plant, a nearby station with a similar period of record to Rixs Cree is also graphed. Mean evaporation is similar to mean rainfall in the winter months, but substantially exceeds rainfall for the remainder of the year.

Table 4: Rainfall and Evaporation

Statistics			Mean Monthly Rainfall (mm)					Mean Daily Evaporation (mm)		
Station	Jerrys Plains Post Office		Scone SCS		Singleton Water Board	Singleton STP	Singleton Army Base	Rixs Creek Mine	Jerrys Plains PO	Scone SCS
	(061086)		(061090)		(061086)	(061398)	(061276)	N/A	(061089)	
Period	1889 -	1980 - 2010	1950 - 2014	1981 - 2010	1991 -	2002 -	1969 - 1990	1999 -	1957 - 1972	1965 -
Record Length	128 yr	30 yr	65 yr	30 yr	11 yr	13 yr	21 yr	13 yr	10 yr	45 yr
January	77.1	71.8	81.3	63.9	70.2	50.8	94.3	46.5	7.1	7.1
February	73.1	86.8	76.9	67.5	107.6	105.1	88.9	111.2	6	6.2
March	59.7	55	52.9	49.6	75.1	66.1	72.7	94.0	5	4.9
April	44	45.9	38.8	38.7	38.3	43	58.4	53.7	4	3.5
May	40.7	41.3	46	40.6	35.4	28.5	59.7	36.5	2.9	2.2
June	48.1	43.1	45.3	40.2	31.7	69.8	37.9	66.6	2	1.6
July	43.4	43.6	36.5	44.3	41.7	26.8	28.2	27.6	2.3	1.8
August	36.1	37.2	38.3	36.6	27.6	30.9	37.1	30.6	2.6	2.7
September	41.7	46.3	38.3	41.4	44.1	39.4	45.3	35.9	3.7	4
October	51.9	56.9	57.8	55	32.8	45.6	69.1	46.2	5.3	5.1
November	61.9	76.4	63.5	68.5	59.2	89.1	68.3	85.4	6.5	6.1
December	67.5	73.8	67.2	78	86.6	63.7	63	58.1	6.6	7.1
Annual	645	678	642	624	645	661	720	661	4.5	4.4

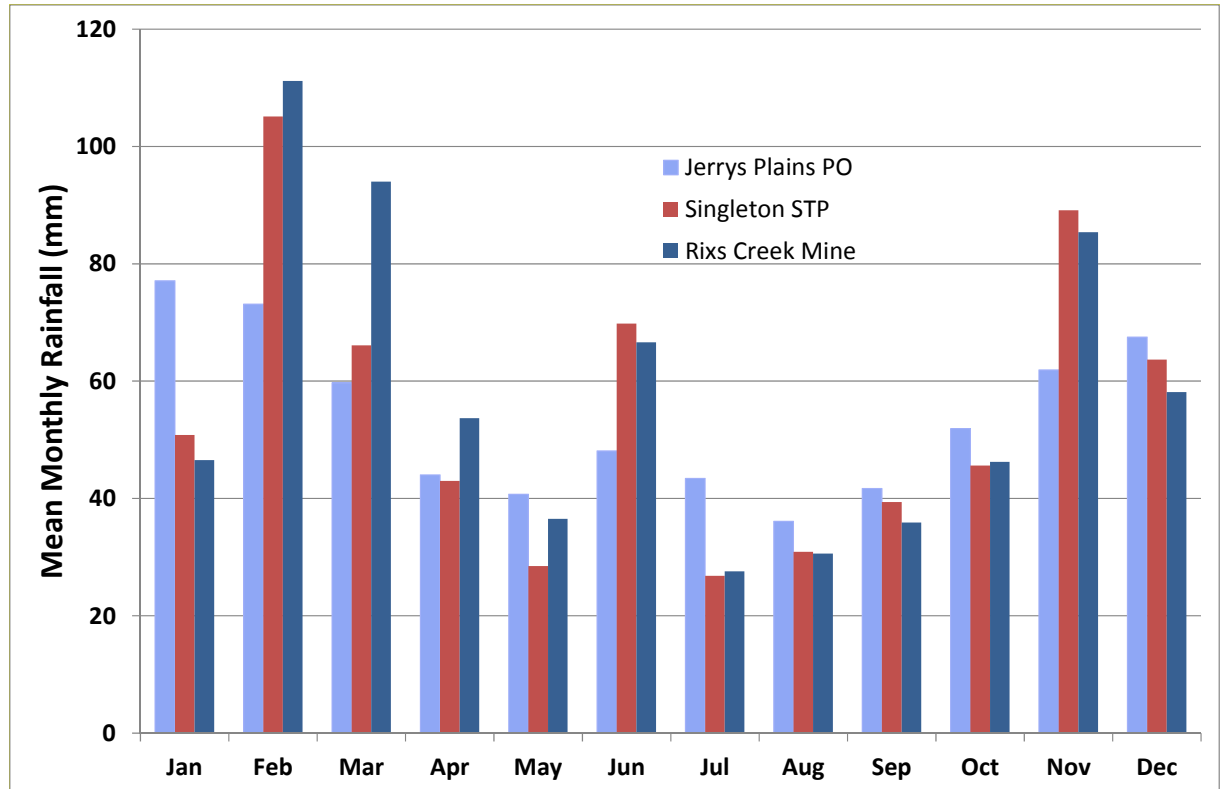


Figure 6: Comparison of Rainfall Records

3.6 Rixs Creek

3.6.1 Hydrology

Methodology

Modelling was generally conducted at three locations within the Rixs Creek catchment. The modelling locations are detailed in **Table 5: Modelled Catchment Node Areas and Locations**, and are shown on **Figure 7**.

Peak discharges within the catchment were determined at locations set out in **Table 5** for the 1, 2, 5, 10 and 100 year Average Recurrence Interval (ARI) rainfall intensities using the Probabilistic Rational Method as detailed in Australian Rainfall and Runoff Volumes 1 and 2 (1987). Rainfall intensity-frequency-duration (IFD) data for the area around RXC was generated by the method described in AR&R [1] (1987). The Probabilistic Rational Method was developed to apply to rural catchments, and here is being applied to modified rural catchments that contain some mature rehabilitated surfaces. Nevertheless it is considered suitable for the purpose of providing scale and comparison.

Table 5: Modelled Catchment Node Areas and Locations

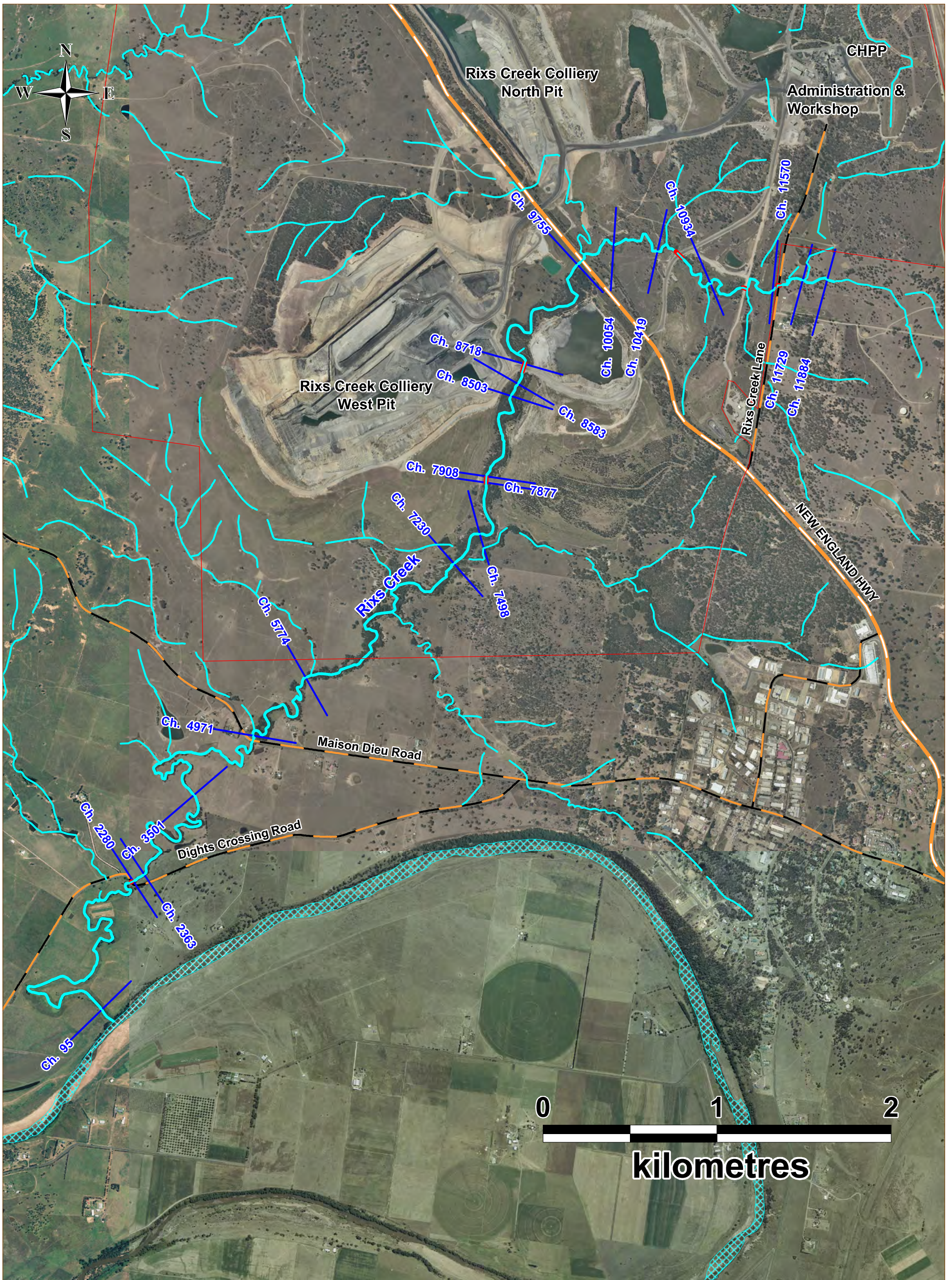
Location (Chainage [m])	Pre-mine Catchment Area (ha)	Current Catchment Area (ha)	Node Location
11730	139	201	Confluence with the clean catchment diversion.
7250	1522	1087	RXC monitoring Point described as "Below Operation".
00	2562	1986	Confluence with Hunter River.

Note: Areas shown are cumulative, moving down the catchment.

The current overall catchment area for Rixs Creek has reduced due to mining activity when compared to the original. At chainage 11730 in the upper part of Rixs Creek, the catchment area reporting to Stonequarry Gully has increased by 53% due to a clean water diversion that joins the Gully at this point. Flow rates will be elevated above Pre-Mining levels despite the retarding effect of Clean Water Dam 6. The influence of the clean water diversion on flow and total runoff in the natural stream would extend as far as the New England Highway where Stonequarry Gully joins Rixs Creek.

Peak Flow Estimates

Peak flows at the three locations of interest in the Rixs Creek catchment are summarised in **Table 6: Indicative Peak Flow – Probabilistic Rational Method**. The peak flow at each location for the Pre-Mine and the Current Catchment (mining affected) were estimated for the 1, 2, 5, 10 and 100 year ARI rainfall.



Legend

- Major Road
- Minor Road
- Rixs Creek
- Reference Creek Cross Section
- Culvert
- Project Area

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Figure 7: Rixs Creek Channel: Reference Cross Sections

Peak flows in Stonequarry Gully at the confluence with the existing clean catchment diversion (Ch. 11730) are already 40% higher than Pre-Mining levels due to the increased catchment reporting from the existing clean water diversion drain. At Ch. 7250, Below Operations, the reduced mining catchment area has depressed the estimated peak flows in the Creek to about 78% of the Pre-Mine values. At the confluence with the Hunter River Ch. 00 the reduced mining catchment area has lowered the estimated peak flows in the Creek from the Current Catchment to about 83% of the Pre-Mine values.

Table 6: Indicative Peak Flow – Probabalistic Rational Method

ARI	Details	Unit	Ch. 11730 ¹	Ch. 7250	Ch. 00
1	Pre-Mine Catchment	m ³ /s	1.0	5.9	8.7
	Current Catchment	m ³ /s	1.4	4.6	7.3
	Effect of Changed Catchment Area on Peak Flow	%	140%	78%	83%
2	Pre-Mine Catchment	m ³ /s	1.5	9.1	13.4
	Current Catchment	m ³ /s	2.1	7.1	11.1
	Effect of Changed Catchment Area on Peak Flow	%	139%	78%	83%
5	Pre-Mine Catchment	m ³ /s	2.2	13.8	20.4
	Current Catchment	m ³ /s	3.1	10.7	16.9
	Effect of Changed Catchment Area on Peak Flow	%	139%	78%	83%
10	Pre-Mine Catchment	m ³ /s	2.9	17.7	26.2
	Current Catchment	m ³ /s	4.0	13.7	21.6
	Effect of Changed Catchment Area on Peak Flow	%	139%	78%	83%
100	Pre-Mine Catchment	m ³ /s	6.2	38.7	57.6
	Current Catchment	m ³ /s	8.7	30.0	47.5
	Effect of Changed Catchment Area on Peak Flow	%	139%	77%	82%

Note: At the completion of mining, the catchment at the Hunter River will be only 4% less in area than the original Rixs Creek catchment. The current Rixs Creek catchment is likely to be the minimum catchment size over the mine life.

Environmental Flows

Modelling indicates that Rixs Creek is ephemeral with water flowing in the creek 40 – 60% of the time depending on the location in the reach. At the location “Below Operations”, Site 10 on the Monitoring Plans **Figure 14** and **Figure 44**, the flow regime can be summarised:

- The stream flow rate is zero 44% of the time.
- At a flow rate of about 2.5 l/s (0.2 ML/day), flow is dominated by groundwater accession i.e. base flow. This flow rate occurs about 6% of the time.

¹ Any retarding effect of Dam 6 not considered.

- Above 2.5 l/s surface runoff begins to influence flow rate.
- Assuming that the base flow is of elevated salinity, a suitable flushing flow might be about 10 l/s which would occur a little less than 5% of the time.

Rather than an environmental flow, there appears to be 3 distinct flow regimes operating in Rixs Creek. The predominant flow condition is dry, potentially creating its own habitat in and adjacent to the riverbed. Trickle and base flow with potentially elevated salinity provides another habitat, keeping pools full. Larger, freshwater flows flushing out nutrients and sediment; and moving litter and organic matter into the stream bed provides an environmental service but is not necessarily the dominant or most important flow regime, occurring only 5% of the time.

3.6.2 Geomorphology

A geomorphologic review of the existing watercourse has been done to examine the condition of the Rixs Creek catchment and consider potential impacts due to mining activity.

Field inspections of Rixs Creek were undertaken in October 2013 by JP Environmental for a separate study to the current study. Some 21 representative cross sections were surveyed for modelling purposes. Typical cross sections and photographs from the inspections of the Rixs Creek system are included in **Appendix C**.

The River Styles® in the Hunter Catchment Report (DNR 2006) states: “The Hunter region was among one of the first areas in NSW to be settled by Europeans and is also one of the most degraded of the coastal catchments. Historical records have documented the extent of clearing along riverbanks and floodplains within the region. They also highlight the changes in flooding regimes and the form and morphology of the Hunter River and its tributaries (Raine and Gardiner 1995).”

The history of the Rixs Creek catchment typifies the above statement having been cleared and impacted by mining, quarrying and agricultural activity in the 19th, 20th and 21st centuries.



Figure 8: Erosion Rixs Creek Circa 1906 (National Library of Australia)



Figure 9: Coal Mine at Rixs Creek Circa 1906 (National Library of Australia)



Figure 10: Coke Ovens Rixs Creek Circa 1906 (National Library of Australia)



Figure 11: Coke Ovens at Rixs Creek Circa 2013

Geomorphology Assessment Methodology

The stability of the Rixs Creek discharge channel bed and banks was assessed by considering peak flows and velocities within the discharge channel for the natural, current and proposed catchment flow regimes.

The susceptibility of the soil type to entrainment and the likelihood of a change in the natural channel flow regime as a result of the increased flow frequency are discussed here.

The assessment of the geomorphology of Rixs Creek discharge channel utilised the following:

- Consideration of the River Styles[®] Report 2006
- Discharge channel (creek) bed soil inspection and geomorphology review; and
- Hydraulic modelling.

Geomorphological Values

The primary geomorphological value to be considered is a stable stream section with riparian vegetation that acts as a filter and influences the stream itself by modifying the flow pattern by fallen

trees and branches. The stream and riparian corridor will then provide habitat necessary for a well established aquatic community which promotes nutrient removal to maintain water quality.

Existing Creek Characteristics

The River Styles[®] Report was prepared to “help the Hunter-Central River Catchment Management Authority develop proactive management strategies that more effectively prioritise the allocation of resources to specific management issues.....based on geomorphological understanding of stream processes, evolution and timeframe. The Department of Natural Resources will utilise the information to prioritise compliance actions.....as well as utilise the information when assessing licence applications. This reference is more than 10 years old, and work is under way within DPI NSW Water to revise and improve the document.

The River Styles[®] Report reviewed Rixs Creek and the Unnamed Tributary which flow generally eastwards through the Project Area to the Hunter River. The report categorises the lower reaches of each stream as Planform Controlled, Meandering, Gravel (PCVS) and the upper reaches as Cut and Fill (CVS DC). A section of Rixs Creek at the Hunter River was classified as a Confluence Wetland (CUV DC). The condition of Rixs Creek was mapped as being of Poor Geomorphic Condition extending from Maison Dieu Road upstream to the headwater of the Creek, and the reach downstream from Maison Dieu Road to the Hunter River was mapped as being of Moderate Geomorphic Condition – refer **Figure 12** and **Figure 13**. Both streams are mapped as having moderate recovery potential.

PCVS: This style of stream generally comprises a single, continuous, asymmetric channel although this may differ depending upon the condition. These reaches have variable width and depth with channel width and depth highly dependent on streambed stability and the process of incision and channel widening. The channel itself generally has a low gradient with a sinuous planform. Some lower gradient areas are highly sinuous, that is the ratio of channel length to valley length is much greater than 1.3. Channel meanders are often asymmetric in shape. The channel tends to have a high amount of lateral and vertical stability due to the cohesive fine-grained sediments within the streambanks and the bedrock steps controlling channel incision. There are few robust natural controls on this River Style; however road crossings, culverts and bedrock steps where they exist, provide a large amount of vertical control to the streambed of this Style.

CUV DC: Reaches with the Cut and Fill Style naturally go through phases of cutting and filling. Reaches that are incised / entrenched over part of their length (cutting phase) tend to be compound in channel geometry while the filled reaches have an undefined channel (where the whole valley is the channel (intact / filled phase). Often incision will occur down to natural bedrock steps with channel

depth and width highly variable. The channel bed is generally uniform / homogeneous although there are the occasional scour features and instream deposits downstream of head cuts. Lateral stability is variable, but generally stable due to the low gradients. Lateral movement is a consequence of vertical movement (incision or accretion) of the streambed.

Field Work

Field inspections and survey of Rixs Creek were undertaken in October 2013. Some 21 representative cross sections were surveyed for modelling purposes. Typical cross sections and photographs from the inspections of the Rixs Creek system are included in **Appendix C**.

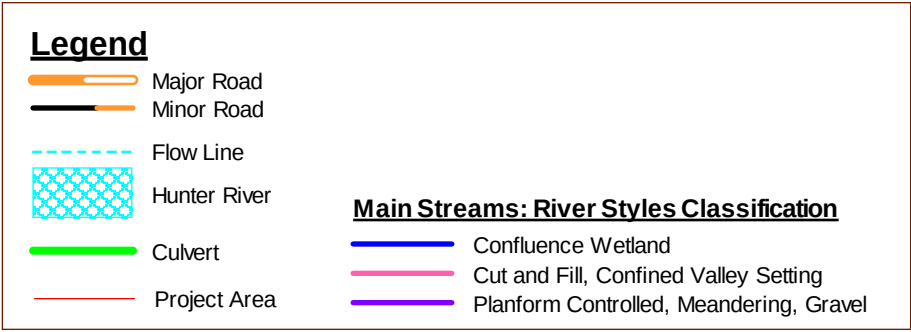
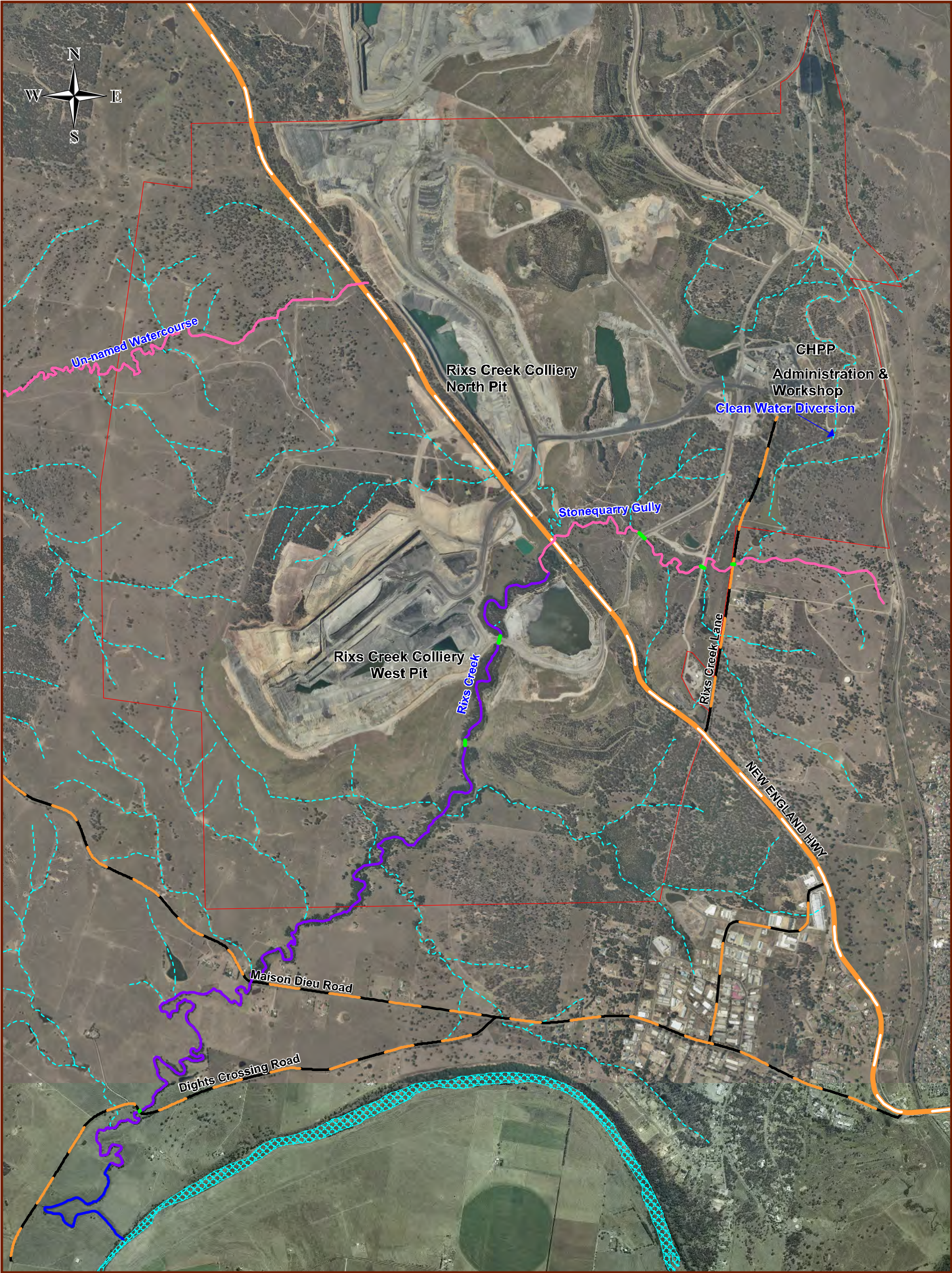
The following observations were made:

- Stonequarry Gully and Rixs Creek are essentially ephemeral streams. Rixs Creek extends from the Hunter River upstream to the New England Highway – see **Figure 12 and Figure 13**. Above the New England Highway Rixs Creek has been mined out. Stonequarry Gully drains the unmined section of the Rixs Creek catchment above the New England Highway to the north east. Both Creeks were not flowing and the bed was predominately dry at the time of inspection with only small pools of stagnant water present within the upper reaches. Water monitoring data indicates Rixs Creek does not flow for around 8 months of the year, i.e. “No Flow” records are reported about 2/3 of the time in monthly water quality data collected since 1999. No statistical analysis was done of the time distribution of flows, but by inspection there is no apparent seasonality to the data that would justify describing these streams as intermittent. These observations are at odds with the “Hydrolines” mapping data obtained from Lands NSW which classifies Rixs Creek downstream of the New England Highway as perennial.
- The bed and bank material in the upper and middle reach of Stonequarry Gully is typically yellow brown silty clay over grey silty clay. The soils would be at best mildly dispersive. Sandstone is exposed in the bed over several short sections. The middle reaches of Stonequarry Gully were extensively disturbed by coal mining in the early 20th century and the stream has deviated from the natural route in several places. Vegetation along the stream is characterised by salt tolerant spiny rush, which appears to be resisting erosion. Stream cutback was occurring at several locations including culverts. The land adjacent to the stream is lightly wooded and there is no riparian zone. The upper reach was heavily grazed on the date of inspection with significant proportion of soil surface exposed. Sandstone boulders are exposed in the bed over several short sections. Overall the geomorphic condition of the stream is poor.
- The bank material in the lower reach of Stonequarry Gully is typically grey silty loam topsoil 0.1 – 0.2 m thick over yellow brown silty clay. The bed material is typically brown silty clay, however sandstone boulders were observed closer to the highway. Tree density and age along

this reach is higher than in the upper and middle reaches of the Gully and the banks are generally well vegetated above the regularly wetted perimeter. The riparian zone is poorly developed, general between 1 – 3 trees wide. The stream is active, cutting into the bank at several locations on outer bends and there is a head cut in the vicinity of the old coke ovens. Overall the geomorphic condition of the stream is poor.

- The upper reach of Rixs Creek extends from the New England Highway to just downstream of the mining operation, a stream distance of around 2.5 kilometres. The upper 150 metres or so of the Creek has been straightened during a past highway culvert installation, and although well grassed shows signs of active erosion (scarping) of the embankments. The upper 150 metre has no tree coverage on the banks at all. The stream bed is characterised by reaches of grey silty loam alternating with near horizontal layers of sandstone or jumbled boulders. One section of sandstone bed extended for 350 metres. There are regular nick points in the rock channel, with shelf drops ranging in from 0.2 metres to 0.8 metres, however there are no sills that provide ponding. The banks consist of mainly grey silty clays with sand and a loamy texture. Except for the diversion below the highway, the stream banks and floodplains are densely wooded (mainly casuarina regrowth) and well vegetated, with trunk diameters regularly exceeding 100 mm. There is evidence of bank vegetation encouraging deposition at the bank toe, allowing colonising vegetation to encroach further into the channel, especially in the sections constrained by the rock bed.. Woody debris, some large, is collecting in the channel in this reach. The total width of the riparian zone generally exceeded 50 metres, often reaching 80 metres, with two pinch points at culverts installed for mining.
- The middle reach of Rixs Creek extends to just short of the Maison Dieu Road bridge crossing. The bed is characterised by reaches of brown clayey loam and the banks consist of mainly grey sandy clays, probably colluvium. The bank vegetation transitions downstream from densely wooded younger trees on well grassed banks (on land managed by Rixs Creek Coal) to more widely spaced mature trees closer to Maison Dieu Road. The downstream sections outside the mining area are grazed, the bank vegetation cover is generally good, but there is evidence of damage from stock movements up and down the bank.
- The lower reach of Rixs Creek crosses the Hunter River floodplain. The banks and bed generally consist of grey-brown clayey silts. The tree cover on the banks of the middle half of the reach consists of medium density mature trees which do not extend out past the banks, whilst the remainder of the reach is sparsely populated. The banks are well grassed. Most banks show evidence of shaping by stock movement. Larger permanent pools became more prevalent in the lower reaches south of Dights Crossing
- Vegetation on and adjacent to the banks, including trees and grasses characterise the more stable sections of the channel, with areas denuded of vegetation being the key indicator of more unstable sections.

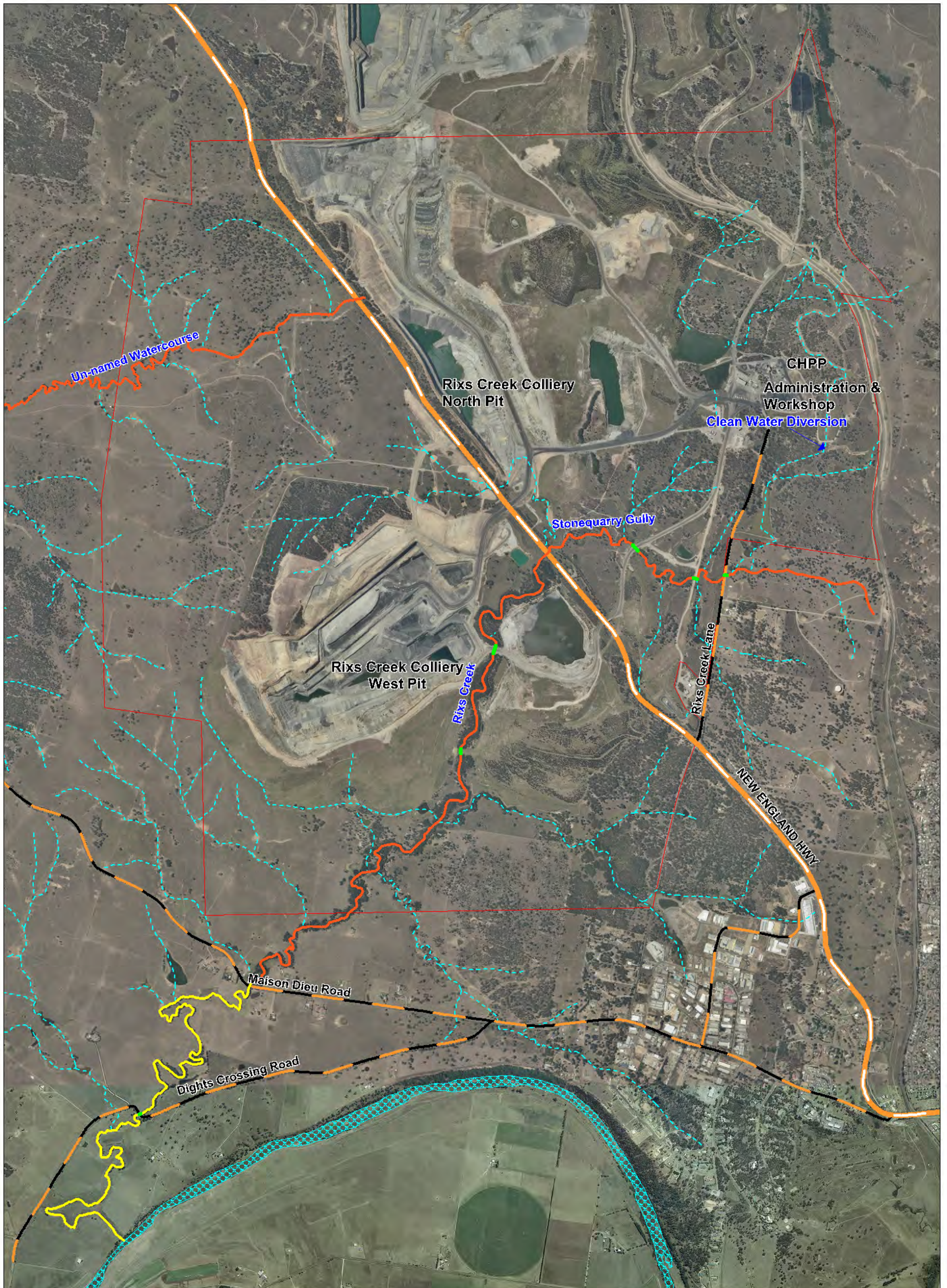
- The typical channel shape is a trapezoidal shaped cross-section with relatively steep side slopes. Reaches with U-shaped sections and relatively wide floodplains are indicative of more stable creek sections, and confined or incised sections indicate more unstable creek sections.
- Evidence of scour was observed primarily along Stonequarry Gully in the middle and upper reaches immediately downstream of the proposed dam DW3. Rixs Creek had only minor areas of bank instability identified during the field inspections with the exception of short section downstream of the New England Highway.



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Figure 12: Main Streams: River Style Categories



Legend

- Major Road
- Minor Road
- Stream Line
- ▤ Hunter River

Main Stream Geomorphic Condition

- Culvert
- Project Area
- MODERATE
- POOR

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Figure 13: Main Streams: Geomorphic Condition

Stream Stability Indicators

Thresholds for velocity, tractive stress and stream power thresholds were selected based on visual observations during the field inspections, hydraulic modelling and reference sources. Typical, widely adopted specific stream power (SSP) thresholds are summarised in **Table 7**. These quantitative values are based on work by Brookes (1983, 1987) on channelised perennial, gravel bed streams in Denmark, England and Wales.

Table 7: Typical Quantitative Stream Stability Thresholds

Bed Material or Vegetative Cover	Velocity (m/s) ²	Tractive Stress ¹¹ (N/s ²)	Stream Power ³ (W/m ²)
Firm loam	0.76	3.59	35
Stiff Clay	1.4	12.45	35
Alluvial silt (colloidal)	1.14	12.45	35
Short native and bunch grasses	1.22	45.49	35
Long native grasses	1.83	81.4	35
All substrate types	-	-	0.1<SSP<130 ⁴

Brookes concluded that when a stream has enlarged to the point that it has a SSP below 35Wm⁻², then the major phase of erosion is over. This 35Wm⁻² threshold has been widely applied in stream rehabilitation work as it provides a neat target for waterway design and assessment. For example, the measure appears prominently in the influential stream restoration book edited by Brookes and Shields (1996). It has also been used in Australia, Japan and the USA.

Stacey (2007) reviewed data from 1,279 streams with both stable and unstable profiles in the USA to test whether the accepted SSP of 35Wm⁻² (Brookes) discriminates between stable and unstable stream reaches, i.e. unstable sites would have stream powers above 35Wm⁻² while stable sites would have stream powers below. No such threshold of stability was found to exist. Furthermore, the difference between mean SSP at stable and unstable sites of all substrates was not significant. SSP's were generally within the range of 10 to 50Wm⁻² although several values were substantially higher (up to 130 Wm⁻²) or lower (0.1 Wm⁻²) than this range. In short, the values proposed by Fischenich for velocity and tractive stress and the stream power values proposed by Stacey were adopted for this study.

² Source Fischenich, 2001

³ Source: Brookes and Shields, 1996

⁴ Stacey 2007

3.6.3 Hydraulics

Hydraulic Values

The hydraulic capacity of the creek should be such that excessive erosion does not occur, thus promoting sedimentation and turbidity of flow.

Hydraulic Modelling Assumptions

Data for selected cross sections is presented in **Table 8**. The surveyed cross sections and photographs are included in **Appendix C**. The HEC RAS 2D model was used to assess the stream performance based on the surveyed cross sections.

Flow Regime

Normal flow regime was assumed to occur within the channel for the purpose of estimating velocities. Backwater effects from the Hunter River under High Flow and Flood Flow conditions were considered. The backwater effects tended to only affect sections below Dights Crossing Road.

Cross Section Geometry

Some 16 creek cross sections were surveyed with a GPS during field inspections. Cross sections detailed the defined creek line geometry and overbank regions which varied considerably.

Cross sections were interpolated as required for inclusion in the HEC RAS model. The interpolated sections were based on additional survey points taken in the stream bed, and using 2 metre contour data sourced from RXC and Lands NSW.

Energy Loss Coefficients

Manning's 'n' value for friction losses for each channel cross section were set based on observations and photographs taken during 2 days of field inspections. Multiple Manning's values were set for each cross section in HEC RAS to reflect variations in substrate and vegetation.

Hydraulic Calculations

The critical hydraulic indicators of stream stability are summarised in **Table 8**. **Table 8** supports field inspection assumptions of risk of erosion between Rixs Creek Lane and the location of the proposed discharge. The yellow shaded cells indicate where indicator values are close to or outside the

adopted acceptable range of Stream Stability Thresholds. When all three indicators exceed acceptable values a high risk of erosion is indicated.

Table 8: Geomorphological Impacts

Location	Creek Chainage	Flow	Shear	Specific Stream Power	Average Velocity
		(m ³ /s)	(N/m ²)	(W/m ²)	(m/s)
		Bank Full			
Headwater	11729	1.6	112.85	198.93	1.76
Near Highway	10054	5.5	172.57	396.18	2.3
Below Workings	7246	10.7	47.52	39.51	0.78
Maison Dieu Rd	4971	11.6	30.78	49.1	1.6
Near Hunter River	95	16.0	24.49	35.52	1.45

Culverts

The locations of culverts are shown on **Figure 7**.

Hydraulic analysis indicates that the culvert on Rixs Creek Lane at Ch. 11570 is likely to be overtopped during discharges exceeding about 2.3 m³/s. A stilling pond has scoured out at the downstream end of this culvert.

Culverts at Ch. 8718 and Ch. 7908 in the upper reach of Rixs Creek provide habitat for *Hirundo ariel* (Fairy Martin) and a number of microbat species. Hydraulic calculations indicate that at both of these culverts, the barrels flow full at a stream flow of about 10.7 m³/s; approximately a 1 in 5 year ARI flood based on current mining reduced catchments. Refer **Appendix C - Figure 18: Cross Section Chainage 8718**; and **Appendix C - Figure 21: Cross Section Chainage 7908** for culvert details. Channel conditions downstream of each of these culverts was good, with little scour. One barrel of the culvert at Chainage 7908 was silted to 2/3 barrel at the downstream end.

Travel Time to River

An average velocity of 1.1m/s was assumed after examination of HEC RAS outputs for bank full flow. The travel time over the 11,924m reach in a wet channel is estimated at 181 minutes, or 3 hours.

Impacts and Mitigation

Erosion impacts will most likely be worsening of existing scours and generation of new scour. The impacts will most likely occur in the “at risk” areas identified in **Table 8**.

An Erosion and Sediment Control Plan (ESCP) already exists for Rixs Creek. The following measures should be considered for inclusion within the plan to minimise the potential impacts of water discharges into the creek:

- Repair the areas of existing erosion and scour as identified in **Table 9** to control future erosion.
- Inspection of erosion controls and the identified “at risk” reaches of the channel should be undertaken after significant flow events to ensure their erosion does not develop or accelerate. Should adverse erosion impacts from mine water flows be identified, these should be included within the site erosion and sediment control plan identifying suitable management options.
- The ESCP should describe proposed erosion monitoring measures and frequency.

Table 9: Actions at Existing Erosion Locations

Location	Action
Chainage 11729 - 11884	Monitor and act as required by the site ESCP. Some erosion may be outside RXC managed land.
Chainage 11570	Stabilise the existing erosion immediately downstream of the culvert at Rixs Creek Lane. Then monitor and act as required by the site ESCP.
Chainage 10934 Coke Ovens	Stabilise the existing erosion at this location – head cut. Then monitor and act as required by the site ESCP.
Chainage 10419	Monitor the existing left batter scour at this location. Act as required by the upgraded ESCP.
Chainage 9755 New England Highway	Monitor the existing left and right batter scour (on RXC land) at this location. Act as required by the upgraded ESCP.

3.6.4 Ecology

Introduction

Advitech Environmental was engaged by JP Environmental in 2013 to prepare an Ecological Impact Assessment to address aquatic and terrestrial impacts that may arise as a result of proposed mine water discharges into Rixs Creek. However it is valid to reference this report for discussions in this section.

The full report is “Rixs Creek - Ecological Impact Assessment”, Revision: 0 (Final), Date: 11 December 2013, included as **Appendix F**.

Potential Impacts

The potential impacts discussed here are based on a desktop assessment of the study area and field investigations. Potential impacts to ecological values (flora, fauna and vegetation communities) as a result of the proposed works may include the following.

Modification of Riparian Vegetation

Where present, the native riparian vegetation in the upper reaches of Rixs Creek (Stonequarry Gully, north of the New England Highway) is predominantly composed of remnant or regrowth Central Hunter Ironbark – Spotted Gum – Grey Box Forest, an endangered ecological community. Any increased quantity and frequency of saline flows into the upper reaches may create conditions more suited to the Swamp Oak community which is common downstream. This may see the Swamp Oak community extend further upstream over time.

Stock has been excluded from the reach of Rixs Creek that passes through the operating mine. The stream section below the New England Highway has experienced extensive regrowth of the Swamp Oak community to such an extent that the stream banks are protected against erosion; woody debris is accumulating in the stream bed and the stream banks are accreting sediment which is then stabilised by vegetation.

Culvert Flooding

The flooding of culverts along Rixs Creek has the potential to impact on species that may roost or nest in the culvert such as *Hirundo Ariel* (Fairy Martin) and a number of microbat species. This may result in species utilising the culvert to temporarily vacate during flooding events with increased the risk of nestling mortality if culverts are fully submerged. As noted in C1.4.4 this event corresponds to a 1 in 5

year ARI flood based on existing catchment sizes. The flood frequency would marginally increase as catchments are re-instated. The risk of a 1 in 5 year flood coinciding with nesting seasons is considered low and no ameliorative actions are proposed. It is expected that roosting microbats would also vacate the culvert long before flood water posed a danger.

Weeds

The movement of soil by increased water flows and the disturbance of soil from consequent erosion can lead to further weed infestation within the study area. Increased weed growth often results in decreased native diversity and can further degrade local native flora and fauna habitats.

Erosion

Unstable creek banks have the potential to increase erosion within the riparian zone, particularly in areas with minimal vegetation or. During flood events there is potential to wash away disturbed and unstable soils resulting in sedimentation and periods of increased turbidity.

Aquatic Impacts

Rixs Creek is already subject to high levels of disturbance from surrounding land uses. Potential impacts are from increased turbidity and sedimentation due to erosion and increases to pH and average salinity.

The remnant vegetation that occurs along discharge channel and at the Hunter River is already tolerant to salinity levels; and due to the intermittent nature of natural runoff flows in the creek is more likely to be sourcing water from groundwater or soil moisture from more frequent rainfall. Increasing salinity is considered unlikely to affect the plant composition or structure downstream in Rixs Creek.

In general, the macroinvertebrate assessment confirms that Rixs Creek is subject to high levels of disturbance with pollutant sensitive invertebrates mostly absent. The number and diversity of invertebrates tended to increase downstream and this is likely to be related to the availability of larger pools and permanent water.

Salinity within Rixs Creek tends to vary significantly depending on the testing location and prevailing rainfall conditions. Mine water currently stored within the dams on site has, on average, significantly higher salinity levels and slightly higher pH. Whilst water quality within Rixs Creek is generally poor, there is potential that any uncontrolled mine water discharges may further decrease water quality with

increased salinity levels, potentially impacting upon aquatic biodiversity. However, this impact is unlikely to be significant given that invertebrates within the creek must be well adapted to moderately saline and variable environments.

Actions and Mitigation

The following mitigation measures are recommended to minimise further ecological impacts on Rixs Creek:

Creek Protection

An erosion and sediment control plan already exists for Rixs Creek. The following measures should be considered for inclusion within the plan to minimise the potential impacts of water discharges into the creek:

- Inspection of erosion controls (**Table 9**) should be undertaken after significant flow events to ensure their effectiveness is maintained. Should adverse erosion impacts from water flows be identified, these should be included within the site erosion and sediment control plan identifying suitable management options.
- Promote the re-establishment of the riparian corridor of streams crossing the project area and passing through land owned or managed by Rixs Creek Coal. This applies equally to Rixs Creek and the Unnamed Tributary to the north of the Project Area. The primary method suggested is natural regeneration by excluding stock, which has proven successful for the Rixs Creek reach below the New England Highway. Consult with DPI Water NSW to trial the establishment of sills in Rixs Creek to promote in stream ponding as habitat.
- Establish a survey regime for the riparian zones as an analogue for stream recovery e.g. number of stems exceeding 100 or 150mm diameter. Establish a photographic record of recovery at selected stream locations.
- Any riparian revegetation works should utilise native species (trees, shrubs and ground cover) characteristic of local vegetation communities found along Rixs Creek. Suitable species for replanting are described in the Flora Species List in the full ecology report for Rixs Creek attached as **Appendix F**.

Fauna Protection

No recommendations regarding protection of shelter at culverts. Consideration should be given to retaining the culverts post mining to provide ongoing habitat.

3.7 Existing Surface Water Quality

The existing water quality monitoring locations are shown on **Figure 14**. Water quality monitoring data collected for the Mine since 1999 is summarised in **Table 10** and presented graphically on **Figure 15** to **Figure 17**.

The Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have prepared a guideline for water quality management for use throughout Australia and New Zealand based on the philosophy of ecologically sustainable development (ESD). The guideline is called the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) and is often referred to as the 'ANZECC guideline'.

The NSW Department of Environment and Heritage issues a booklet titled Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC, 2006) to assist technical practitioners with applying the ANZECC guidelines in NSW (the NSW guideline).

The NSW guideline defines the 'environmental values' of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem. The environmental values of the receiving waters of the Hunter River are regarded as:

- Aquatic ecosystem;
- Irrigation water supply;
- Livestock water supply;
- Primary and secondary contact recreation; and
- Visual amenity.

The ANZECC guidelines specify three levels of protection, from stringent to flexible, corresponding to whether the condition of the particular ecosystem is:

- Of high conservation value;
- Slightly to moderately disturbed; or
- Highly disturbed.

The receiving waterways adjacent to the study area are regarded as moderately disturbed.

The Report Card for Singleton Water Source, Department of Water and Energy, August 2009 states:

- Low economic dependence of the local community on water extracted for irrigation.
- Low risk to instream value (from extraction)
- Medium relative instream value (within catchment): 2 threatened bird species; 3 threatened amphibian species; 1 endangered ecological community, moderate fish community integrity•
- The ecology value for invertebrates is deemed to be moderate.

The Rixs Creek and Unnamed Tributary catchments low value as an irrigation source, being ephemeral.

3.7.1 Clean Water Catchments and Dams

Three clean water dams, CWD1, CWD2 and CWD6 collect runoff from undisturbed land within the Rixs Creek Catchment. The assessment of clean water quality is based on analyses of 156 monthly water samples taken from each of the three dams since 1999. The dams are a suitable analogue for the salinity of rainfall runoff, although EC in dams tends to increase during extended dry periods as evaporation removes water.

The average electrical conductivity (EC) of runoff from undisturbed areas is of low salinity and falls well within the range for palatable potable water after treatment. The average of all records is 212 μ S/cm and the maximum value is 731 μ S/cm. Examination of **Figure 15** demonstrates similar consistent trends for all three clean water dam monitoring stations.

The bulk of the recorded pH values of clean water runoff fall between 6.5 and 8.5 are shown on **Figure 16**. The results fall inside the range for potable water in terms of potential corrosion of pipes. The average pH of all samples since 1999 is 7.5.

The highest average Total Suspended Solids (TSS) is 49mg/l for CWD6 which has the largest clean water catchment of the three dams at 138ha. The average of all site TSS values is 30mg/l. Examination of **Figure 17** indicates almost all TSS values fall below 100mg/l. The low TSS values do not necessarily correlate with low turbidity as there appears to be a high proportion of colloidal material in the water on the Mine site. The high proportion of colloidal material also impacts the Total Dissolved Solids results such that the relationship between Total Dissolved Solids and EC often can depart markedly from the 0.6 – 0.65 ratio which is normally expected.

3.7.2 Disturbed Catchments (Sediment Dams)

The assessment of water quality of runoff from disturbed catchments is based on analyses of a limited number of samples – 5 each from sediment dam Pit 3 - East and Pit 3 –West, as well as 5 miscellaneous samples. Consequently, the trends have not been plotted.

The average electrical conductivity (EC) of runoff from disturbed areas is of low salinity and falls well within the range for treated potable water. The average of all records is 269 μ S/cm, about 27% higher than the clean water dams, and the maximum value is 491 μ S/cm.

The bulk of the recorded pH values of clean water runoff fall between 6.5 and 8.5 are shown on **Figure 16**. The average pH of all samples since 2002 is 7.2.

The average of TSS is 217mg/l. TSS ranges from 5mg/l to 850mg/l. To be of suitable quality to be discharged off site, the TSS would need to be reduced to 50mg/l to meet Blue Book requirements; otherwise the water would need to be taken into the mine water management system.

Salinity and pH are suitable for direct discharge into the receiving waters (Hunter River) falling well within the ranges of quality seen in that stream. There is insufficient data to confidently set trigger levels as per ANZECC Guidelines.

Comprehensive analysis - **Appendix B** – indicates alkalinity, major ions, total metals and nutrients are within acceptable ranges.

3.7.3 Mine Water

The assessment of mine water quality is based on analyses of approximately 168 water samples taken monthly from each of three mine water dams since 1999. The dams are: Dirty Water Dam 1 (DWD1), Dirty Water Dam 2 (DWD2), and Dirty Water Dam 4 (DWD4 formerly Clean Water Dam 4).

The EC of mine water stored at the Mine has ranged from 1,300 to 11,730 microsiemens per centimetre (μ S/cm). Two distinct EC trends are observed at **Figure 15**. Averages of mine water EC readings during an extended dry period from 2003 to 2007 are around 7,000 μ S/cm with occasional forays above 10,000 μ S/cm. During average rainfall periods since 2007, the average EC value trends at around 4,500 μ S/cm. The absence of the dilution effect from fresh water runoff during drought

periods contributes to a gradual increase of EC values in mine water at the Mine during extended periods of dry weather due to evaporation and leaching from mine spoil.

Recorded pH values for mine water average 8.6 over the period since 1999 (**Figure 16**). The average annual mine water pH has increased from around 8.1 to 8.8 between 1999 and 2006, and has remained more or less unchanged since.

Total Suspended Solids (TSS) in DWD1 and DWD2 averages around 17mg/l, and some 95% of all results are less than 59mg/l (**Figure 17**). DWD4 has a large catchment containing mostly undisturbed and revegetated surfaces that influences the TSS values for DWD4, which are slightly higher than the other two dams. The average TSS for DWD4 is 27mg/l with 95% of all results less than 94mg/l. If TSS data since July 2007 is considered, the average TSS for DWD4 is 20mg/l, in line with the other two mine water dams.

The quality of the mine water would generally be suitable for discharge under the HRSTS. The EC of the mine water is below 10,000µS/cm for 98% of the time. Some 97% of all recorded pH values are less than 9.5, and TSS is below 120mg/l for 98% of the time.

The Mine has experienced an extreme wet and an extreme dry period since the first monitoring record. Mine water quality has generally remained within acceptable limits for release under the HRSTS and there is no reason to expect the water quality to go outside the bound established by the data shown on **Figure 15 to Figure 17**.

Comprehensive analysis - **Appendix B** – indicates major ions, total metals and nutrients are within acceptable ranges.

3.7.4 Rixs Creek and Other Streamlines

The assessment of Rixs Creek water quality is based on analyses of approximately 145 monthly water samples from each of three creek monitoring stations taken since 1999. A fourth station has been monitored since June 2004 for 84 samples.

The average EC of water in the stream falls within the “acceptable” range for potable water, ranging from 773 to 1178µS/cm - **Figure 15**. Since 2003, the EC in the upper reaches of the creek system

has averaged 223 μ S/cm. When the creek is flowing, even at low flows, the water would be quite acceptable for stock watering.

The bulk of the recorded pH values for Rixs Creek fall between 6.0 and 8.0 since 1999 as shown in **Figure 16**. The average pH for all samples in Rixs Creek is 7.3.

Total Suspended Solids (TSS) appears to be lower in the middle reaches of the stream line, averaging around 65mg/l and higher in the upstream and downstream reaches, averaging 146 – 177 mg/l. The 95th percentile data shows a similar trend. Examination of **Figure 17** indicates TSS in the stream line is generally below 100mg/l.

Rixs Creek and other local streams are not typical lowland rivers as described in ANZECC 2000, being ephemeral with a significant portion of the flow regime either dry or influenced by groundwater accession. Nevertheless the water quality and quantity remains suitable for stock water, probably the only practical environmental use. The variable water quality provides a wide range of habitats that change over time. Trigger levels for these streams could be set wider in recognition of the variability in flow and quality.

Comprehensive analysis - **Appendix B** – indicates alkalinity, major ions, total metals and nutrients are within acceptable ranges.

3.7.5 The Hunter River

Electrical conductivity in the Hunter River has been measured regularly since 1994 by the NSW Office of Water (NOW) at Long Point (Station 210134) about 4.0km downstream of the confluence of Rixs Creek. The installation of the station occurred shortly after the commencement of the trial HRSTS in 1993.

Water quality at Long Point is directly influenced by management of the regulated Hunter River upstream. Irrigation water is normally released into this reach of the Hunter River from Glennies Creek Dam and tends to keep EC low at Long Point. When Glennies Creek Dam is not releasing water, EC trends upwards towards 900 μ S/cm because the main influence then becomes the through-flow from Glenbawn Dam, which is located in the upper reaches of the Hunter River. By the time water from Glenbawn reaches the Long Point station, irrigation abstraction and natural accession of saline ground water has generally increased the salinity to around 800 μ S/cm.

Average daily EC at the Long Point gauging station is 627 μ S/cm, 93% of all results are less than 900 μ S/cm, and about 30% are less than 500 μ S/cm. The majority of data points fall within the range 300 – 900 μ S/cm.

3.8 Mine Water Management System

Future water management will utilise and extend the current water management system. The goals of the mine water management system are to:

- Divert natural catchment runoff around the mine site where practical.
- Maintain site workability by the capture and storage of pit seepage and disturbed area runoff.
- Maximise the usage of stored mine water for process water supply in the CPP; for dust minimisation on haul roads, trafficable areas and stockpiles.
- Maximise the usage of surplus water and re-cycling across all operations.
- Minimisation of river make-up water during dry and drought periods by: reducing losses to evaporation; harvesting water from licenced diversions on the mine site; forming agreements to import surplus mine water from neighbouring operations.

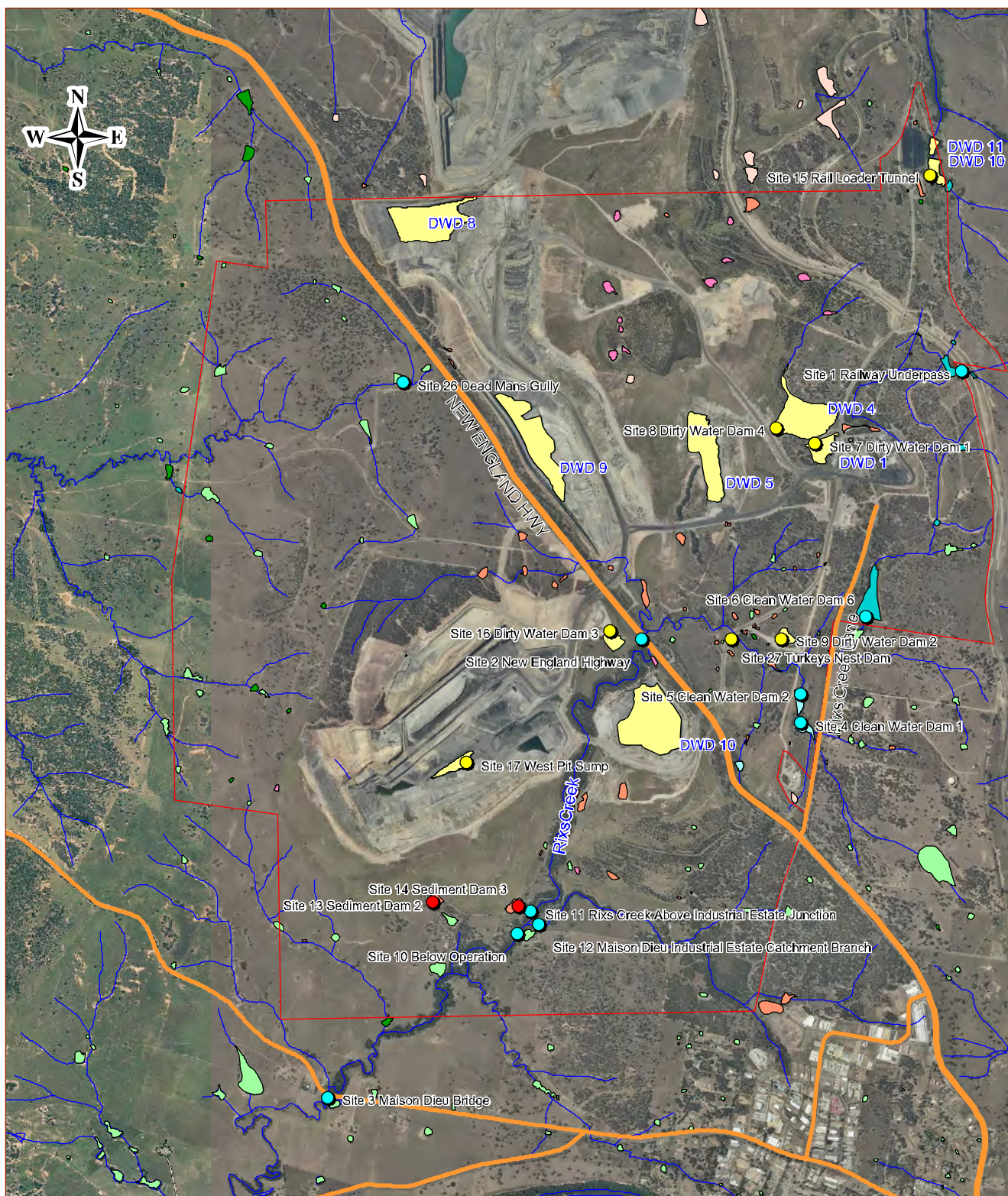
3.8.1 Water Supply

Principal water requirements are:

- Make-up water for the coal preparation plant.
- Dust suppression on mining roads, coal conveyors and stockpile areas.
- Machinery washing.
- Fire-fighting; and
- Potable supplies for bathing and other domestic uses.

Water requirements for mine dust suppression and the CPP are normally met by mine water harvested from mining operations. The current mine operations have rarely required external water sources, having drawn approximately 200 ML from external sources since commencement of operations in 1991. The Mine has carried an excess water inventory since the “Pasha Bulker” storm of June 2007. The excess inventory has only drawn down to pre-2007 levels during 2014.

All potable water supplies are sourced from the Singleton Shire Council potable supply.



Existing Water Sample Locations

- Clean
- Contained
- Sediment

2014 Site Dams by Purpose

- Clean
- Containment
- Diversion
- Erosion Control
- Other Operation
- Rural
- Sediment
- Sewage
- Soil Conservation

Roads

- Major Road
- Minor Road

Other

- Project Boundary
- Stream Line

JP Environmental

**Surface Water Study for Rixs Creek
Continuation of Mining**

Figure 14: Water Quality Monitoring Plan - Existing