Hy-Tec Industries Pty Limited

ABN: 90 070 100 702

Austen Quarry
Stage 2 Extension Project

Aquatic Ecology Assessment

Prepared by

Cardno (NSW/ACT) Pty Ltd

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Aquatic Ecology Assessment

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EXECUTIVE SUMMARY

Introduction

This Aquatic Ecology Assessment has been prepared by Cardno (NSW/ACT) Pty Ltd to support the Environmental Impact Statement for the Stage 2 Extension of Austen Quarry that R.W. Corkery & Co. Pty. Limited is preparing on behalf of Hy-Tec Industries Pty. Limited. The Stage 2 Extension involves extension of the existing extraction area and associated overburden emplacement by a combined area of approximately 25.7 ha. The existing processing areas, stockpiles and water management practices would continue to operate in their current capacity. The Application Area encompasses four broad catchments within the Mid-Coxs River sub-catchment of the Hawkesbury-Nepean catchment, which have been referred to as the Coxs River North, Coxs River South, Coxs River West and Yorkeys Creek catchments. The Stage 2 extraction area and overburden emplacement extensions overlap small upland drainages of the Coxs River North and South catchments.

Regulatory Environment

The major legislation, policies and guidelines that are relevant to the Stage 2 Extension are the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) under which the proposed Quarry extension will be assessed; provisions in the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act); NSW Threatened Species Conservation Act 1995 (TSC Act); NSW Fisheries Management Act 1994 (FM Act) (including Fisheries Management Amendment Act 1997) that relate to the conservation of threatened species, populations and communities; and the Protection of the Environment Operations Act 1997 (POEO Act) which regulates the volume and concentration of key pollutants discharged to the aquatic environment. Other policies and guidelines considered include: the Policy and Guidelines for Fish Habitat Conservation and Management; NSW Office of Water Guidelines for Controlled Activities and; NSW Aquifer Interference Policy.

Conservation Issues

Eight threatened aquatic species could potentially occur within the Lithgow City local government area (LGA), but only one, Macquarie Perch, is likely to occur in the vicinity of the Application Area. Four Key Threatening Processes were identified under state and federal legislation as relevant to the Stage 2 Extension, these being: novel biota and their impact on biodiversity; degradation of native riparian vegetation along New South Wales watercourses; instream structures and other mechanisms that alter natural flows, and alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands. Two Groundwater Dependent Ecosystems, baseflow streams and subsurface phreatic aquifer ecosystems, could potentially be impacted by the Stage 2 Extension.

Existing Environment

Aquatic ecology monitoring has been conducted since 2005 at locations on the Coxs River upstream, adjoining and downstream of the Application Area. In September 2013, further sampling to support the assessment of the Stage 2 Extension was undertaken at these locations. Sites within the Coxs River North and South catchments were also visited in September 2013 but their biota was not sampled. Data collected during other monitoring undertaken at the upstream and downstream locations was also included.

The electrical conductivity (EC) and dissolved oxygen (DO) levels of the water at all locations were generally higher and lower respectively than the relevant physicochemical guidelines. The Coxs River locations were considered to be highly sensitive, major fish habitats and the general condition of the riparian habitat was good. The fish habitat at the sites in the Coxs River North and South catchment tributaries was considered less sensitive and of poorer quality. The macroinvertebrate fauna in edge and riffle habitat at most locations along the river was equivalent to that expected in undisturbed reference creeks. Two native and four introduced fish species were recorded, with native fish observed at all locations. No threatened species were observed.

The riparian vegetation along the Coxs River has a high potential for groundwater interaction and is likely to be classified as a Groundwater Dependent Ecosystem (GDE). This GDE was primarily located outside the Application Area, although some minor overlap exists along the Coxs River boundary. Other vegetation within the Application Area may also display some groundwater dependence. Subsurface GDEs such as hyporheic fauna (fauna inhabiting water in the hyporheic zone, the area of interaction between surface and groundwater) and stygofauna (groundwater dwelling organisms) have the potential to occur within and adjacent to the Application Area.

Potential Impacts and Avoidance, Mitigation and Management Measures

Development Stage

Potential impacts associated with the development phase, i.e. access creation, clearing and stripping of soil and rock above the target rhyolite resource, are primarily associated with the mobilisation, suspension and deposition of sediment and other contaminants in the aquatic environment. This could occur through runoff from cleared areas, stockpiles and roadways, dust mobilised from the Site, accidental release of hydrocarbons and other materials used in Site development works and further development of access tracks over watercourses, if undertaken. An increase in the sediment load of watercourses could potentially alter the nature and availability of aquatic habitats, increase turbidity levels, and impact on aquatic biota. These impacts are likely to be temporary and localised and therefore not significant. Work around watercourses could lead to changes in the pattern of water flow, disturbance and erosion of stream banks and bed, removal of instream and riparian vegetation and, could potentially impede or prevent passage of aquatic organisms. Changes in water management may also impact on aquatic ecosystems through changes to the location and size of dams for water storage and treatment.

Such impacts could be minimised by limiting the area of riparian zone and aquatic habitat disturbed, implementing a Sediment and Erosion Control Plan, maintaining a bunded area for storage of fuels, oils, refuelling and maintenance of vehicles and mechanical plant, minimising direct access to watercourses by construction vehicles and mechanical plant, prohibiting re-fuelling, washing and maintenance of vehicles and plant within 30 m of watercourses, reporting spillages to the appropriate officer and immediately deploying spill containment kits to restrict their spread into or within drainage lines.

Adhering to recommendations outlined in the surface water management and discharge assessment, including development of storage and transfer infrastructure in the most appropriate and feasible manner for the control and treatment of water on site would facilitate more effective water management and improved treatment of water before re-use on site and/or discharge.

Operation Phase

Potential impacts associated with the operation phase include those associated with resource extraction and overburden emplacement, dewatering, water retention and operational use and water discharge.

Resource extraction and overburden emplacement

The Stage 2 Extension would result in the loss of a further 810 m of aquatic habitat and any associated aquatic flora and fauna along the mapped 1st and 2nd order drainages within the Coxs River North and South Catchments. Aquatic habitat in this area is minimal in extent and quality compared with the larger river systems in the area. Impacts are therefore considered to be minimal on a regional scale.

The impact could be reduced by the area of the catchment that is disturbed, diverting clean water around the active disturbance area, capture and treatment of runoff, discharge of treated water to maintain environmental flows, active and appropriate decommissioning and rehabilitation actions and dust suppression activities.

Dewatering

Dewatering of the extraction area would result in a one-off loss of groundwater storage and a permanent lowering of the groundwater table within the isolated rhyolite hosted aquifer to be impacted by the extraction area. Drawdown would be restricted to a distance of approximately 225 m from the perimeter of the extraction area. While there is no record of GDEs occurring and the local ecological and geological setting indicating the potential for these to occur is very low, should any be present, impact would be limited in spatial extent. Impacts to base flows and resident in-stream flora and fauna from dewatering are expected to be nil to negligible within Yorkeys Creek and the Coxs River as a percentage of their total discharge.

The potential impacts associated with dewatering on the receiving aquatic environment would be mitigated by implementation of a Water Management Plan (WMP) coupled with a site water balance dictating the volume of water anticipated, rates of production and retention/discharge planning. The volume and quality of water removed from the Quarry extraction area and the discharge at Yorkeys Creek during the Stage 2 Extension should be monitored to ensure these are equivalent to predictions.

Water Retention and Operational Use

Increased operational water requirements due to an expanded operating area and increased water retention within the extraction area has the potential to impact on aquatic ecology and GDEs. This could occur through reduced groundwater quality if contaminated water seeps into the underlying aquifer. Elevated on-site erosion from increased water transfers may occur around pipe outlets. Small changes to the availability of water for local waterways could also occur as a result of increased seepage of groundwater and/or collection and retention of surface water in dams.

Adherence to the WMP and site water balance would assist in minimising potential impacts associated with water retention and operational use through separation of potential sources of contaminants from potential aquatic receptors and maintenance of appropriate wet weather storage. Improvements to water management infrastructure, including scour protection at outlet and discharge points would mitigate the potential for erosion.

Water Discharge

Groundwater seepage accumulating in the extraction area sump(s), as well as water accumulated from surface runoff would need to be discharged when there is an excess supply.

The associated release of water into the aquatic environment could affect nearby aquatic flora and fauna. Assessment of the likely quantity and quality of discharged water indicates that impacts, if any, would be minimal.

Explosives used during blasting contain nitrogen based compounds, which if accumulated in high concentrations can reduce oxygen levels of water and lead to nuisance algal blooms. Evidence from current operations, including the results of water sampling at various points along the water management system (from in-pit sumps to the receiving environment), illustrate that it is highly unlikely that water discharged will result in elevated nitrogen levels above those naturally occurring.

Impacts would be minimised by ensuring water is discharged in accordance with the conditions specified in the Environmental Protection Licence. The use of appropriate sized, managed and maintained water storages and discharge points is recommended, as well as addition of flocculent and subsequent sampling to confirm water quality prior to discharge. Improvements to site water management and discharge point infrastructure are also proposed to mitigate potential impacts associated with water discharge.

Groundwater Quality

Extraction activities such as blasting and the use of fuels, oils and other plant chemicals could potentially affect the quality of groundwater and impact subsurface GDEs (if present). As the hydraulic gradients generated over the life of, and following Stage 2 Extension would provide for in-flow of groundwater to the extraction area, the potential for contaminated water to leach into the surrounding aquifer is minimal.

Decommissioning and Rehabilitation Phase

Potential impacts may include erosion of the final landform and runoff containing sediments and contaminants such as fertilisers and herbicides. Seepage of contaminants into local groundwater from the retained extraction area void could also occur, such as from the bitumen spray used on the wall of the extraction area. The construction of new landscape features, could impact on downstream aquatic ecosystems if they lead to slumping and/or increased erosion/mass wasting.

These potential impacts would be managed through appropriate Rehabilitation Management and Erosion and Sediment Control Plans, stabilisation of earthworks, drainage lines and disturbed areas in the short to medium term, minimising the areas of exposed surfaces that could be potential sources of aquatic contaminants and windblown dust and ultimately creating a stable and safe landform with minimal erosion.

Impact on Threatened Species and Key Threatening Processes

It is unlikely that the Stage 2 Extension would have a significant effect on known Macquarie Perch populations within the Coxs River downstream of the Application Area. Key Threatening Processes associated with degradation of riparian vegetation and alteration of natural flow regimes could be amplified, although the extent and magnitude of occurrence was considered low.

Cumulative Impacts

The upper Coxs River catchment has been impacted by coal mining, power generation and wastewater disposal. Water from the upper Coxs River catchment flows downstream to the mid Coxs River, past Austen Quarry. The Stage 2 Extension contributes to the cumulative

impact on water quality and hydrological pressures on the Coxs River system through the disturbance of the pre-existing natural surface water and groundwater environment.

Conclusions

The information available indicates the Stage 2 Extension would not have any significant impacts on aquatic habitats, aquatic flora or aquatic fauna, provided that appropriate measures to avoid, minimise and manage impacts associated with the development, operation, rehabilitation and decommissioning phases of the Stage 2 Extension are implemented.

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1. INTRODUCTION

1.1 BACKGROUND

Cardno (NSW/ACT) Pty Ltd (RWC) has commissioned Cardno (NSW/ACT) Pty Ltd, trading as Cardno Ecology Lab, to prepare an Aquatic Ecology Assessment to support the Environmental Impact Statement (EIS) they are preparing on behalf of Hy-Tec Industries Pty Limited (The Applicant), for the Stage 2 Extension of Austen Quarry (The Proposal). The Austen Quarry (the Quarry) is located on and adjacent to the banks of the Coxs River, 3.5 km south-southwest of Hartley village and 10 km south of Lithgow. At the Quarry, rhyolite, a volcanic rock that is used to produce hard rock aggregates, road construction materials, landscaping products and other specialty products, is extracted, crushed and screened. The location of the existing and proposed workings (referred to as the Site) within the Application Area (including infrastructure such as the Quarry Access Road which forms part of the overall quarry operation), are shown in **Figure 1-1**.

The Applicant is seeking approval from the NSW Department of Planning & Infrastructure (DP&I) for an extension of the extraction area and overburden emplacement covering approximately 25.7 ha within Lots 1 and 2, DP1005511 and Lot 31, DP10099672 (Stage 2 Extension). The existing and proposed extraction, processing, stockpiling and transport operations are located in an area leased from the Hartley Pastoral Corporation Pty Ltd (HPC). Development Consent (DA 103/94) for the construction and operation of the Quarry on Lot 1, DP1005511 was issued by the Council of the City of Greater Lithgow (now Lithgow City Council) in March 1995. A modification to DA 103/94 allowing an extension of operations at the Quarry until March 2020 was approved by Lithgow City Council in November 2012. For the purpose of the development application, the Application Area includes areas of Lots 1 and 2, DP1005511, Lot 31 DP1009967 and Lot 4, DP876394, leased from HPC, the sealed Quarry Access Road between the processing area and Jenolan Caves Road and existing internal roads.

1.2 OVERVIEW OF THE PROPOSAL

For the purposes of this document reference is made to existing approved components or activities as “Stage 1” and new or extended components or activities as “Stage 2”. **Figure 1-1** displays the locations of all components, which together are referred to as the Site (an area of approximately 144ha).

It is noted that should development consent be granted for the Stage 2 Extension, the Stage 2 extraction area would incorporate the existing Stage 1 extraction area and likewise, the Stage 2 overburden emplacement would incorporate the Stage 1 overburden emplacement. The following provides a description of the relevant component areas and activities of Stage 1 and 2.

1.2.1 Approved Stage 1 Component Areas

1.2.1.1 Extraction Area

The approved extraction area covers 12.1 ha, however, a ridge on the northern side of the approved limit of extraction has been excised from the area to provide a visual barrier across much of the extraction area for viewers at Hassans Walls. The loading hopper of the primary

crushing station is located at the north-western corner of the Stage 1 extraction area at approximately 750 m AHD (the footings are at an elevation of approximately 735 m AHD).

1.2.1.2 Stage 1 Overburden Emplacement

The overburden emplacement covers approximately 6.8 ha, and has been developed immediately adjacent to the Stage 1 extraction area. Overburden placement in this area has involved the partial in-filling of the head of a gully between 730 m AHD and 780 m AHD.

1.2.1.3 Secondary Processing Area

The secondary processing area encompasses the area from the surge stockpile at the end of the conveyor from the primary crushing station to the site office. This area covers approximately 6.1 ha and incorporates three crushers, six screens, 17 conveyors and the air separation unit. Aggregates of various sizes are separated or blended to produce customised products and temporarily stockpiled before transportation to their destination or to the Yorkeys Creek stockpile area.

1.2.1.4 Yorkeys Creek Stockpile Area

The bulk of the road pavement materials, manufactured sands, select fills, drainage materials and road construction materials are stockpiled within the Yorkeys Creek stockpile area to the northwest of the secondary processing area along the Quarry Access Road. This area covers approximately 4.4 ha and is defined by the area between the Quarry Access Road, Yorkeys Creek and the northern boundary of the Application Area.

1.2.1.5 Quarry Access Road

The sealed private Quarry Access Road from the Jenolan Caves Road to the Quarry weighbridge provides the only access to the Site. The road has centre and edge line markings the full length of the road between the intersection with Jenolan Caves Road and the substantial culvert crossing of Yorkeys Creek to the west of the outgoing weighbridge.

1.2.1.6 Other Areas

The Site also incorporates additional existing infrastructure and services including:

- the on-site road network;
- the administration building, amenities, laboratory and other structures;
- water management structures (including three sediment basins and six storage dams);
- the hydrocarbon storage area;
- two weighbridges; and
- facilities to house services such as power and communications.

1.2.2 Proposed Stage 2 Component Areas

1.2.2.1 Proposed Stage 2 Extraction Area

The proposed Stage 2 extraction area would incorporate a lateral extension of and deepening the existing Stage 1 extraction area along an adjacent southwest-northwest trending ridge. The northern side of the ridge within in the existing Stage 1 extraction area would remain as a visual barrier to views from the north. The area of the extension covers approximately 15.8 ha and lies immediately to the southeast and east of the Stage 1 extraction area. The combined area of the Stage 1 and Stage 2 extraction areas would be 28.3 ha.

1.2.2.2 Proposed Stage 2 Overburden Emplacement

The proposed overburden emplacement would laterally extend (9.9 ha) and increase the elevation of the existing Stage 1 overburden emplacement. In total, the overburden emplacement would cover approximately 13.5 ha. The Stage 2 overburden emplacement would continue to in-fill the small valley to the southwest of the Stage 2 extraction area.

Rhyolite would be initially crushed at the primary crushing station before being conveyed to the surge pile of secondary processing area for additional screening and stockpiling prior to sale and despatch. The product would be transported from the secondary processing area via a weighbridge and the sealed Quarry Access Road to Jenolan Caves Road. Surplus select fill, road base, manufactured sand and other products would be stockpiled and managed within the Yorkeys Creek stockpile area. The established infrastructure and services located on the elevated terrace to the west of the processing area would continue to be used as Quarry office and maintenance area.

1.2.2.3 Water Management System

Groundwork Plus (2014) reviewed the quarry water management system and identified a need for increased capacity of various water storages and sediment basins. The following modifications to the water management system would be undertaken as part of the Stage 2 Extension to accommodate these requirements:

- An additional sediment basin (SB3b) would be constructed beyond the final toe of the overburden emplacement. This would be constructed with a minimum storage capacity of 12.3ML within 6 months of the approval of development consent. The existing sediment basin for the overburden emplacement catchment (SB3a) would be retained as a basin forebay until such time as overburden emplacement development progresses over this;
- The final sediment basin capturing runoff from the Yorkeys Creek stockpile area (SB2b) would be increased in capacity to at least 4.5ML to provide the minimum settlement and storage requirements for a 95th percentile 5-day rainfall event (with an additional allowance to account for water below effective pumping level) within 6 months of the approval of development consent;
- An additional diversion weir would be constructed between storage dams to the south of the Yorkeys Creek stockpile (SD5 and SD6) such that except under exceptional circumstances (e.g. prolonged drought), overflow from SD5 would flow directly to Yorkeys Creek. This would increase the capacity of SD5 to accept water from the sediment basin in the secondary processing area (SB1).

1.3 LOCAL SETTING

The Application Area encompasses four broad catchments within the Mid-Coxs River sub-catchment of the Hawkesbury-Nepean Catchment (refer to **Figure 3-3**):

- Coxs River North - which includes the Stage 1 extraction area and secondary processing area and a number of ephemeral drainage lines and gullies which flow in a generally northerly direction towards the river;
- Coxs River South – which includes the overburden emplacement, a large proportion of the quarry extension and receives runoff from a number of ephemeral drainage lines and gullies that converge near the toe of the overburden emplacement and flow along an easterly oriented drainage line into the river;
- Coxs River West – which includes the Quarry Access Road beyond the Site boundary; and,
- Yorkeys Creek – which receives the drainage from the Yorkeys Creek stockpile area and a small section of the Quarry Access Road that crosses the creek and flows into the river.

The Risk Assessment for the Stage 2 Extension identified three major sources of potential impacts on surface water: on-site capture of water, discharge of dirty or contaminated water and erosive power of water (R.W. Corkery 2013).

On site capture of water could potentially lead to:

- Reduction in flows to the Coxs River (medium risk);
- Reduced availability of water to downstream users (low risk);
- Stress to and possible reduction in viability of native vegetation (low risk); and
- Degradation of aquatic habitats (medium risk).

Discharge of dirty or contaminated water could potentially result in:

- Sedimentation or hydrocarbon pollution of downstream waters (medium risk);
- Health related impacts (people) due to consumption of contaminated water (medium risk);
- Pollution of local waterways resulting in detrimental effects to flora and fauna (medium risk); and
- Health related impacts (stock) due to consumption of contaminated water (low risk).

The erosive power of water could lead to:

- soil erosion and loss of agriculturally productivity (medium risk); and
- Decreased availability of soil for rehabilitation (medium risk).

1.4 SCOPE OF WORKS

The scope of works for the Aquatic Ecology Assessment included:

- Identification of legislative requirements, policies and guidelines that are relevant to the effects of the Proposal on aquatic ecology (including consideration at NSW State and Commonwealth legislation);

- Compilation and synthesis of existing information on the condition of aquatic habitats, biota and quality of water in the section of the Coxs River within and immediately downstream of the Application Area;
- Description of the existing aquatic environment and its associated biota;
- Identification of threatened aquatic species, populations, ecological communities, groundwater dependent ecosystems (GDEs) and key threatening processes that could be affected by the Proposal;
- Assessment of the potential impacts of the Proposal on aquatic habitats and their biota, particularly threatened species, populations and communities, and GDEs occurring within and immediately downstream of the Application Area; and
- Recommendations on measures to avoid, mitigate or offset potential impacts associated with The Proposal on aquatic ecology of the watercourses within and downstream of the Application Area.

The Aquatic Ecology Assessment also addresses the specific requirements of DP&I, NSW Office of Environment and Heritage (OEH) and Department of Primary industries (NSW Fisheries and NSW Office of Water [NOW]). These issues are summarised in **Table 1-1** to **Table 1-4**.

Table 1-1 Director General's Requirements (of DP&I) pertinent to the Aquatic Ecology Assessment

Assessment Requirements	Relevant Section of the Report
Description of the existing environment, using sufficient baseline data.	Section 3.6 and 4
Assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant guidelines, policies, plans and statutes.	Section 2, 3 and 5.2
Assessment of impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including GDEs and environmental flows, in particular the Coxs River	Section 7
Detailed assessment of potential impacts of the development on aquatic threatened species or populations and their habitats, endangered ecological communities and GDEs	Section 6.3.2.2 and 6.5
Description of measures that would be implemented to avoid, minimise and, if necessary, offset the potential impacts of the development on biodiversity.	Section 6.2.3, 6.3.2.5 and 6.3.2.5

Table 1-2 NSW Office of Environment and Heritage (OEH) requirements pertinent to the Aquatic Ecology Assessment

Assessment Requirements	Relevant Section of the Report
Identification and assessment of Matters of National Environmental Significance	Section 3.2 and 6.5
Identification of national and state-listed threatened species that could potentially occur on the site and their conservation status	Section 3.3
Description of survey methodology	Section 3.2.1, 3.3.1 and Appendix A
Likely impacts on biodiversity, native vegetation and habitat	Section 5.2
An Assessment of Significance on threatened biodiversity	Section 6.5.1
Measures to avoid, mitigate and manage impacts	Section 6.2.3, 6.3.2.5 and 6.3.2.5

Table 1-3 Department of Primary Industries (NSW Fisheries) requirements pertinent to the Aquatic Ecology Assessment

Assessment Requirements	Relevant Section of the Report
A map of the area which may be affected either directly or indirectly by the development with all water bodies and waterways identified.	Figure 1-1, Figure 3-1 and Figure 4-1
A description and maps of aquatic vegetation, snags, gravel beds and any other protected, threatened or dominant habitats should be presented. Description should include area, density and species composition.	Section 3.11 and Appendix D
A survey of fish species should be carried out and results included. Existing data should be used only if collected less than 5 years previously.	Section 3.14.2 and Appendix D
Identification of recognised recreational and commercial fishing grounds, aquaculture farms and/or other waterways users.	Section 3.14.2.1
A threatened aquatic species assessment. List threatened species and consider habitat types present within the study area, recent records of threatened species in the locality and the known distributions of these species.	Section 3.5, Table 3-1 and Table 3-3
A description of aquatic habitat including such components as stream morphology, in-stream and riparian vegetation, water quality and flow characteristics, bed morphology, vegetation (both aquatic and adjacent terrestrial), water quality and tide/flow characteristics.	Section 3.10, 3.11 and 3.11.7
Provide a description of the habitat requirements of threatened species likely to occur in the study area.	Section 3.5

Table 1-4 Department of Primary Industries (NSW Office of Water) requirements pertinent to the Aquatic Ecology Assessment

Assessment Requirements	Relevant Section of the Report
Identification of potential groundwater-dependent ecosystems (GDEs)	Section 4.2
Assessment of GDEs for condition and water quality and quantity requirements for aquatic ecosystems (macroinvertebrates, macrophytes, stygofauna)	Section 4.2
Assessment of impacts on groundwater and surface water dependent ecosystems within and adjacent to the Quarry	Section 6.2.2, 6.3.2 and 6.4.2
Mitigation measures to address impacts on groundwater and surface water dependent ecosystems	Section 6.2.3, 6.3.2.5 and 6.3.2.5

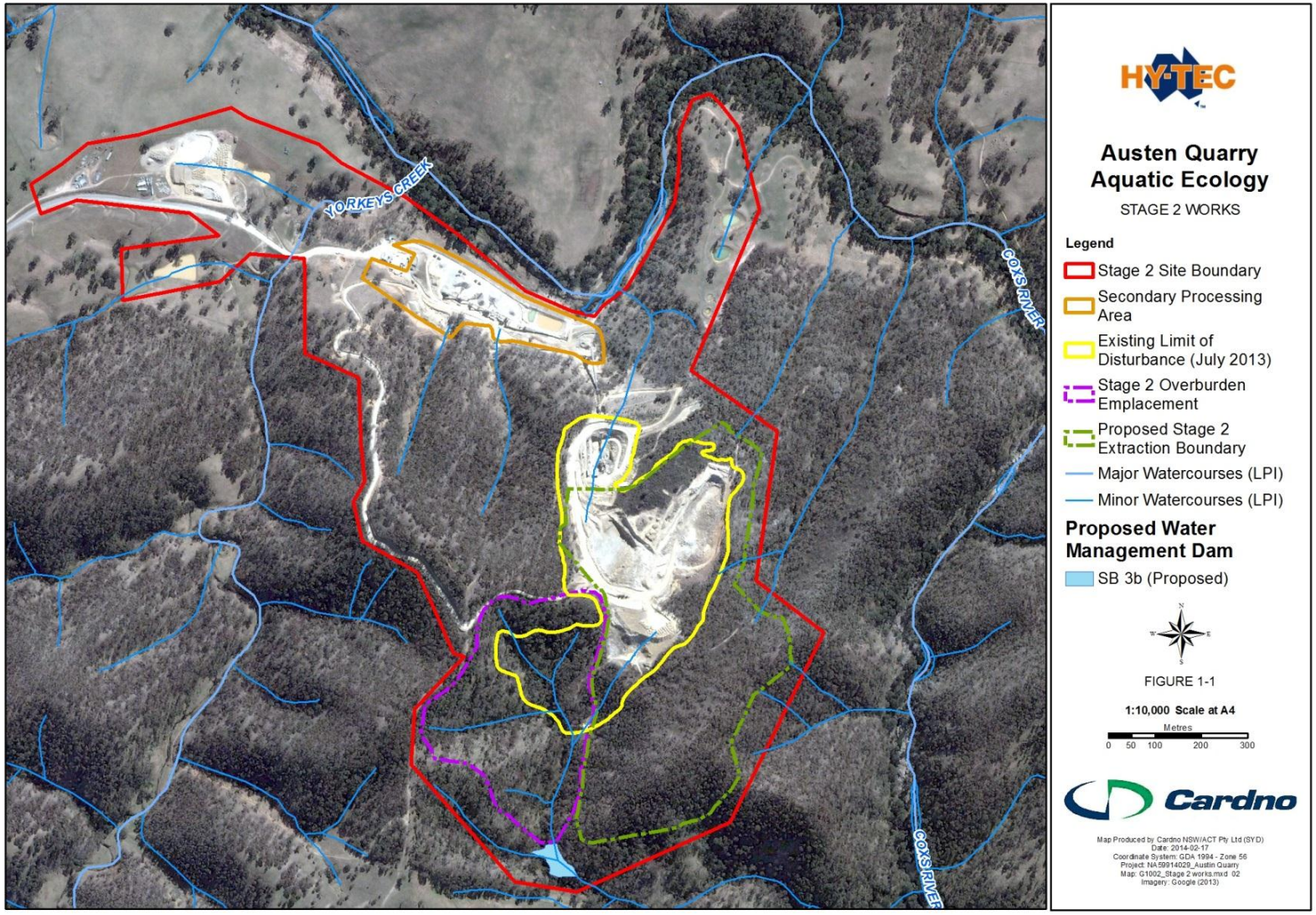


Figure 1-1 The Application Area showing existing and proposed work areas, nearby watercourses and the proposed new sediment dam

2. LEGISLATIVE REQUIREMENTS, GUIDELINES AND POLICY

2.1 LEGISLATIVE REQUIREMENTS

2.1.1 Development Application

The Proposal is considered a State Significant Development (SSD) and will therefore be assessed under Division 4.1, Part 4 of the Environmental Planning and Assessment Act 1979 (*EP & A Act*). The development application must be accompanied by an Environmental Impact Statement (EIS) that addresses the issues specified in the Director-General Requirements (DGRs) issued on 3 September 2013. One of the requirements relevant to the ecological studies supporting the EIS is that specific factors and assessment guidelines must be taken into account when deciding whether the Proposal is likely to have a significant effect on threatened species, populations or ecological communities, as defined under the NSW Threatened Species Conservation Act 1995 (*TSC Act*) administered by the NSW Office of Environment and Heritage (OEH), and NSW *Fisheries Management Act* (*FM Act*) 1994 (including *Fisheries Management Amendment Act 1997*), administered by the NSW Department of Primary Industries (DPI). The factors to be considered are specified in Section 5A of the *EP & A Ac*t and constitute what was known as the eight-part test, but is now referred to as the Assessment of Significance. The factors relevant to consideration of effects on threatened species, for example, are:

1. Whether the proposed action is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;
2. The extent to which the species habitat is likely to be removed or modified as a result of the action proposed, whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and whether the habitat to be removed, modified, fragmented or isolated is important to the long-term survival of the species in the locality;
3. Whether the proposed action is likely to have an adverse effect on critical habitat (either directly or indirectly;
4. Whether the proposed action is consistent with the objectives or actions of a recovery plan or threat abatement plan;
5. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Similar factors need to be considered when assessing effects on threatened populations and ecological communities.

Division 4.1, Part 4 of the *EP & A Act* indicates some of the authorisations required under other Acts are not required of SSDs (in accordance with Section 89J). These include provisions under the *FM Act* with respect to permits for dredging and reclamation work, harm to marine vegetation and blockage of fish passage. Controlled activity approvals issued under section 91 of the Water Management Act 2000 (that confers a right on its holder to carry out a specified controlled activity at a specified location in, on or under waterfront land), is also not required. An aquifer interference approval that confers a right on its holder to carry out one or more specified aquifer interference activities at a specified location, or in a specified area, in the course of carrying out specified activities, however, is still required.

2.1.2 Threatened Species, Populations and Communities

Threatened freshwater species, populations and communities are listed under the Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act*) administered by the commonwealth Department of the Environment (DOE), the *TSC Act* and *FM Act*.

The *EPBC Act* provides a legal framework for the protection and management of nationally and internationally important flora, fauna, ecological communities and heritage places. It also includes provisions for nationally threatened species of plants, fish, birds, frogs, reptiles, mammals and other animals. These conservation assets are referred to collectively as Matters of National Environmental Significance (MNES). DOE is also responsible for the development and implementation of recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the *EPBC Act*.

The *TSC Act* provides for the conservation of species, populations and ecological communities of animals and plants in NSW that are threatened with extinction. The *TSC Act* contains provisions for the preparation of recovery plans for listed threatened species, populations and ecological communities, the declaration and mapping of habitats that are critical to their survival and threat abatement plans to manage key threatening processes. The *TSC Act* also provides for the facilitation of the appropriate assessment, management and regulation of actions that may damage critical or other habitat or significantly affect threatened species, populations and ecological communities and contains provisions related to Biodiversity Banking and offsets. The provisions of the *TSC Act* apply to algae, aquatic plants, invertebrates and all major vertebrate groups except fish.

The *FM Act* contains provisions for the conservation of fish stocks, key fish habitat, biodiversity, threatened species, populations and ecological communities of fish, marine vegetation and some aquatic macroinvertebrates and the development and sharing of the fishery resources of NSW for present and future generations.

2.1.3 Key Threatening Processes

Key Threatening Processes (KTPs) that threaten or may threaten the survival or evolutionary development of threatened species, population or ecological communities are listed under the *EPBC Act*, *TSC Act* and *FM Act*.

2.1.4 Noxious Species

Noxious species threaten the conservation of native species and have the potential to impact on fisheries, agriculture and other important industries. Noxious species of fish are listed under the *FM Act*. Noxious species of terrestrial and freshwater vegetation are listed under the Noxious Weeds Act (*NW Act*), administered by the NSW Department of Primary Industries (DPI).

2.1.5 Protected Species

Native fauna and flora are also protected under the NSW National Parks and Wildlife Act 1974 (*NP and W Act*) administered by the Office of Environment and Heritage (OEH).

2.1.6 Critical Habitat

Critical habitats are areas of land or water that are crucial to the survival of particular threatened species, populations and ecological communities. Registers of critical habitats are maintained by OEH and DPI.

2.1.7 Key Fish Habitat

The *FM Act* also contains provisions relating to conservation of key fish habitats, i.e. aquatic habitats that are important to sustainability of recreational and commercial fishing industries, maintenance of fish populations generally and survival and recovery of threatened aquatic species. In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies that flow for a short period after rain and farm dams on such systems are excluded, as are artificial water bodies except for those that support populations of threatened fish or invertebrates.

2.2 GUIDELINES AND POLICIES

2.2.1 NSW Office of Water Guidelines for Controlled Activities

Approval is required under the *Water Management Act 2000* (*WM Act*) for certain types of developments and controlled activities that are carried out in or near a river, lake or estuary. Four types of controlled activities are recognised:

- Erection of a building or the carrying out of a work (within the meaning of the *EP&A Act*);
- Removal of material or vegetation from land, by way of excavation or other means;
- Deposition of material on land as a result of landfill operations or other means; and
- Carrying out any other activity that affects the quantity or flow of water in a water source.

The NSW Office of Water, the agency responsible for administering the *WM Act*, has developed guidelines to assist applicants who are considering carrying out controlled activities on waterfront land (i.e. the land within forty metres of the highest bank of the river, lake or estuary). These guidelines provide information on the design and construction of a controlled activity, and other mechanisms for the protection of waterfront land. The following guidelines are relevant to the potential effects of The Proposal and are applicable to all developments on waterfront land.

- Laying pipes and cables in watercourses (NSW Office of Water 2010a);
- Riparian corridors (NSW Office of Water 2011a);
- In-stream works (NSW Office of Water 2010b); and
- Outlet structures (NSW Office of Water 2010c).

Note that although controlled activity approval under section 91 of the *WM Act* is not required for SSDs it is understood that controlled action guidelines are government policy and will be promoted by the NSW Office of Water within any assessment process.

2.2.2 NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management

The NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management (2013) is an update of the Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (NSW Fisheries 1999). The new document also incorporates the requirements of the former Fisheries NSW Policy and Guidelines for Fish Friendly Waterway Crossings (2003) and two Fish Habitat Protection Plans No. 1 (General) and 2 (Seagrasses), which are in the process of being revoked.

The aims of the updated policies and guidelines are to maintain and enhance fish habitat for the benefit of native fish species, including threatened species, in marine, estuarine and freshwater environments. The updated document assists developers, their consultants and government and non-government organisations to ensure their actions comply with the legislation, policies and guidelines that relate to fish habitat conservation and management. It is also intended to inform land use and natural resource management planning, development planning and assessment processes, and to improve awareness and understanding of the importance of fish habitats and how impacts can be mitigated, managed or offset. The policies and guidelines outlined in this document are taken into account when NSW DPI assesses proposals for developments and other activities that affect fish habitats.

The document contains:

- Background information on aquatic habitats and fisheries resources of NSW;
- An outline of the legislative requirements relevant to planning and development which may affect fisheries or aquatic habitats in NSW;
- General policies and classification schemes for the protection and management of fish habitats and outlines the information that NSW DPI requires be included in development proposals that affecting fish habitats;
- Specific policies and guidelines aimed at maintaining and enhancing the free passage of fish around in-stream structures and barriers;
- Specific policies and guidelines for foreshore works and waterfront developments; and
- Specific policies and guidelines for the management of other activities affecting waterways.

The document indicates NSW DPI will consider the ‘sensitivity’ of any key fish habitats that would be affected by the Proposal. The term ‘sensitivity’ refers to the importance of the habitat to the survival of the fish and its ability to withstand disturbance. In freshwater ecosystems, instream gravel beds, rocks greater than five hundred millimetres in two dimensions, snags greater than three hundred millimetres in diameter or three metres in length, and native aquatic plants, and areas known or expected to contain threatened and protected species are considered to be highly sensitive key fish habitats. Other freshwater habitats plus weir pools and dams across natural waterways are considered to be moderately sensitive key fish habitats. Ephemeral aquatic habitat that does not support native aquatic or wetland vegetation is considered to be of minimal sensitivity. It is important to note that aquatic habitats within first and second order gaining streams, sections of stream that have been concrete-lined or piped (but excluding waterway crossings) and artificial ponds are not regarded as key fish habitat unless they support a listed threatened species, population or ecological community or ‘critical habitat’. NSW DPI may in addition assess development proposals in relation to waterway

class (i.e. their ability to provide habitat that is suitable for fish). Details of this classification are provided in **Appendix B.**

The general policies and /or guidelines that may be relevant to the Proposal include those for:

- Riparian and freshwater aquatic vegetation (Section 3.2.4.2); and
- Habitat rehabilitation and environmental compensation (Section 3.3.3.2).

The specific policies and guidelines that may be relevant include those for:

- Design and construction of waterway crossings (Section 4.2.2);
- Temporary instream structures (e.g. coffer dams, construction pads, sediment erosion booms) (Section 4.5.2);
- Instream rehabilitation works (Section 4.6.2);
- Instream structure removal (Section 4.7.2); and
- Minimizing water pollution (Section 6.5.2).

2.2.3 NSW State Groundwater Dependent Ecosystems Policy

The NSW Groundwater Dependent Ecosystems (GDEs) Policy (DLWC 2002) is designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of their dependent ecosystems are maintained or restored, for the benefit of present and future generations. The document provides guidance on the protection and management of GDEs and includes information on:

- The location of groundwater systems in NSW;
- Different types of GDEs;
- Value of and threats to GDEs;
- The principles that underpin the management of GDEs; and
- Policies and legislation relating to management of GDEs, including how policy will be implemented and reviewed.

The species composition and natural ecological processes within some ecosystems (e.g. wetlands, red gum forests, limestone caves, springs, hanging valleys and swamps) are dependent on water that has filtered down below the surface of the earth and is held in rocks, gravel and sand. In NSW, groundwater often provides the base flows in rivers and streams after rainfall events that appears as springs or as diffuse flows from saturated sediments or rock underlying the watercourse or its banks.

2.2.4 NSW Office of Water's Risk Assessment Guidelines for GDEs

The NSW Office of Water and Office of Environment and Heritage (OEH) have developed comprehensive risk assessment guidelines to manage the effects of land and water use activities on GDEs. These guidelines are available in four volumes:

- Volume 1 - Risk assessment guidelines for groundwater dependent ecosystems – the conceptual framework;
- Volume 2 – Risk assessment guidelines for groundwater dependent ecosystems. Worked examples for seven pilot coastal aquifers;

- Volume 3 – Identification of high probability groundwater dependent ecosystems on the Coastal Plains of NSW and their ecological value; and
- Volume 4 – The ecological value of groundwater sources on the Coastal Plains of NSW and the risk from groundwater extraction.
- The conceptual framework (Serov *et al. 2012)* provides:
- Definitions of groundwater, GDEs and high priority GDEs;
- A classification of different types of GDEs;
- A description of the relevant policy and legislative framework;
- Information on ecological valuation and risk assessment process and activities that threaten aquifers and/or their associated GDEs;
- A method for determining the ecological value of an aquifer and associated GDEs to assist in reporting against the state-wide Target for Groundwater;
- A method for assessing the risk of an activity to the ecological value of an aquifer and associated GDEs; and
- A method for developing management strategies for aquifers and identified GDEs based on a Risk Matrix Approach.

The accompanying appendices contain background information, including:

- A method to identify the type and location of GDEs within an aquifer or defined area;
- A method for inferring the groundwater dependency of identified ecosystems; and
- A description of surface and subsurface activities that threaten aquifers and associated GDEs.

This volume of the guidelines is the most relevant to the Proposal. The others show how the framework has been applied to groundwater resources and GDEs on the Coastal Plain.

2.2.5 NSW Office of Water's Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources

The NSW Office of Water has developed a water sharing plan for the management of groundwater resources within the Greater Metropolitan Region. The provisions in the plan provide water to support the ecological processes and environmental needs of high priority GDEs and direct how the water available for extraction is to be shared. The plan also sets management rules for water access licences, water allocation accounts, dealings in licences and water allocations, water supply works approvals and the extraction of water.

The Proposal is located within the Coxs River Fractured Rock groundwater management unit. The water sharing plan governing this area commenced on 1 July 2011 with a proposed term of 10 years. The Water Sharing Plan for the Greater Metropolitan Region identifies high value GDEs and culturally sensitive groundwater sites within the Coxs River fractured rock aquifer management unit.

3. CONSERVATION ISSUES

3.1 INTRODUCTION

In this section, threatened aquatic species, populations and communities of national and state significance that may occur in the Application Area are identified. Information on the occurrence of threatened amphibians, terrestrial fauna and flora and migratory species and assessments of potential impacts on these are presented in the report prepared by Niche (2014).

The potential impacts of the development, operational, and post-operational phases of the Proposal and measures for avoiding, minimising and managing such impacts on threatened aquatic species, populations and communities are discussed in **Section 0**.

3.2 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

3.2.1 Methods

The Protected Matters Search Tool, a database maintained by DOE, was used to identify threatened aquatic species and communities of national environmental significance that occur or may occur in the Lithgow City LGA. A search was undertaken over the entire LGA to ensure that mobile, threatened species that may periodically move into the Application Area were taken into consideration.

3.2.2 MNES identified and their Likelihood of Occurrence

3.2.2.1 Threatened Species

The Protected Matters Search Tool indicated that three threatened fish species listed under the *EPBC Act* may occur or suitable habitat for them may occur within the Lithgow City LGA. Two of these species, Australian Grayling (*Prototroctes maraena*) and Murray Cod (*Maccullochella peelii*) are considered to be vulnerable to extinction, whilst the third, Macquarie Perch (*Macquaria australasica*), is endangered.

The Australian Grayling occurred historically in coastal streams from the Grose River, west of Sydney, southwards through NSW and Victoria (DSEWPAC 2013). The Australian Grayling is diadromous and requires access to freshwater, estuarine and marine habitats to complete its life cycle. The construction of dams, weirs and other barriers to fish passage has had a major impact on their populations in some river systems. It is currently found in streams and rivers, on the eastern and southern flanks of the Great Dividing Range from Sydney southwards to the Otway Ranges in Victoria (NSW DPI 2006a). The records on the NSW DPI Record Viewer indicate that this species does not occur north of Wollongong. Its identification by the Protected Matters Search Tool therefore probably reflects its historical distribution.

Murray Cod are endemic to the Murray-Darling River system, but both hatchery-bred and wild-caught individuals have been translocated and stocked outside this natural distribution range. This species has been recorded in the Hawkesbury-Nepean Catchment, but the records are all from coastal rivers and represent stocked fish (NSW DPI 2006b). This species has been found in flowing and standing waters, including small, clear, rocky streams on the inland slopes and uplands of the Great Diving Range, to large, turbid, meandering slow-flowing rivers, creeks, anabranches, and lakes and larger billabongs, of the inland plains of the Murray

Darling Basin (National Murray Cod Recovery Team 2010). Murray Cod are usually found in association with large rocks, large snags and smaller structural woody habitat, undercut banks and over-hanging vegetation, but also frequent the main river channel and larger tributaries and anabranches.

The NSW DPI Fish Record Viewer indicates Macquarie Perch has been recorded in the Capertee River, Colo River, lower Coxs River, Warragamba Dam and other parts of the Hawkesbury-Nepean River system. The 2010 Audit of the Sydney Drinking Water Catchment, which spanned the years between 2007 and 2010, indicates Macquarie Perch have also been recorded in the mid Coxs River (OEH 2010). Macquarie Perch are found in rivers and lakes, but particularly the upper reaches of rivers and their tributaries. This species prefers clear water and deep, rocky holes with extensive cover in the form of aquatic vegetation, large boulders, debris and overhanging banks (DSEWPAC 2010). They spawn in spring or summer and lay their eggs in shallow, fast-flowing water over stones and gravel in shallow upland streams or flowing parts of rivers.

The current distribution ranges of Murray Cod and Australian Grayling indicate they are highly unlikely to occur in the Application Area. The presence of Warragamba Dam downstream of the Application Area poses a formidable barrier to upstream passage of these species if they were present in the lower Hawkesbury-Nepean Catchment. In view of this, the preparation of assessments of the significance of impacts for these species is considered unnecessary.

Macquarie Perch have been recorded in relatively close proximity to the Application Area in recent years (OEH 2010) and suitable habitat exists for this species within the Coxs River adjacent to the Quarry. For this reason, an assessment of significance was prepared for this species.

3.2.2.2 Endangered Ecological Communities

There are no aquatic endangered ecological communities listed as occurring within the Application Area or in the aquatic environment directly downstream.

3.2.2.3 Key Threatening Processes

One Key Threatening Processes (KTPs) listed under the EPBC Act may be relevant to the Proposal, this being 'novel biota and their impact on biodiversity'. This KTP is concerned with the potential for invasive organisms to spread at the detriment of native ecosystems. The risk to aquatic ecosystems associated with this KTP is considered to be low due to the nature of the Proposal; however, this is addressed in the impact assessment as a precautionary measure.

3.3 MATTERS OF STATE CONSERVATION SIGNIFICANCE

3.3.1 Methods

A search for information regarding records and distribution of threatened and protected species of fish in the Lithgow City LGA and Hawkesbury-Nepean CMA was undertaken using the online Record Viewer developed by the Threatened Species Unit of the former I&I NSW.

A second online search facility, NSW BioNet managed by OEH's Wildlife Unit, was used to search for records of flora and fauna sightings within Lithgow City LGA held in the Atlas of NSW Wildlife. This Atlas contains records of plants, mammals, birds, reptiles, amphibians,

some fungi, some invertebrates (such as insects and snails listed under the *TSC Act* and some fish). The Atlas was also searched for information on known and predicted distributions of vegetation communities, endangered populations and key threatening processes listed under the TSC Act occurring within the Lithgow City LGA.

3.3.2 Threatened Species and their Likelihood of Occurrence

According to Record Viewer, the Macquarie Perch is the only threatened fish species listed under the *FM Act* to have been recorded in the Lithgow City LGA. This record is for a specimen caught in the Capertee River in 2006. A search for records of this species over the entire Hawkesbury-Nepean Catchment Management Area revealed it had been found in Warragamba Dam and the lower Coxs River catchment in 1994, 2005, 2006 and 2007 and in the Colo River in 2007. The 2010 Audit of the Sydney Drinking Water Catchment indicates Macquarie Perch have also been recorded in the mid Coxs River (OEH 2010). The wider geographic search indicated that two other threatened fish species (Silver Perch and Trout Cod) listed under the *FM Act* have been recorded in the Hawkesbury-Nepean catchment. As these records are all from coastal rivers and represent stocked fish (NSW DPI 2006b) an assessment of the significance of impacts on Silver Perch and Trout Cod is considered unnecessary.

The expected distribution ranges of Adams Emerald Dragonfly (*Archaeophya adamsi*) and Sydney Hawk Dragonfly (*Austrocordulia leonardi*), listed as endangered species under the *FM Act,* include the Hawkesbury-Nepean catchment. Both dragonflies are extremely rare having been collected from only a few localities, suggesting that their distribution is highly localised. The Sydney Hawk Dragonfly is known to occur at three locations between Audley and Picton to the south of Sydney and in the Hawkesbury-Nepean, Georges River and Port Hacking drainages (NSW DPI 2007). The predicted distribution range of this species, however, does not extend much beyond Penrith (NSW DPI 2007), so it is highly unlikely to occur in the Application Area. The Adams Emerald Dragonfly has been collected from four localities near Sydney: Somersby Falls and Floods Creek in Brisbane Waters National Park near Gosford, Tunks Creek near Berowra and Hornsby, Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. The larvae of this species have been found in narrow, shaded riffle zones with moss and abundant riparian vegetation in small creeks with gravel or sandy bottoms (NSW DPI 2012b). Suitable habitats for these species are not present within the Application Area, so preparation of assessments of significance was considered unnecessary.

The search undertaken using NSW Bionet showed that one endangered semi-aquatic invertebrate species, the Giant Dragonfly (*Petalura gigantea*), listed under the *TSC Ac*t has been recorded in the Lithgow City LGA. The Giant Dragonfly is considered to be an obligate groundwater dependent mire (peat-forming wetland) dwelling species because its breeding success is dependent on sites with a groundwater regime that provides enough surface moisture to minimise desiccation of eggs and early larval instars, peatland soils suitable for burrowing by larvae, and that have a water table height that allows larvae to access or extend their burrows (Benson and Baird 2012). This species is typically found in permanent swamps and bogs containing some free water and open vegetation (NSW Scientific Committee, 2004). The Giant Dragonfly has been recorded in a number of swamp or mire types in the Blue Mountains region, including the Newnes Plateau Shrub Swamps (Baird 2012) and Long Swamp on the upper Coxs River (Baal Bone Colliery 2012). The aquatic habitat within the Application Area is unsuitable for this species so preparation of an assessment of significance was considered unnecessary.

3.3.3 Threatened Populations

Three threatened populations of freshwater fish are listed under the *FM Ac*t. The distribution range of these populations does not include the watercourses that traverse the Application Area. No threatened populations of aquatic organisms are listed under the *TSC Act*.

3.3.4 Threatened Communities

None of the listed threatened aquatic communities occur within the Application Area or in the aquatic environment directly downstream.

3.3.5 Key Threatening Processes

The Key Threatening Processes (KTPs) listed under the *FM Act* that may be relevant to the effects of the Proposal on aquatic ecology are:

- Degradation of native riparian vegetation along New South Wales watercourses; and
- Instream structures and other mechanisms that alter natural flows.

The following KTPs listed under the *TSC Act* may also be relevant:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.

3.3.6 Protected Species

Australian Grayling, one of the threatened fish species listed under the *EPBC Act* as potentially occurring in the Lithgow City LGA, is listed as a protected species under the *FM Act*. The information on its current distribution range presented in Section 3.1.2.1 indicates this species is highly unlikely to occur within the Application Area.

The search of the Bionet website for the Atlas of NSW Wildlife indicated that two semi-aquatic mammals, the platypus (*Ornithorhynchus anatinus*) and water rat (*Hydromys chrysogaster*), that are listed as protected under the *TSC Act* occur within the Lithgow City LGA. According to the Bionet records, Platypuses have been observed in the Coxs River upstream and downstream of the Application Area. Water Rats have not been observed in the Application Area or surrounding waterways.

3.3.7 Critical Habitat

None of the critical aquatic habitats listed under the *TSC Act* or *FM Act* are found within the Application Area.

3.4 GROUNDWATER DEPENDENT ECOSYSTEMS

The definition and classification of GDEs adopted in this report are those from the *Risk Assessment Guidelines for GDEs* produced by the NSW Office of Water (Serov *et al. 2012*). GDEs are ecosystems in which the species composition and natural ecological processes are wholly or partially determined by groundwater. The classification scheme recognises three broad types of GDEs associated with underground ecosystems:

- Karst and caves;
- Subsurface phreatic aquifer ecosystems; and
- Baseflow stream (hyporheic or subsurface water ecosystems).

And four broad types of GDEs associated with above ground ecosystems:

- Groundwater dependent wetlands;
- Baseflow streams (surface water ecosystems);
- Estuarine and near shore marine ecosystems; and
- Phreatophytes – Groundwater dependent terrestrial ecosystems.

Each of these GDE types comprises a number of distinct subtypes.

The Proposal could potentially impact on two GDEs:

- Baseflow streams (surface water ecosystems); and
- Subsurface phreatic aquifer ecosystems.

3.5 SUMMARY OF CONSERVATION ISSUES AND LIKELIHOOD OF OCCURRENCE

The aquatic threatened species that could potentially occur and their likelihood of occurrence within the Application Area are summarised in **Table 3-1**. Likelihood of occurrence was determined by examining historical species records, published distributions and habitat preferences and using professional judgement.

Table 3-1 Relevant aquatic species and communities listed as threatened under state and federal legislation

Species name	*TSC Act* status	*FM Act* status	*EPBC Act* status	Likelihood of occurrence
Australian Grayling			Vulnerable	Unlikely
Murray Cod			Vulnerable	Unlikely
Trout Cod		Endangered		Unlikely
Silver Perch		Vulnerable		Unlikely
Macquarie Perch		Endangered	Endangered	Possible
Adams Emerald Dragonfly		Endangered		Unlikely
Sydney Hawk Dragonfly		Endangered		Unlikely
Giant Dragonfly	Endangered			Unlikely

3.6 EXISTING ENVIRONMENT - SURFACE WATER ECOSYSTEMS

3.7 INTRODUCTION

In this section, information is presented on the three sub-catchments adjacent to the Application Area, rainfall and stream hydrology, water quality, aquatic habitats, aquatic flora and fauna of the watercourses that could potentially be impacted by the Proposal. The information on water quality and aquatic ecology is derived from the aquatic macroinvertebrate monitoring undertaken since 2005 in compliance with the original development consent (Condition 18(c) of DA 103/94) for Austen Quarry (The Ecology Lab 2006, 2007 and 2008; Cardno Ecology Lab 2009, 2010 and 2011), biological monitoring in the Coxs River conducted on behalf of Energy Australia (formerly Delta Electricity) from 2002 to 2013 and a field-based investigation undertaken in September 2013 by Cardno. A brief outline of the sites and methods used in the monitoring programs has been included in Section 4.2 to assist the reader. Further details are presented in **Appendix A**.

3.8 OVERVIEW OF STUDY SITES AND SAMPLING PROGRAMS

Aquatic macroinvertebrate monitoring in relation to Austen Quarry was undertaken at paired sites situated at four locations on the Coxs River spread between Glenroy Bridge and Duddawarra Bridge, which are approximately two and a half kilometres north and five kilometres south of the Application Area, respectively. The designation of the study sites and their geographic coordinates are presented in **Table 3-2** and their relative positions are shown in **Figure 3-1**. The macroinvertebrates associated with riffle and pool edge habitats at all four locations were sampled during both spring and autumn in 2005 and 2006, but only in spring from 2007 to 2011 and at the Quarry Treatment, Upstream Control and Quarry Control locations. Water quality was also assessed during these monitoring events.

Sites 1, 2, 5, 7 and 9 were sampled for macroinvertebrates, fish and water quality during the 2013 event, with an additional site (Site 11) sampled downstream of the Coxs River South Catchment. Additional sites on a North Catchment tributary (NC1) and South Catchment Tributary (SC1) were also sampled for water quality only.

Table 3-2 Site descriptions and GPS coordinates

Location	Site Number	Easting	Northing
Upstream Control	4	234697	6284142
	5*	235071	6283998
Quarry Control	6	235270	6283394
	7*	234953	6282535
	8	235110	6282200
Quarry Treatment	1*	236445	6281702
	2*†	236812	6281523
	3	236926	6281331
Downstream Control	9*	236532	6276035
	10	236725	6276152
South Catchment (Coxs River)	11*	237075	6280218
North Catchment Tributary	NC*	236705	6281720
South Catchment Tributary	SC*	236665	6280374

GPS coordinates for site 1-10 taken on the initial survey in April 2005 (Datum: AGD66), other sites data collected in 2013 (WGS84)
* Indicates sites sampled in 2013
† Site 2 at the Quarry treatment location was sampled as the North Catchment (Coxs River) site

Additional information on water quality, aquatic macroinvertebrates and fish occurring near the Glenroy Bridge and Duddawarra Bridge crossings were obtained from the reports on biological monitoring undertaken on behalf of Energy Australia. This included water quality and aquatic macroinvertebrate data from spring 2005, both spring and autumn 2006 to 2009, and spring 2011 to 2013. The fish occurring at these locations were also surveyed in 2006-2012.

The objective of the field-based investigation undertaken for the Proposal in September 2013 was to establish the existing condition of the aquatic environment and its associated biota in the reach of the Coxs River between Glenroy Bridge and Duddawarra Bridge in which the Application Area is located. Eight sites were surveyed. The position of these sites relative to the Stage 2 Site boundary is shown in **Figure 3-1** and their geographic coordinates are presented in **Table 3-2**.

The methods used during the monitoring and/or field-based investigation included:

- Description of surface water habitats and vegetation using the AUSRIVAS habitat assessment (Turak *et al.* 2004), a modified version of the RCE inventory (Chessman *et al.* 1997) with RCE scores of 13-22, 23-32, 33-42 and 43-53, classified as poor, fair, good and excellent, respectively and the NSW DPI fish habitat assessment criteria (DPI 2013) (See **Appendix B** for further details);
- Measurement of temperature, electrical conductivity (EC), salinity, pH, dissolved oxygen (DO) and turbidity just below the surface of the water column;
- Sampling of macroinvertebrates from edge and/or riffle habitats using the NSW Australian Rivers Assessment System (AUSRIVAS) sampling methods (Turak *et al.* 2004); and
- Sampling of fish using a backpack electrofisher.

The EC, DO, pH and turbidity measurements were compared with the upper and lower default trigger values (DTVs) for slightly disturbed rivers in south-east Australia (ANZECC/ARMCANZ 2000). These trigger values provide an indication of risk to environmental value, with measurements within the upper and lower DTV range indicative of a low risk and those outside the range indicating that the environmental value may not be protected.

An assessment of 'creek health' based on the AUSRIVAS predictive modelling software (Coysh *et al.* 2000) was completed. The AUSRIVAS software compares the macroinvertebrates collected at a site (i.e. Observed) to those predicted to occur (i.e. Expected) at undisturbed reference sites with similar environmental characteristics.

Three of the indices generated by the AUSRIVAS model were examined:

- OE50 Taxa Score - This is the ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50 % probability of occurrence. OE50 taxa values range from 0 to greater than 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands derived from OE50 Taxa scores which indicate the level of impairment of the assemblage. These bands are graded as follows:
  - Band X = Richer invertebrate assemblage than reference condition;
  - Band A = Equivalent to reference condition;
  - Band B = Sites below reference condition (i.e. significantly impaired);
  - Band C = Sites well below reference condition (i.e. severely impaired); and
  - Band D = Impoverished (i.e. extremely impaired).
- OE50Signal Score – The AUSRIVAS model also calculates the expected SIGNAL2 score based on the families predicted to occur with a probability of greater than 50% in an otherwise undisturbed reference site. The OE50Signal Score is the ratio of the SIGNAL2 score predicted to that of the sample collected. OE50SIGNAL Score values range from 0 to greater than 1 and provide a measure of the environmental condition of the water based on the sensitivity of the organisms observed in the sample. OE50Signal values close to 0 indicate that the SIGNAL2 score was much lower than expected and values close to 1 indicating a SIGNAL2 score close to that expected by the AUSRIVAS model.

The SIGNAL2 score (Stream Invertebrate Grade Number Average Level), a biotic index that uses information on the occurrence of macroinvertebrate families and their sensitivity to pollution was also used as an indicator of water quality (Chessman 2003).

3.9 SUB CATCHMENTS

The Application Area is located within the Mid-Coxs River sub-catchment of the Hawkesbury-Nepean Catchment. The Coxs River runs along the Application Area boundary to the north and eventually flows to Sydney's drinking water supplies at Lake Burragorang. Disturbance associated with the Quarry occurs within three catchments (refer to **Figure 3-3**).

3.9.1 Coxs River North

The Coxs River North catchment incorporates seven mapped drainage lines with a total area of approximately 107 ha, which flow in a northerly direction into the Coxs River via a series of small ephemeral streams. The Stage 1 extraction area occurs over or upstream of five drainages on the eastern side of the Coxs River North catchment while the secondary processing area occurs over two drainages on the western side. Runoff captured within these catchments is used on site for dust suppression and leaves the Site via evaporation and/or via licensed discharge at nominated points during excess supply.

Areas of these catchments have been highly modified by the existing extraction and processing areas. The Proposal would increase the total disturbed area within this catchment by 3.6 ha. Undisturbed sections of the catchment would remain to the north and northeast of the Stage 1 extraction area (R. W. Corkery 2013).

3.9.2 Coxs River South

The Coxs River South catchment consists of two drainage systems with a total area of approximately 145 ha. The larger catchment incorporates the existing overburden emplacement area and a large proportion of the proposed extraction area extension and flows to the Coxs River via an easterly-oriented stream. This larger drainage system contains 1st and 2nd order waterways within the Application Area and becomes a 3rd order stream outside the Application Area before discharging into the Coxs River. This is the largest sub-catchment drainage contained within the Application Area and the only 3rd order drainage exiting the Site. The smaller catchment flows into the Coxs River, north (upstream) of the larger drainage via an easterly flowing 2nd order stream and is largely outside of the Site.

Currently, 7.8 ha of this catchment has been disturbed by the Quarry, with additional disturbance of 21.8 ha proposed. The catchment would therefore remain largely undisturbed on completion of the Quarry extension (R. W. Corkery 2013).

3.9.3 Yorkeys Creek

This catchment has a total area of 761 ha and receives drainage from the Yorkeys Creek stockpile area and a small section of the Quarry Access Road that passes over the creek. Appropriate sediment and erosion control is currently in place to ensure any discharge to the Coxs River via Yorkeys Creek, meets the criteria of EPL 12323. No changes to area of disturbance are proposed within this catchment as part of the Stage 2 Extension (R. W. Corkery 2013).

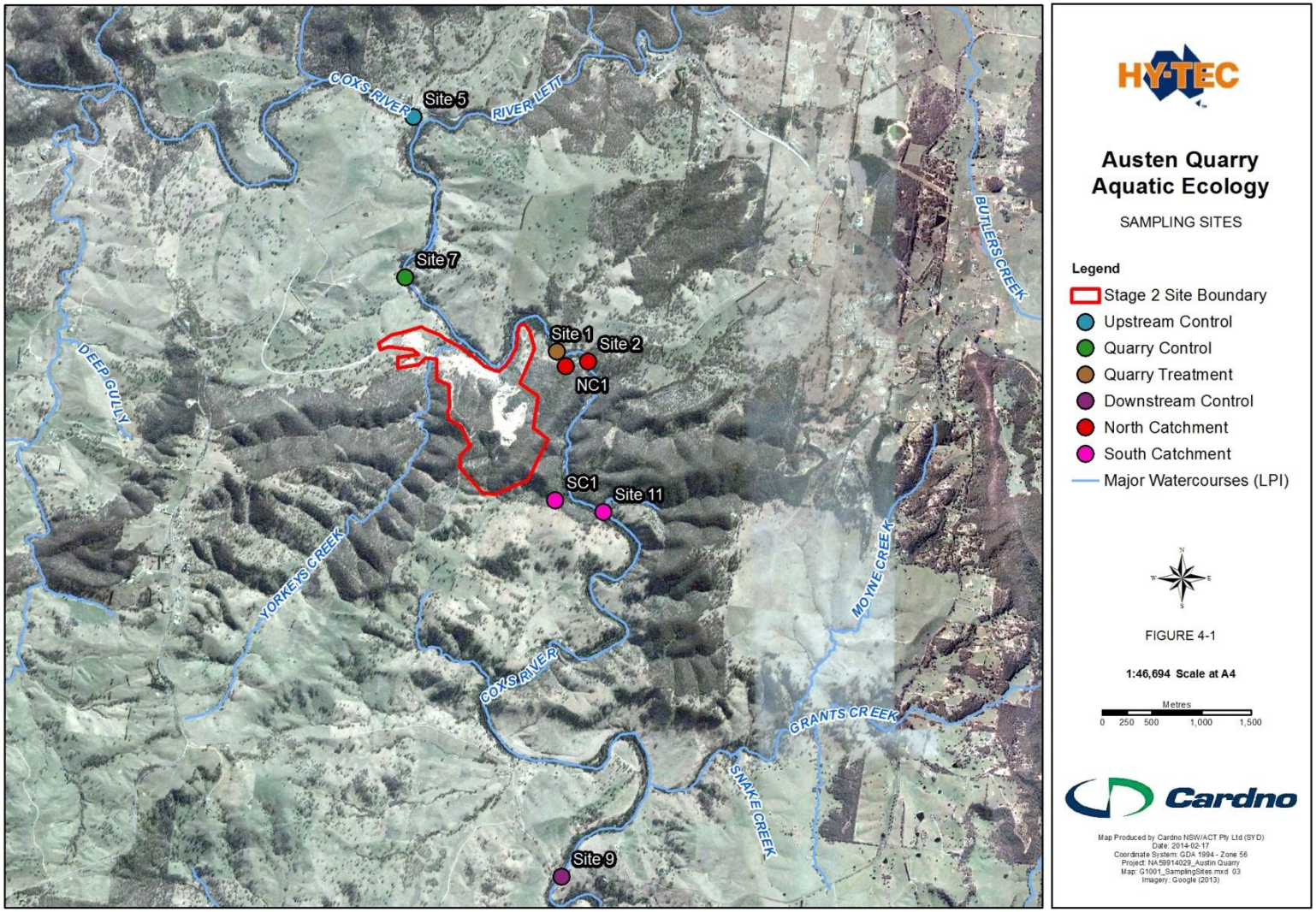


Figure 3-1 Aerial photograph showing sites investigated during the September 2013 sampling event (sites from all surveys can be found in Appendix E)

3.10 RAINFALL AND STREAM HYDROLOGY

Rainfall statistics for the years 1912 to 2013 were sourced from the Bureau of Meteorology (BOM) gauge at the Lithgow Birdwood Street (Station #063224), for the period 1912 to 2006, and Cooewul (Station #063226), from 2006 to 2013, by R. W. Corkery (2013). Mean annual rainfall is 834.6 mm, with the highest rainfall occurring between October and March. Statistically, the highest average rainfall occurs in January (91.5mm). The December to February period of above average rainfall poses the greatest risk for soil erosion.

The flow regime of the section of the Coxs River of interest has been impacted by land clearing, regional climatic variations; and the construction and operation of Lyell Dam (Young *et al.* 2000). Hydrological data were sourced from the NSW Water Information website administered by the NSW Office of Water (2013) for the gauging station on the Coxs River at Lithgow (Station No. 212011), which is located between Lake Lyell and the McKanes Falls Road Bridge. Water level, daily discharge (flow) and cumulative discharge data for the period 2002-2013 are depicted in **Figure 3-2**.

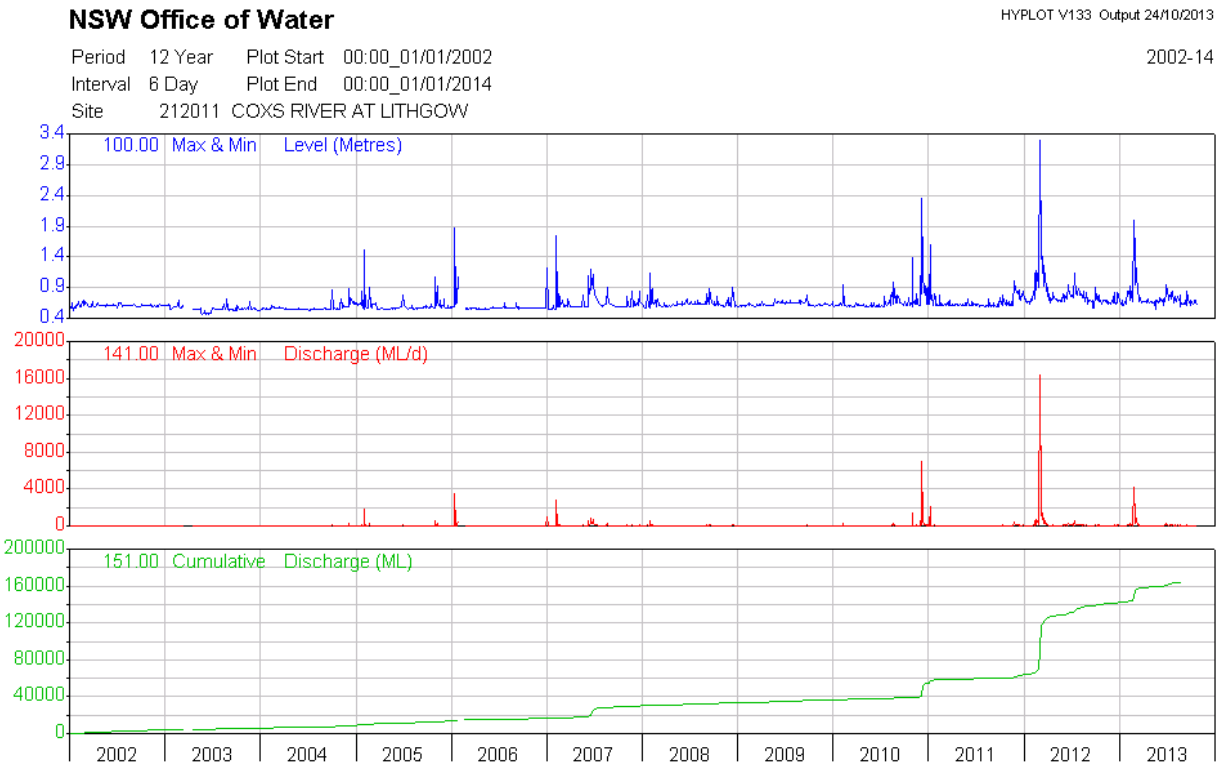


Figure 3-2 Hydrological data for the Coxs River at Lithgow for 2002-2013

The most prominent feature of the hydrological data depicted in **Figure 3-2** is the large increase in discharge after late 2010, compared with preceding years, associated with several large flood events. The substantial increase in discharge is likely to have influenced the aquatic environment and biota, particularly in the weeks and months after these events.

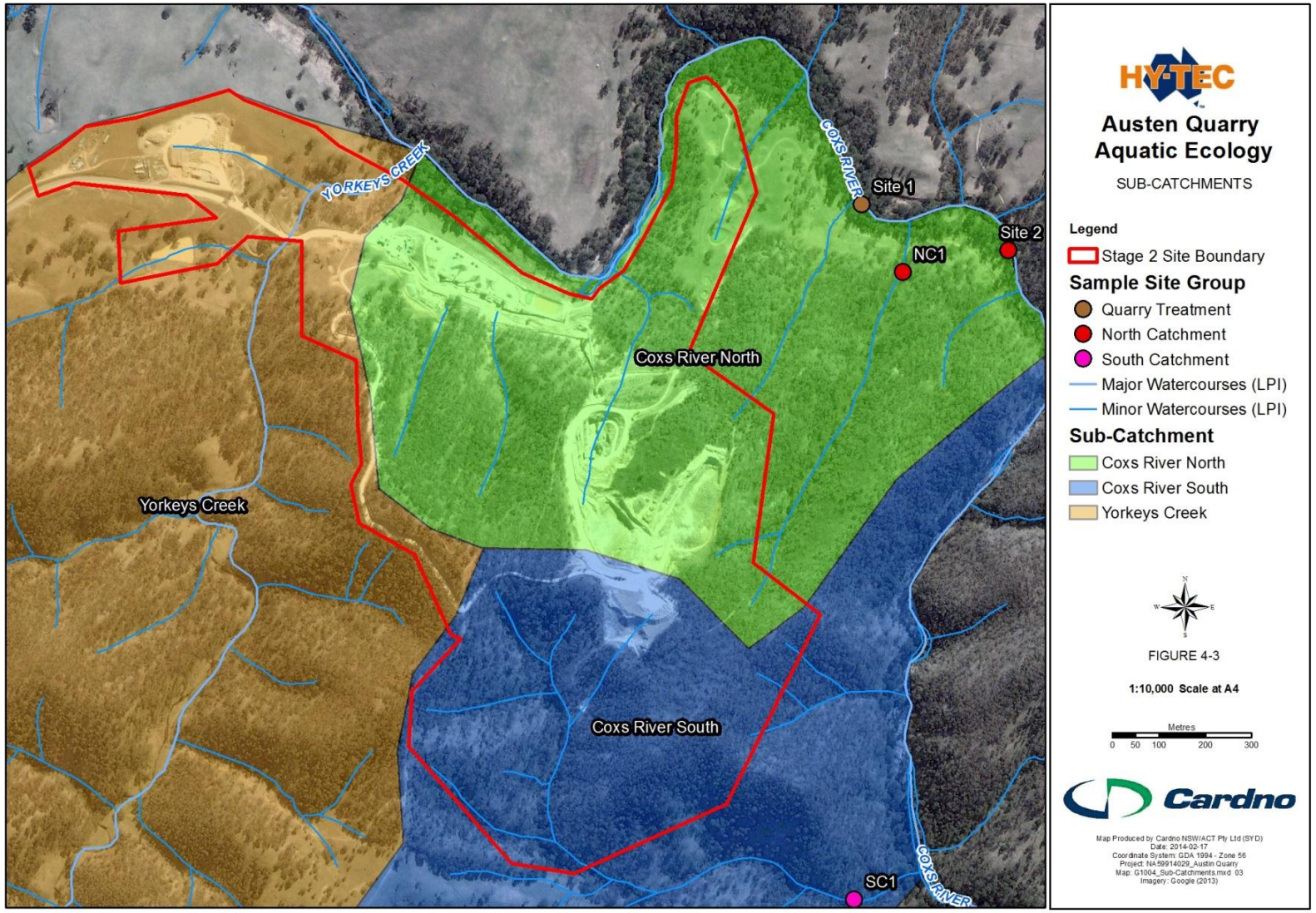


Figure 3-3 Sub-catchments and major watercourses within the Site boundary

3.11 AQUATIC HABITAT

The aquatic habitat at each site visited in 2013 is described below, along with information from literature reviews. The sites (identified on **Figure 3-1**) are listed in order from upstream to downstream. At all sites in the Coxs River, the water level was elevated from base flow conditions at the time of sampling in 2013 and water clarity was poor. All sites on the Coxs River were considered Class 1 (highly sensitive) Type 1 (major) fish habitat. Habitat classification information is provided in **Appendix B**.

3.11.1 Coxs River at the Upstream Control (Site 5)

This site was located in the Coxs River Valley, immediately upstream of the Glenroy Bridge on the Jenolan Caves Road (**Plate 1**). Riffle habitat was present immediately upstream of the bridge to a distance of approximately 50 metres, where the river flowed among large boulders and small grassy islands. A large pool extended upstream of the riffle, with the grassed area of Glenroy Cottages campsite present on the northern bank. The river was approximately five metres wide and around 0.5 metres deep around the riffle at the bridge, becoming deeper (greater than 1 metre) and wider (greater than 20 metres) upstream in the pool. The substratum in the riffle habitat was predominantly large angular to rounded bedrock, boulder and cobble. A larger proportion of finer grained rock, sand and silt was present in the edge habitat. Anoxic sediment was present in the substratum fringing the large pool.

Riparian vegetation consisted of a sparse to moderate canopy of tall to sapling sized river she-oak (*Casuarina cunninghamiana*), sparse shrubs including *Acacia* sp. and extensive groundcover of various grasses and weeds. A sedge (*Carex* sp.) was the dominant emergent aquatic macrophyte along the littoral fringe, with a small stand of cumbungi (*Typha* sp.) also observed on the edge of the large pool. No submerged macrophytes were observed in 2013, probably due to the poor water clarity, although a sparse cover of a number of species has been reported along this stretch of the river (OEH 2010). This site was given RCE scores between 39 and 42 on visits between 2005 and 2007, indicating good quality aquatic habitat, and a score of 41 during the 2013 visit.

3.11.2 Coxs River at the Quarry Control location (Site 7)

This site was located at a ford on the river within farming land, approximately one kilometre northwest of the secondary processing area (**Plate 2**). A large, slow flowing pool was present at the ford around the middle of the site and riffle habitat was present at its upstream and downstream boundaries. The pool was approximately 70 metres long, 25 metres wide and had a maximum depth of one metre. The riffle habitat upstream and downstream was approximately 5 metres wide and 30 to 50 centimetres deep with moderate to rapid flow. The substratum in the riffle habitat was predominantly large rounded bedrock, boulder and cobble, while sand and silt were more dominant in the edge and pool.

Riparian vegetation consisted of a moderate canopy of tall *Casuarina cunninghamiana*, few shrubs and extensive grass and weed groundcover. Moss and various emergent macrophytes were present along the banks, with *Carex* sp. dominant. The submerged aquatic macrophyte *Potamogeto*n sp. was found in the sample net but not observed due to poor water visibility. Common Eastern Froglets (*Crinia signifera*) were audible during the 2013 visit. This site received an RCE score of between 35 to 44 on visits between 2005 and 2007, indicating good to excellent quality aquatic habitat, and a score of 41 during the 2013 visit.

a)

b)

c)

d)

Plate 1 Coxs River at Glenroy Bridge (Site 5), 18 September 2013: a) looking downstream from the middle of the site at bridge and riffle habitat; b) looking upstream from the middle of the site at riffle habitat; c) looking downstream from the bottom of the site at riffle and pool habitat; and, d) looking upstream from near the top of the site at pool habitat and the Glenroy Cottages camping ground.

a)

b)

c)

d)

Plate 2 Coxs River at the Quarry Control (Site 7), 17 September 2013: a) looking downstream from the middle of the site at pool habitat; b) looking upstream from the middle of the site at pool habitat; c) looking downstream from the bottom of the site at riffle habitat; and, d) looking upstream from the top of the site at riffle habitat.

a)

b)

c)

d)

Plate 3 Coxs River at the Quarry Treatment (Site 1), 17 September 2013: a) looking downstream from the middle of the site at riffle habitat; b) looking upstream from the middle of the site at pool habitat; c) looking downstream from the bottom of the site at riffle habitat; and, d) looking upstream from the top of the site at riffle habitat.

3.11.3 Coxs River at the Quarry Treatment location (Site 1)

This site was located in the Coxs River valley to the north of the extraction area, within the Coxs River North catchment (**Plate 3**). Moderate to rapid flowing riffle habitat extended across most of the site, with a short, wide pool near the centre. The stream width was less than five metres in some sections of riffle but increased to greater than 10 metres in the pool. Stream depth was generally less than 50 centimetres in the riffle and deeper in the pool. The substratum in the riffle habitat was predominantly large rounded bedrock, boulder and cobble, while gravel, sand and silt were more dominant in the edge and pool.

Riparian vegetation consisted of a moderate canopy of tall *Casuarina cunninghamiana*, some *Salix* sp. (willows), few shrubs and extensive grass and weed groundcover. Various emergent macrophytes were present along the banks, with *Carex* sp. dominant. Common Eastern Froglets (*Crinia signifera*) were audible during the 2013 visit. This site received an RCE score of between 39 to 45 on visits between 2005 and 2007, indicating good to excellent quality aquatic habitat, and a score of 43 during the 2013 visit.

3.11.4 Unnamed Tributary of the Stage 2 Extension North Catchment (Site NC1)

This site was located on a small, unnamed, 2nd order drainage on the eastern side of the Coxs River North catchment, upstream of the 4WD access track and approximately 100 metres upstream of the confluence with the Coxs River (**Plate 4**). A small pipe culvert was in place at the 4WD crossing. This site had not been visited during monitoring events. The drainage consisted of a series of small pools (approximately 1-2 metre diameter, less than 1 metre deep) that were semi-connected by a trickle of flow at the time of sampling. The flow was almost certainly ephemeral considering the size of the catchment, although the pools may have persisted for some time during dry weather. Approximately 50 metres upstream of the road sub-surface interflow was apparently occurring, as surface flow was not observed. The substratum in the pools appeared to be fine material dominated by silt as indicated by the banks. Water clarity was very poor at the time of sampling.

Riparian vegetation was dominated by a sparse canopy cover of *Eucalyptus* sp. and some smaller native shrubs including tea-tree (*Leptospermum* sp.). The understorey consisted of a variety of grasses, with mat-rush (*Lomandra* sp.) being dominant upstream where the surface flow was absent. Vegetation upstream along the centre of the drainage appeared to be relatively undisturbed with less tree cover and more low grasses. Water Striders (Gerridae) and Backswimmers (Notonectidae) were observed in one of the larger pools indicating the semi-permanence of this habitat. This and the other tributaries within the Coxs River North catchment were not considered to be sensitive fish habitat (Type N/A) as they are ephemeral 1st and 2nd order streams. They were considered Class 3 (minimal) fish habitat close to the Coxs River and Class 4 (unlikely) fish habitat further upstream according to the NSW DPI (2013) Policy and Guidelines for Fish Habitat Conservation and Management. This location received an RCE score of 35, indicating good quality aquatic habitat.

a)

b)

c)

d)

Plate 4 Unnamed Tributary within the North Catchment (Site NC1), 17 September 2013: a) looking at trickle flow through the small pipe culvert under the four wheel drive access road; b) looking downstream at small pool directly upstream of the four wheel drive access road; c) looking upstream at small pools along the drainage line; and, d) looking upstream along the dry surface of the drainage line.

a)

b)

c)

d)

Plate 5 Coxs River downstream of the North Catchment Unnamed Tributary (Site 2), 17 September 2013: a) looking downstream from the middle of the site at pool habitat; b) looking upstream from the middle of the site at riffle habitat; c) looking downstream from the bottom of the site at riffle habitat; and, d) looking upstream from the top of the site at riffle habitat.

3.11.5 Coxs River downstream of the North Catchment Unnamed Tributary (Site 2)

This site was located at a small ford on the Coxs River, approximately one kilometre to the northeast of the extraction area, near the boundary of the Coxs River North and South catchment areas (**Plate 5**). A pool was present near the upstream extent of the site before the river split into two channels along a riffle section upstream of the ford, followed by another pool at the ford and another riffle downstream. The river was approximately 2-3 metres wide at several sections of riffle and greater than 10 metres wide at the pool containing the ford. Water depth was similar to that of the upstream sites. An isolated area of standing water was present in an alluvial depression on the southern bank, constituting lateral aquatic habitat that would be connected during higher flows. Substratum was predominantly large rounded bedrock, boulder and cobble in the riffle habitat, while gravel, sand and silt were more dominant in the edge and pool.

Riparian vegetation consisted of a moderate canopy of tall *Casuarina cunninghamiana* and extensive grass and weed groundcover. Various emergent macrophytes were present along the banks, with *Carex* sp. dominant. This site received an RCE score of between 39 to 44 on visits between 2005 and 2007, indicating good to excellent quality aquatic habitat, and a score of 43 during the 2013 visit.

3.11.6 Unnamed Tributary of the Stage 2 Extension South Catchment (Site SC1)

This site was located along the channel of the larger of the Coxs River South catchment waterway, close to the confluence with the Coxs River (**Plate 6**). This site had also not been visited previously. The drainage consisted of small pools (maximum diameter of approximately 2 metres and 50 centimetres deep) that were interconnected at the time of observation by a flow of approximately 2 litres per second. Substratum was primarily boulder and cobble, with some pebble, sand and silt also present. A large gravel, sand and silt bar formed by deposited material from the catchment protruded into the Coxs River at the confluence point. Moderate bank undercutting was observed along the channel upstream of this point.

Riparian vegetation was *Eucalyptus* sp. woodland with some shrub cover and a grassy understorey. Several tall *Casuarina cunninghamiana* were present closer to the Coxs River confluence, where weeds, including Blackberry (*Rubus fruticosus* spp. agg.) and Willow (*Salix* sp.), were more common. Some green alga was present in some pools. The tributary at this location was considered a Type 3 (minimally sensitive), Class 3 (minimal) fish habitat according to the NSW DPI (2013) Policy and Guidelines for Fish Habitat Conservation and Management. Upstream of this location where the creek becomes a 2nd and 1st order tributary, fish habitat classification was reduced to Type N/A, Class 3 and/or 4. This location received an RCE score of 35, indicating good quality aquatic habitat.

a)

b)

c)

d)

Plate 6 Unnamed Tributary of the Stage 2 Extension South Catchment (Site SC1), 18 September 2013: a) looking upstream along the Coxs River at the sediment bar at the tributary confluence; b) looking downstream at a larger pool on the creek line; c) looking downstream along the creek line, with at pool habitat; and, d) looking upstream at another pool and small waterfall approximately 200 metres upstream from the Coxs River.

a)

b)

c)

d)

Plate 7 Coxs River downstream of the South Catchment Unnamed Tributary (Site 11), 18 September 2013: a) looking downstream from the middle of the site at pool habitat; b) looking upstream from near the top of the site at riffle habitat; c) looking downstream near the top of the site at pool habitat; and, d) looking upstream the top of the site at riffle habitat.

a) 

b) 

c) 

d) 

Plate 8 Coxs River at the Downstream Control location (Site 9), 18 September 2013: a) looking downstream from near the top of the site riffle habitat; b) looking upstream from the middle of the site at riffle habitat; c) looking downstream from the bottom of the site at pool habitat; and, d) looking upstream from near the top of the site at pool habitat and the Duddawarra bridge.

3.11.7 Coxs River downstream of the South Catchment Unnamed Tributary (Site 11)

This site was located at a small ford on the Coxs River, in relatively dense riparian forest approximately one kilometre to the southeast of the extraction area (**Plate 7**). This site also had not been visited previously. A large (approximately 10-15 metres wide), slow moving pool spanned the centre of the site at the ford, with two narrower (5-10 metre wide) riffle sections immediately upstream. The water depth was similar to that of the upstream sites and appeared to be deeper in the pools. A large (30-50 metres wide) deep (greater than 1 metre deep) pool extended for several hundred metres upstream of the confluence with the South Catchment tributary. The substratum was similar to that of the sites upstream, being dominated by rocky substratum in the riffle but with a greater proportion of finer material in the pool and edge habitat.

Riparian vegetation consisted of a moderate canopy of tall *Casuarina cunninghamiana* and extensive grass and weed groundcover. Various emergent macrophytes were present along the banks, with *Carex* sp. dominant and some *Lomandra* sp. and *Juncus* sp. also present. This location received an RCE score of 45, indicating excellent quality aquatic habitat.

3.11.8 Coxs River at the Downstream Control location (Site 9)

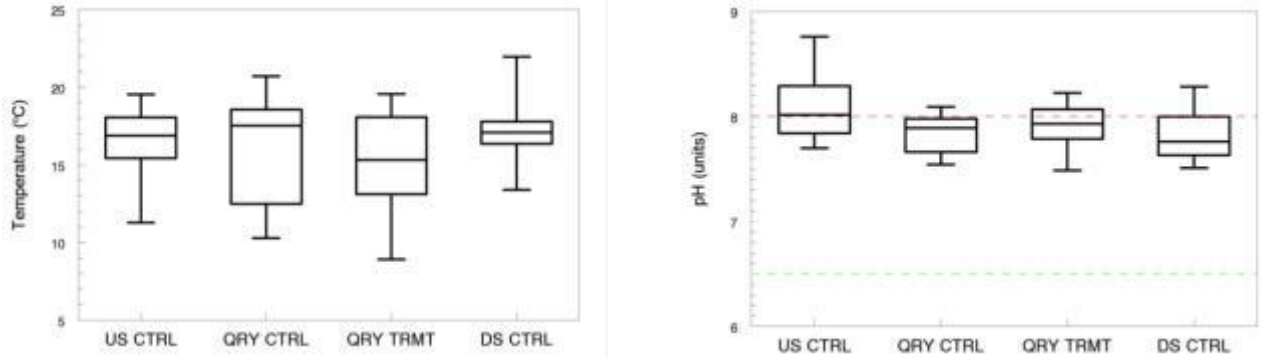
This site was located on the Coxs River, immediately downstream of the Duddawarra Bridge on the Coxs River Road (**Plate 8**). A large, (10-15 metres wide, greater than 1 metre deep) slow moving pool extended across the upstream section of the site to the bridge and a long riffle section extended downstream through a slightly narrower, shallower section of the river. Areas of laterally connected habitat were submerged along the eastern bank at the time of sampling. Substratum was similar to that of the sites upstream, consisting predominantly of rounded boulder and cobble in the riffle and a greater proportion of pebble, gravel, sand and silt in the pool and edge.

Riparian vegetation consisted of a moderate to dense canopy of *Casuarina cunninghamiana* along the high water mark, with some younger saplings also present. The understorey was dominated by a variety of herbs and grasses, including *Lomandra* sp., buttercup (*Ranunculus* sp.) and *Rumex* sp. Frogs were audible at this site during the 2013 visit. This site received an RCE score of between 37 to 45 between 2005 and 2006, indicating good to excellent quality aquatic habitat, and a score of 42 during the 2013 visit.

3.12 WATER QUALITY

Water quality data for each of the locations outlined in **Table 3-2** are presented below as box and whisker plots with locations listed in order from upstream to downstream. The top and bottom of each box, middle horizontal line and top and bottom 'whiskers' represent the 1st and 3rd quartile (25th and 75th percentile), the median value and the 95th and 5th percentiles, respectively. The number of samples (n) per location varies, as data have been derived from two projects with different levels of spatial and temporal replication. Note that 'n' is always greater at the 'Upstream Control' and 'Downstream Control' locations than at the 'Quarry Control' and 'Quarry Treatment' locations, as sites within the former groups were sampled in both the Austen Quarry monitoring and the Energy Australia monitoring of the Coxs River. For this reason, comparison between locations is to some extent biased by different levels of replication.

The majority of water temperature measurements collected at sites along the Coxs River were between 10 and 20 °C (refer to **Figure 3-4a**). The variability in water temperature data reflects diurnal and seasonal trends and individual site characteristics, i.e. river shading.

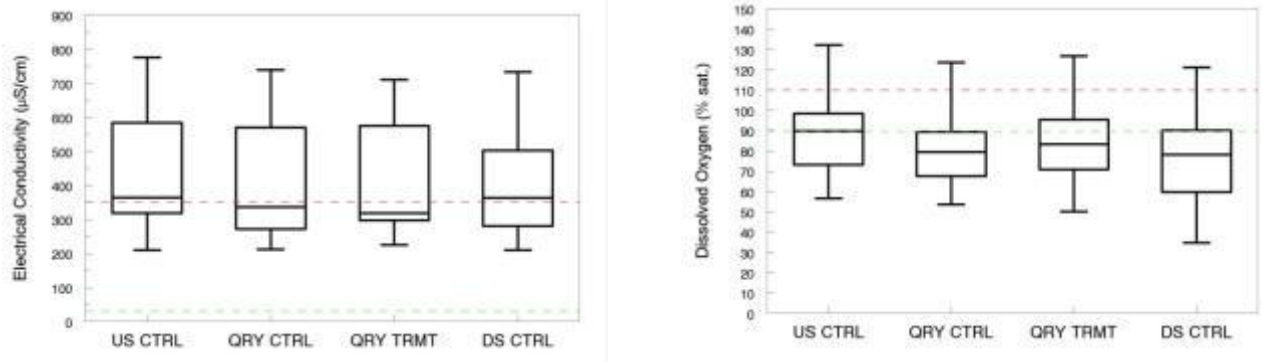


a) **b)**

Figure 3-4 Box and whisker plots for a) temperature and b) pH measurements collected from sites on the Coxs River between 2005 and 2013

The majority of pH measurements ranged between 7.5 and 8.5 units (refer to **Figure 3-4b**). The most alkaline values were recorded in the 'Upstream Control' group (95th percentile of around 8.8 pH units). The 95th percentile pH measurement indicates the upper ANZECC/ARMCANZ (2000) default guideline was occasionally exceeded at all site groups. Exceedances were most common in the 'Upstream Control' group, where the 1st quartile and median value were above the upper guideline and in the 'Quarry Treatment' group, where the 1st quartile was above the upper guideline.

Electrical conductivity measurements were generally in the range of 200 to 800 µS/cm (refer to **Figure 3-5a**). The 95th percentile and 1st quartile electrical conductivity statistics for all groups were well above the upper ANZECC/ARMCANZ (2000) default guideline indicating exceedances were common. A slight reduction in the 95th percentile is evident between the 'Upstream Control' and 'Quarry Treatment' groups followed by marginal elevation in the 'Downstream Control' group.



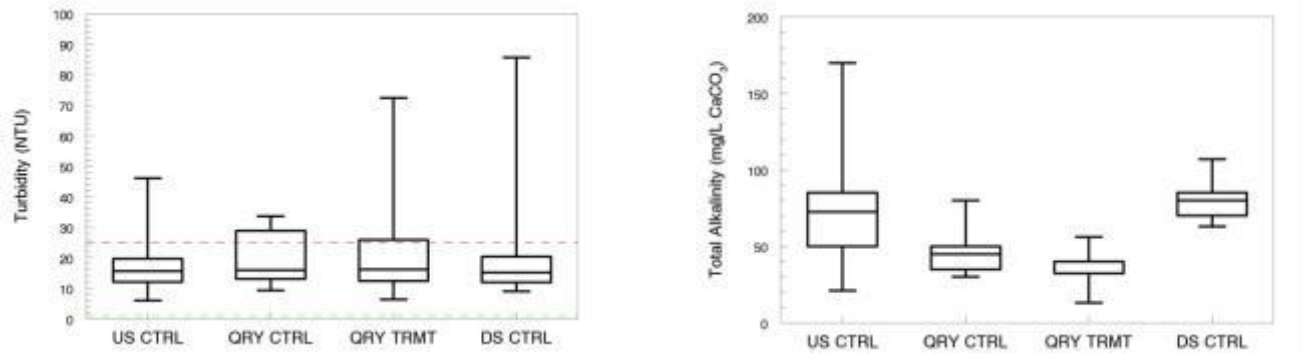
a) **b)**

Figure 3-5 Box and whisker plots for a) electrical conductivity and b) dissolved oxygen measurements collected from sites on the Coxs River between 2005 and 2013

The majority of dissolved oxygen measurements were between 50 and 120 % saturation, with all groups recording supersaturated (greater than 100 % saturation) oxygen concentrations on occasions, as indicated by the 95th percentile values (refer to **Figure 3-5b**). Dissolved oxygen

levels in all groups were generally below the lower ANZECC/ARMCANZ (2000) default guideline, this being most pronounced in the 'Quarry Control' and 'Downstream Control' groups, with the latter showing the lowest 3rd quartile and 5th percentile values of around 60 and 35 % saturation respectively.

The majority of turbidity measurements were between 5 and 50 NTU (refer to **Figure 3-6a**). Higher values were recorded at the 'Quarry Treatment' and 'Downstream Control' groups, with 95th percentile values of around 70 and 85 NTU respectively. The majority of turbidity measurements were within the ANZECC/ARMCANZ (2000) default guidelines, as indicated by the position of the median, 3rd quartile and 5th percentile values of all groups. Exceedances were more common at the 'Quarry Control' group (1st quartile above the upper default guideline level) although the magnitude of exceedance was greater at the site groups downstream of the Quarry (greater 95th percentile and 1st quartile range). Note that the turbidity values depicted have been transformed to remove negative values and that the accuracy of measurements below 10 NTU is poor due to the use of *in-situ* optical probes.



a) **b)**

Figure 3-6 Box and whisker plots for a) turbidity and b) total alkalinity measurements collected from sites on the Coxs River between 2005 and 2013

Total alkalinity measurements show a trend of reduction in the 95th percentile and interquartile range between the 'Upstream Control' and 'Quarry Treatment' groups (refer to **Figure 3-6b**). Total alkalinity at the 'Downstream Control' group is markedly greater than at the 'quarry treatment' group located closest upstream.

3.13 AQUATIC FLORA

The occurrence of submerged aquatic macrophytes could not be documented during the 2013 monitoring event due to elevated water turbidity. The fringing emergent macrophytes and riparian vegetation observed at each of the sites visited are outlined in the site descriptions in **Section 3.11**. A basic map showing the riparian vegetation occurring at sites upstream and downstream of the main sediment basin and licensed discharge point on the eastern end of the secondary processing area is presented in **Appendix D**.

3.14 AQUATIC FAUNA

3.14.1 Macroinvertebrates

The AUSRIVAS results for each location outlined in **Table 3-2** are presented below as box and whisker plots (See Section 4.5 for further explanation). The green, orange and red lines in **Figure 3-7** and **Figure 3-8** represent the upper thresholds for the AUSRIVAS spring season model Bands A, B and C, respectively. Note that the bands displayed are for spring but the OE50 scores are for spring and autumn surveys. The bands for autumn would be slightly different. Raw data and summary statistics are provided in **Appendix D**.

3.14.1.1 Edge Habitat

The median and 75th percentile OE50 taxa scores for edge habitat were all within AUSRIVAS Band A, indicating that the majority of samples collected from the four locations were equivalent to the reference condition (refer to **Figure 3-7a**). The median AUSRIVAS OE50 taxa scores, however, were below 1, indicating that fewer taxa were observed at all locations than expected by the AUSRIVAS model. The 5th and 25th percentile OE50 taxa scores for all locations were within Band B. The Quarry Control and Downstream Control locations occasionally had a richer macroinvertebrate assemblage than the reference condition, as shown by the 95th percentile AUSRIVAS OE50 taxa scores extending above the upper Band A threshold. The lowest OE50 taxa scores were recorded at the Downstream Control location, with the 5th percentile close to the upper Band C threshold (refer to **Figure 3-7a**).

a) **b)**

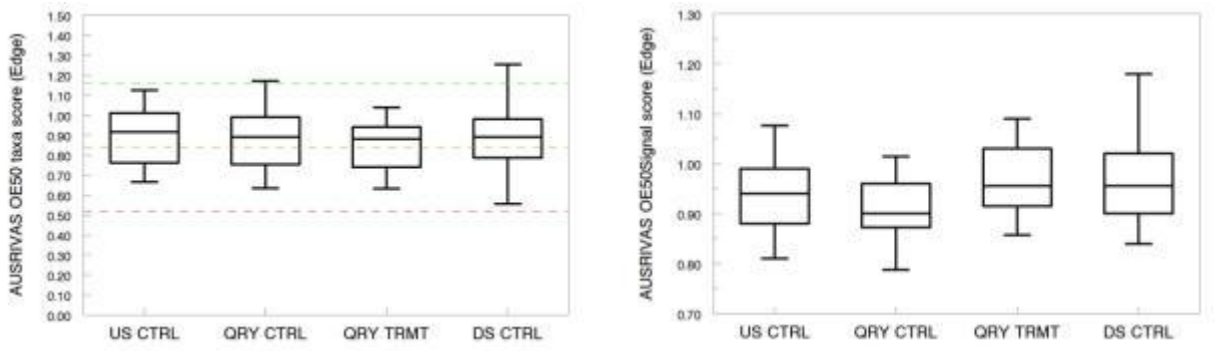


Figure 3-7 Box and Whisker plots of a) AUSRIVAS OE50 taxa scores and b) AUSRIVAS OE50 SIGNAL scores for edge fauna sampled between 2005 and 2013.

The median OE50 SIGNAL scores for all locations were also less than 1. This shows that the majority of samples collected had an OE50SIGNAL score less than that of an equivalent AUSRIVAS reference condition waterway (refer to **Figure 3-7b**). OE50 SIGNAL scores were slightly higher at the Quarry Treatment and Downstream Control locations than the Upstream Control and Quarry Control locations, as indicated by the inter-quartile range (25th to 75th percentile). The Downstream Control location and Quarry Control location had the highest and lowest OE50 SIGNAL scores, respectively, as indicated by the 95th percentile and 5th percentile values (refer to **Figure 3-7b**).

There are no obvious spatial trends in the macroinvertebrate assemblage data from the 2005-2013 surveys. The monitoring of the edge habitat assemblage over the 2005-2011 sampling period also indicated no consistent patterns in variability (Cardno 2011). Cardno (2011) did, however, note that the edge fauna at the Quarry Treatment was significantly impaired relative

to that at both Control locations during one of the seven surveys undertaken and that this may have been due to a transient impact of activities at the Quarry. In 2013, the edge fauna at the Upstream Control and Quarry Control locations was significantly impaired (Band B) relative to that at the Quarry Treatment and Downstream Control locations which were either equivalent to more rich than the AUSRIVAS reference condition (Band A or X).

3.14.1.2 Riffle Habitat

The median OE50 taxa scores for the Upstream Control, Quarry Control and Quarry Treatment locations are all within Band A, showing the majority of riffle samples collected were equivalent to the reference condition, whereas that for the Downstream Control was placed just within in Band B, indicating impairment relative to the reference condition. The OE50 taxa scores increase from the Upstream Control to the Quarry Treatment, but decline at the Downstream Control (refer to **Figure 3-8a**). The Quarry Treatment and Downstream Control locations had the, highest and lowest OE50 taxa scores, respectively, as indicated by the 95th percentile and 5th percentile values (refer to **Figure 3-8a**).

The median OE50 SIGNAL scores were less than 1 for the Upstream Control, Quarry Control and Downstream Control, indicating that the majority of samples collected from these locations had a SIGNAL2 score less than that of an equivalent AUSRIVAS reference condition waterway (refer to **Figure 3-8b**). The median OE50 SIGNAL score for riffle habitat at the Quarry Treatment group, however, was close to 1. The OE50 SIGNAL score for riffle samples showed a slight increase moving downstream between the Upstream Control and Quarry Treatment locations. The Downstream Control location had the lowest AUSRIVAS OE50 SIGNAL scores, with a 5th percentile value of approximately 0.8 (refer to **Figure 3-8b**).

The downstream trend in the riffle fauna between the Upstream Control and the Quarry Treatment locations was also evident in the 2005-2011 data (Cardno 2011). This trend is the opposite of what would be expected for an impact related to the Quarry.

Cardno (2011) noted that the variability in the fauna was not consistent across the two habitats, with the variation in the edge assemblages among locations depending on the year considered, while that in riffle fauna differed only among surveys and locations. Spatial and temporal variability in the macroinvertebrate fauna is likely to be due to a range of factors, including climatic changes, releases from the dams, catchment land use change and licenced discharges. Even with knowledge of these likely sources of change, spatial and temporal variability in the macroinvertebrate fauna over time is difficult to interpret.

a) **b)**

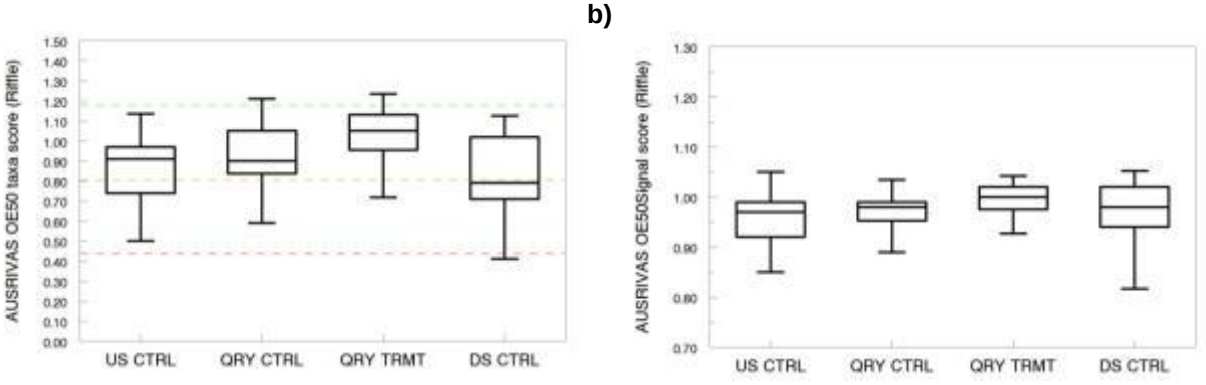


Figure 3-8 Box and Whisker plots of a) AUSRIVAS OE50 taxa scores and b) AUSRIVAS OE50 SIGNAL scores, for riffle habitat collected between 2005 and 2013

3.14.2 Fish

The fish captured during the 2013 survey, along with historical records for the Coxs River and the Hawkesbury Nepean catchment, are listed in **Table 3-3**. Twenty three species of fish (16 native and 7 exotic) from 13 families were identified as occurring in the Hawkesbury Nepean catchment. Eighteen of these were considered likely to occur in the Coxs River. According to Young *et al.* (2000), the fish fauna is limited to six species and that only one of the native species; the Flat-headed Gudgeon is common. Six species have been captured between the Upstream Control and Downstream Control locations during the 2006-2013 sampling events (Cardno 2013; The Ecology Lab 2008). Mountain Galaxias and Flat-headed Gudgeon are the only native species to have been captured in the vicinity of the Application Area. The Goldfish, Eastern Gambusia, Brown Trout and Rainbow Trout caught are all exotic species.

Macquarie Perch, a species that is listed as endangered under the *FM Act* and the *EPBC Act*, was captured in the mid-Coxs River catchment in the 2008-2010 audit of the Sydney drinking water catchment (OEH 2010). Macquarie Perch have also been captured in the lower reaches of the river closer to Lake Burragorang in 1994 and 2005, according to the threatened and protected species Record Viewer administered by NSW DPI.

Two of the species listed as occurring in the greater Hawkesbury Nepean catchment by the OEH 2010 audit of the Sydney drinking water catchment, Non-parasitic Lamprey and Western Carp Gudgeon, have published distributions that do not include the Hawkesbury Nepean system. These species may have been recorded outside of their range, or may have been misidentified Short-headed Lamprey and other Gudgeon species.

3.14.2.1 Fisheries

The Coxs River is a popular location for recreational fishing, with anglers primarily targeting the introduced Brown and Rainbow Trout in riverine habitats around the Application Area. The Coxs River is considered a general trout stream upstream of its confluence with, but not including, Little River according to the NSW DPI website. Commercial fishing grounds and/or aquiculture farms were not identified within the Coxs River catchment.

Table 3-3 Species of freshwater fish recorded in the region of the proposal or whose published distribution includes the study area

Family Name	Scientific Name	Common Name	Current survey (2013)	Cardno (2012)[1]	The Ecology Lab (2008)[2]	OEH (2010)[3]	Young et al. (2000)[4]	Allen et al. (2003)	McDowall (1996)	Likelihood of occurrence in the Coxs River[5]
Anguillidae	*Anguilla australis*	Short finned eel				s		d	d	Likely (distribution and habitat)
	Anguilla reinhardtii	Long finned eel				s	d	d	d	Likely (distribution and habitat)
Cobitidae	*Misgurnus anguillicaudatus* #	Oriental weatherloach				s		d	d	Likely (distribution and habitat)
Cyprinidae	*Carassius auratus* #	Goldfish		s		s		d	d	Likely (distribution and habitat)
	Cyprinus carpio #	Common carp				s		d	d	Likely (distribution and habitat)
Eleotridae	*Gobiomorphus australis*	Striped gudgeon				s		d	d	Unlikely (prefers lowland habitat)
	Gobiomorphus coxii	Cox's gudgeon				s		d	d	Likely (distribution and habitat)
	Hypseleotris klunzingeri	Western carp gudgeon				s				Unlikely (distribution)
	Hypseleotris galii	Firetail gudgeon				s		d	d	Unlikely (prefers lowland habitat)
	Philypnodon grandiceps	Flathead gudgeon	s			s	d	d	d	Likely (distribution and habitat)
	Philypnodon macrostomus	Dwarf flathead gudgeon				s		d	d	Likely (distribution and habitat)
Galaxiidae	*Galaxias olidus*	Mountain galaxias	s	s	s	s	d	d	d	Likely (distribution and habitat)
Percichthyidae	*Macquaria australasica****	Macquarie perch				s	h	d	d	Likely (distribution and habitat)
	Macquaria novemaculeata	Australian bass				s	h	d	d	Likely (distribution and habitat)

Family Name	Scientific Name	Common Name	Current survey (2013)	Cardno (2012)[1]	The Ecology Lab (2008)[2]	OEH (2010)[3]	Young et al. (2000)[4]	Allen et al. (2003)	McDowall (1996)	Likelihood of occurrence in the Coxs River[5]
Petromyzontidae	*Mordacia praecox*	Non-parasitic lamprey				s				Unlikely (distribution)
	Mordacia mordax	Shortheaded lamprey						d	d	Likely (distribution and habitat)
Percidae	*Perca fluviatilis* #	Redfin perch				s		d	d	Likely (distribution and habitat)
Plotosidae	*Tandanus tandanus*	Freshwater catfish				s		d	d	Likely (distribution and habitat)
Poeciliidae	*Gambusia holbrooki* #	Eastern gambusia			s	s	d	d	d	Likely (distribution and habitat)
Retropinnidae	*Retropinna semoni*	Australian smelt				s		d	d	Likely (distribution and habitat)
Salmonidae	*Oncorhynchus mykiss* #	Rainbow trout		s	s	s	d	d	d	Likely (distribution and habitat)
	Salmo trutta #	Brown trout		s	s	s	d	d	d	Likely (distribution and habitat)
Mugilidae	*Myxus petardi*	Freshwater Mullet					h	d	d	Unlikely (prefers lowland habitat)

*** = endangered species (EPBC Act), # = alien species, s = sampled, h = historically recreation, d = published distribution includes the Hawkesbury Nepean system

[1] Survey completed 2008-2012 in the Coxs River at Upstream Control and Downstream Control locations. [2] Survey completed 2006-2009 in the Coxs River at Upstream Control and Downstream Control locations. [3] Study completed 2008-2010 and includes the drinking water catchments of the Hawkesbury-Nepean and Shoalhaven systems and the. [4] Study area included the lower Coxs River between the Island Hill and Kelpie Point gauges. [5] Likelihood of occurrence was determined by examining historical records, published 'distributions' and 'habitat' preferences. These terms are listed in the table to indicate the rationale for the likelihood of occurrence defined.

3.15 SURFACE WATER ECOSYSTEMS SUMMARY

3.15.1 Water Quality Summary

A summary of the comparisons of water quality data relative to the appropriate ANZECC/ARMCANZ (2000) guidelines is provided in **Table 3-4**. The conclusions are indicative, as default trigger values have not been modified for local conditions.

Table 3-4 Comparison of *in-situ* water quality measurements collected between 2005-2013 against ANZECC/ARMCANZ (2000) guidelines

Location	Electrical Conductivity	pH	Dissolved Oxygen	Turbidity
Upstream Control (Coxs)	↑	↑	↓	✓
Quarry Control (Coxs)	↑	✓	↓	✓
Quarry Treatment (Coxs)	↑	✓	↓	✓
Downstream Control (Coxs)	↑	✓	↓	✓
North Tributary (NC1)	✓	✓	↓	↑
South Tributary (SC1)	↑	✓	↓	↑

Up arrows represent median values above the relevant ANZECC/ARMCANZ (2000) guidelines, down arrows represent vales below the guidelines and ticks represent values within the guidelines. Green highlight represents positive water quality, while orange highlight represents less positive water quality.

All locations on the Coxs River and tributary sites within the north and south catchments frequently had water quality below the ANZECC/ARMCANZ (2000) guidelines for at least one of the constituents measured.

3.15.2 Aquatic Habitat Summary

A summary of aquatic habitat characteristics is provided in **Table 3-5**. Fish habitat Type and Class definitions are provided in **Appendix B**. In all cases, the conclusions reached are indicative only and represent a broad brush approach to aquatic habitat quality.

Table 3-5 Summary aquatic habitat characteristics

Location	RCE Score	Fish habitat sensitivity (Type)	Fish habitat class (Class)
Upstream Control (Coxs)	41	1	1
Quarry Control (Coxs)	41	1	1
Quarry Treatment (Coxs)	43	1	1
Downstream Control (Coxs)	42	1	1
North Tributary (NC1)	35	N/A	3
South Tributary (SC1)	35	3	3

Green highlight represents a better aquatic habitat condition than the orange highlight.

The modified Riparian Channel Environment (RCE) inventory (Chessman *et al.* 1997) indicated the aquatic habitat in the Coxs River was in a better overall condition than in the tributary creeks. All sites on the Coxs River were considered highly sensitive, major fish habitat, whereas the tributary sites generally did not contain important fish habitat.

3.15.3 Aquatic Fauna Summary

The aquatic fauna data is summarised in **Table 3-5**. The scores were classified according to the following thresholds to aid interpretation:

- AUSRIVAS OE50 taxa score: median greater than 0.81 (Band A) = equivalent to reference condition;
- AUSRIVAS OE50 SIGNAL score: median greater than 0.9 = positive indicator of water quality;
- Fish: native fish present = positive indicator of fish communities.

Table 3-6 Summary of aquatic fauna characteristics

Location	OE50 taxa (edge)	OE50 taxa (riffle)	Fish
Upstream Control (Coxs)	Band A	Band A	✓
Quarry Control (Coxs)	Band A	Band A	✓
Quarry Treatment (Coxs)	Band A	Band A	✓
Downstream Control (Coxs)	Band A	Band B	✓
North Tributary (NC1)	N/A	N/A	N/A
South Tributary (SC1)	N/A	N/A	N/A

Green and orange highlights represent healthy and impaired aquatic fauna, respectively.

Aquatic macroinvertebrate fauna indicators in the Coxs River around the Application Area were positive in edge and riffle habitat at most locations. Riffle habitat at the Downstream Control location was the only area that aquatic fauna was considered degraded. Native fish have been observed at all locations in recent sampling. Aquatic fauna information was not available for the North and South tributary locations.

4. EXISTING ENVIRONMENT - GROUNDWATER ECOSYSTEMS

4.1 GROUNDWATER HYDROGEOLOGY AND WATER QUALITY

Groundwater hydrogeology investigations for the Proposal have been conducted by Ground Doctor Pty Ltd (2014). The standing water level within the extraction area was estimated to be approximately 730m AHD and appears to be correlated with surface elevation, i.e. is mounded beneath ridgelines but presents at the surface as springs and seepage along valleys. The mounding effect is due to limited permeability within the fractured rock aquifer. Recharge is thought to occur from rainfall on elevated ridges, with percolation of a small proportion of this water into the local, shallow aquifers. Percolating water may recharge the deeper, regional aquifers. Groundwater within the mounded area beneath the ridgelines is understood to be disconnected from aquifers of surrounding ridges due to deeply incised valleys (Ground Doctor 2014).

Groundwater quality from the Site has not been assessed. Data provided in logs of registered groundwater bores in the local area describe the quality is “good” or “fresh”, indicating that it would be suitable for potential beneficial uses with respect to dissolved salt concentrations.

4.2 GROUNDWATER DEPENDENT ECOSYSTEMS

Schedule 4 of the Water Sharing Plan lists GDEs within the Greater Metropolitan Region Groundwater Sources area, including the Coxs River Fractured Rock groundwater source. None of the GDEs currently listed in the Water Sharing Plans occur within the Application Area.

The Atlas of GDEs on the Bureau of Meteorology website was accessed during the desktop assessment. The Atlas of GDEs uses spatial environmental data to indicate potential interaction between groundwater and both terrestrial vegetation communities (phreatophytes) and surface aquatic ecosystems (baseflow streams). The Atlas of GDEs does not provide information on sub-surface GDEs in the vicinity of the Application Area.

4.2.1 Surface Groundwater Dependent Ecosystems

According to the Atlas of GDEs, the Coxs River and Yorkeys Creek are surface water ecosystems with a moderate to high potential for groundwater interaction (refer to **Figure 4-1**).

The Atlas of GDEs also identifies, at a coarse desktop level, vegetation communities with a low to high potential for groundwater interaction have been identified within the Proposal Application Area (refer to **Figure 4-2**). A Terrestrial Ecology Assessment completed for the Stage 2 Extension by Niche Environment & Heritage (Niche, 2014) assessed the likely groundwater dependence of the vegetation communities on and adjacent to the Site. Niche (2014) confirms that only the River Oak riparian forest vegetation community which occurs within the riparian zone, equivalent to the areas noted on **Figure 4-1**, as having high potential for groundwater interaction, could be influenced by changes to local base flows. However, Niche (2014) notes that in such a steep landscape, seasonal flows and storm surges during high rainfall events are far more deterministic of the condition of this vegetation than base flows of groundwater.

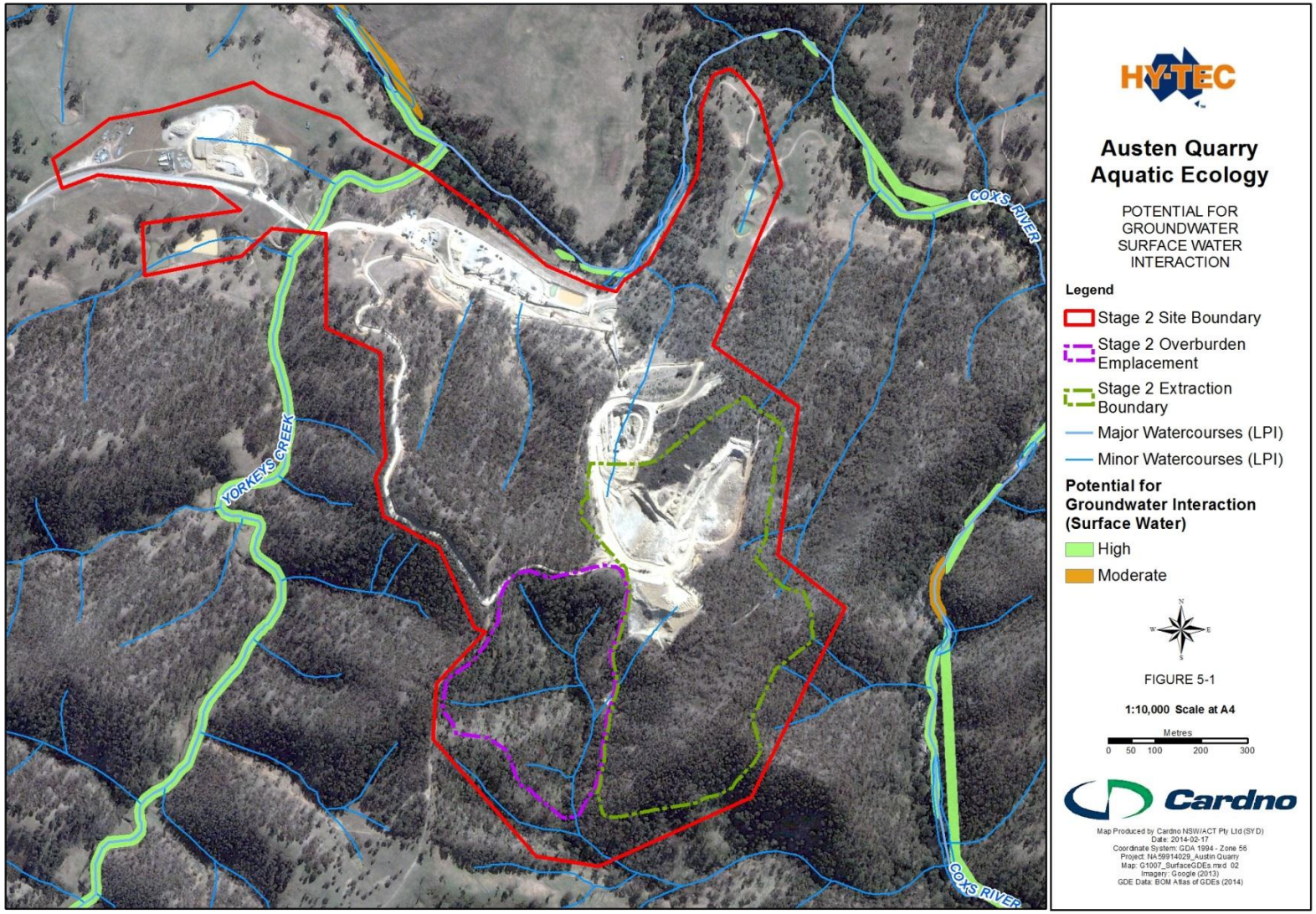


Figure 4-1 Map of the potential for interaction between surface water ecosystems and groundwater in the vicinity of the project area

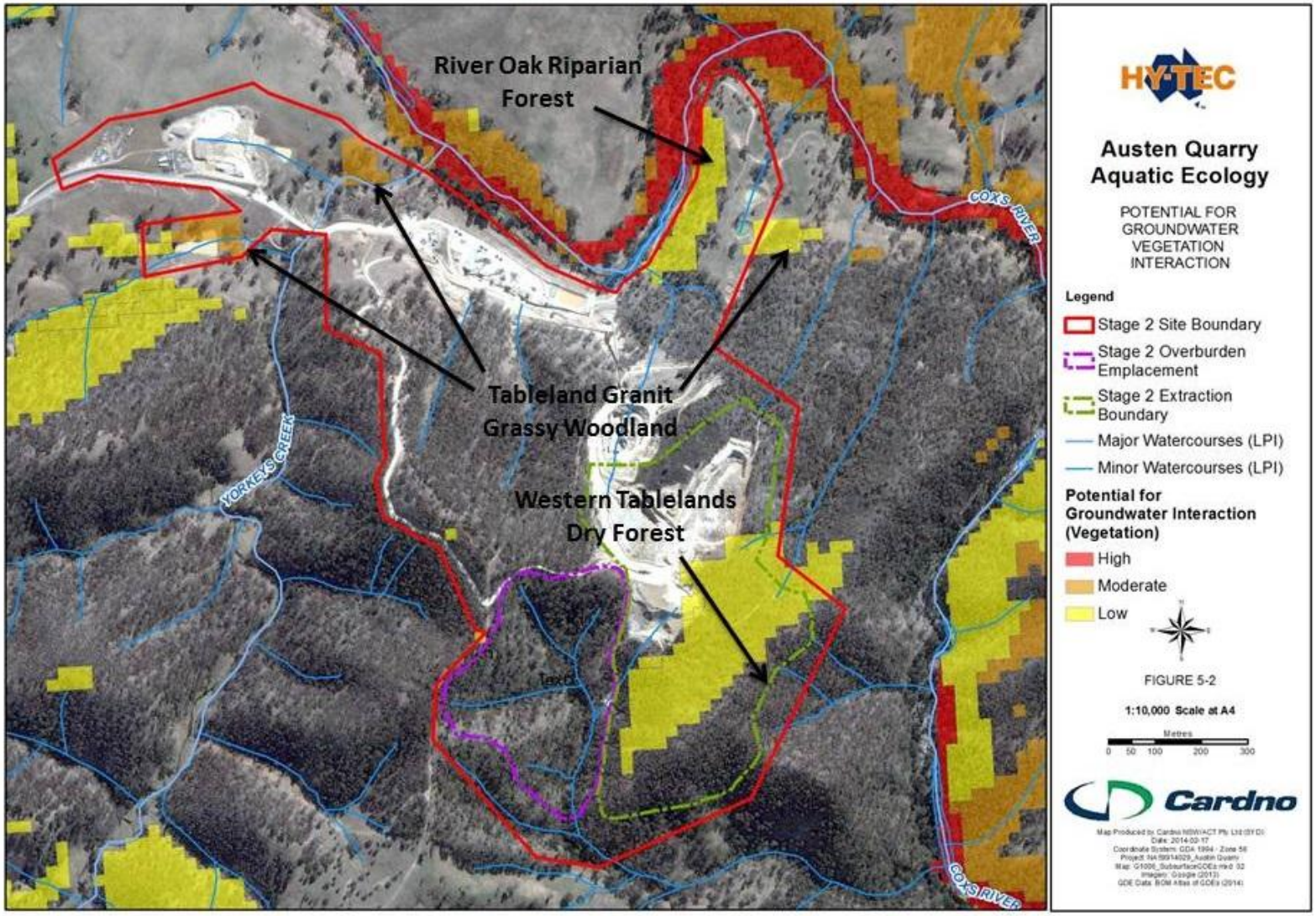


Figure 4-2 Map of the potential for interaction between vegetation communities and groundwater in the vicinity of the project area

Some terrestrial vegetation communities containing Rough Barked Apple (*Angophora floribunda*), which typically grows on alluvial soils (Benson *et. al.* 1998), are listed in the GDE risk assessment guidelines (Volume 3, Part 8, Serov *et. al*. 2012) as having a high likelihood of groundwater dependence. *Angophora floribunda* is dominant along the main drainage of the Coxs River North Catchment, upstream of the NC1 site and the associated community also has the potential to be groundwater dependent.

4.2.2 Subsurface Groundwater Dependent Ecosystems

Subsurface GDEs such as hyporheic fauna (fauna inhabiting water in the hyporheic zone, the area of interaction between surface and groundwater) and stygofauna (groundwater dwelling organisms) also have the potential to occur within and surrounding the Application Area.

Hyporheic habitat is usually associated with stream beds and can exist in creek beds that cease to flow on the surface, but maintain subterranean flow (Pryce *et al.* 2010). Hyporheic fauna may occur in alluvial substrata associated with ephemeral creeks, such as drainages of the Coxs River North and South catchments, within the Application Area. Hyporheic fauna are also likely to occur in alluvium associated with larger creeks outside of the Application Area, such as Coxs River and Yorkeys Creek.

Most stygofauna spend their entire lives in groundwater (stygobites), although some groups are recognised that are capable of living in epigean habitats (stygophiles) or require access to surface environments to complete part of their lifecycle (Humphreys 2006). Stygofauna contribute to the biodiversity of Australia and may also be functionally important, contributing to the maintenance of voids, alteration of redox gradients, enhancing the release of organic carbon and cycling of nutrients, movement and transfer of energy and materials through the sediments and maintenance of community structure (Humphreys 2006).

Information on the distribution of stygofauna within NSW aquifers is sparse and scattered (Serov *et al.* 2012). Preliminary research indicates stygofaunal diversity could be high and that some species may be locally endemic (i.e. restricted to certain areas or sections thereof) (Eberhard and Spate 1995, Hancock and Boulton 2008). The highly localised occurrence of some species combined with their high degree of adaptation to life in subterranean aquatic systems suggests that they may be highly sensitive to changes in the characteristics of the groundwater they inhabit and that disturbance of their habitat could pose a threat to their survival.

Relatively diverse stygofauna assemblages have been found in alluvial aquifers in Queensland and the Hunter Region of New South Wales (Tomlinson and Boulton 2010, Hancock and Boulton 2008, 2009). In the latter studies, stygofauna were more common in bores with low electrical conductivity (i.e. EC < 1500 µS/cm), shallow water table (10 metres below ground) associated with alluvium and phreatophytes, and in geological units with cavities, fractures or interstices.

The likelihood of stygofauna occurring within the isolated rhyolite hosted aquifer of the extraction area is low on the basis of the low porosity of the aquifer (0.7% - Ground Doctor, 2014) and the isolation of the groundwater created by the surrounding gullies, creeks and Coxs River (Ground Doctor, 2014). If present, stygofauna are most likely to occur within perched aquifers, which are unlikely due to the homogeneity of the local geology, or within alluvium which would not be affected by the Proposal.

5. WATER MANAGEMENT

5.1 OVERVIEW

Water management for the Site has been outlined in the Austen Quarry Stage 2 Surface Water Management and Discharge Assessment (Groundwork Plus 2014). Existing and proposed water management dams are illustrated in **Figure 5-2** and proposed water management is detailed in **Figure 5-2**.

The quarry has implemented a sustainable water management system, which aims for the current and future operations to be 100% self-sufficient in water, excluding drinking water supply. A sustainable water management system has been developed based upon capturing stormwater run-off for quarry process uses, dust suppression and environmental controls.

The system is based upon capturing water within the extraction area and pre-existing farm dams; SD1, SD2, SD5 and SD6. These dams capture water prior to being re-used on site or released directly, or indirectly via Yorkeys Creek, into Coxs River as environmental flows.

Runoff from undisturbed areas is and would continue to be diverted around areas disturbed by Quarry operations wherever practicable. This will reduce the potential for clean runoff to be polluted by Quarry activities. Diversion of clean waters will be effected by contour and diversion drains, perimeter bunds and pipe culverts wherever practicable.

During extension and operation of the extraction area and overburden emplacement, drainage will convey water from areas of disturbance to sumps located within the extraction area and sediment basins around the Site (i.e. SB1, SB2 and SB3) to prevent sediment laden or contaminated runoff leaving the Site. Sediment traps and sediment basin fore-bays form part of the Site water management system and improve water quality at various points along water drainage networks.

Excess waters are treated in-situ within SB2a, SB3a and SD2 using a coagulant (i.e. NALCO 8187.15H) to improve water quality prior to being pumped or drained directly or indirectly via Yorkeys Creek into the Coxs River. NALCO 8187 is a patterned coagulant, which is widely used within the water treatment industry. Austen Quarry is licensed, through Environment Protection Licence (EPL) 12323, to discharge water to the Coxs River to maintain storage capacity within site water storages. This discharge water must comply with the water quality criteria of EPL 12323 and S.120 of the Protection of the Environment Operations Act 1997 which prohibits the pollution of surface waters.

Potable water supply is supplied by Lithgow City Council on an as needs basis, while sewage treatment for the offices and amenities are comprised of a self-contained unit that relies upon rainwater captured off the on-site infrastructures roof-tops. No treated effluent is discharged on-site.

A water truck collects water from designated storages and sprays water for dust suppression at an approximate rate of 1.5 L/m^2 per application over exposed hardstand surfaces of the site including the secondary processing area, Extraction Area Access Road (for access between the secondary processing and extraction areas) and various stockpile areas. The total annual water use for dust suppression is 31.5 ML/year with a further 11.7 ML estimated to be lost through evaporation annually.

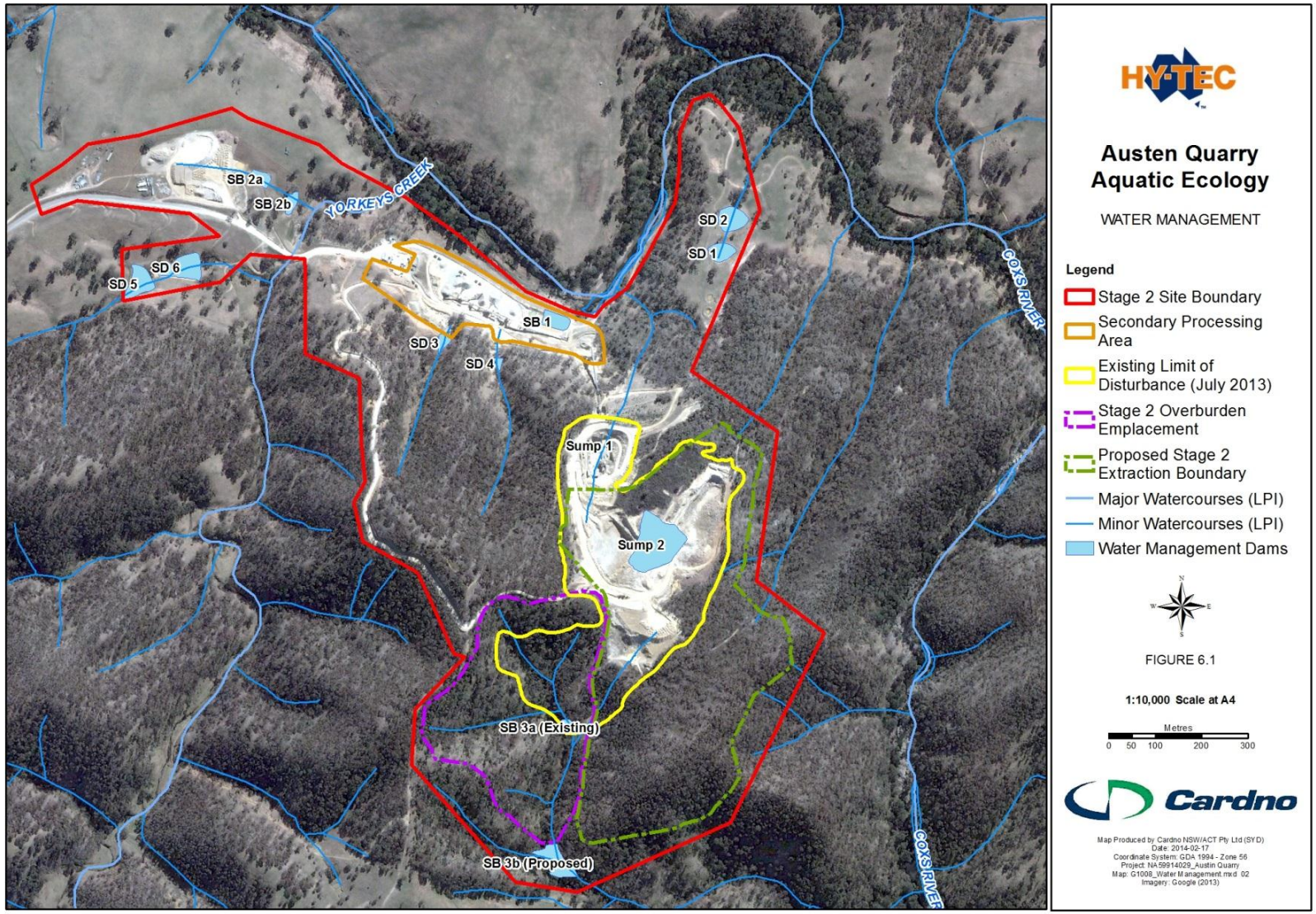


Figure 5-1 Map of water management dams associated with the Proposal

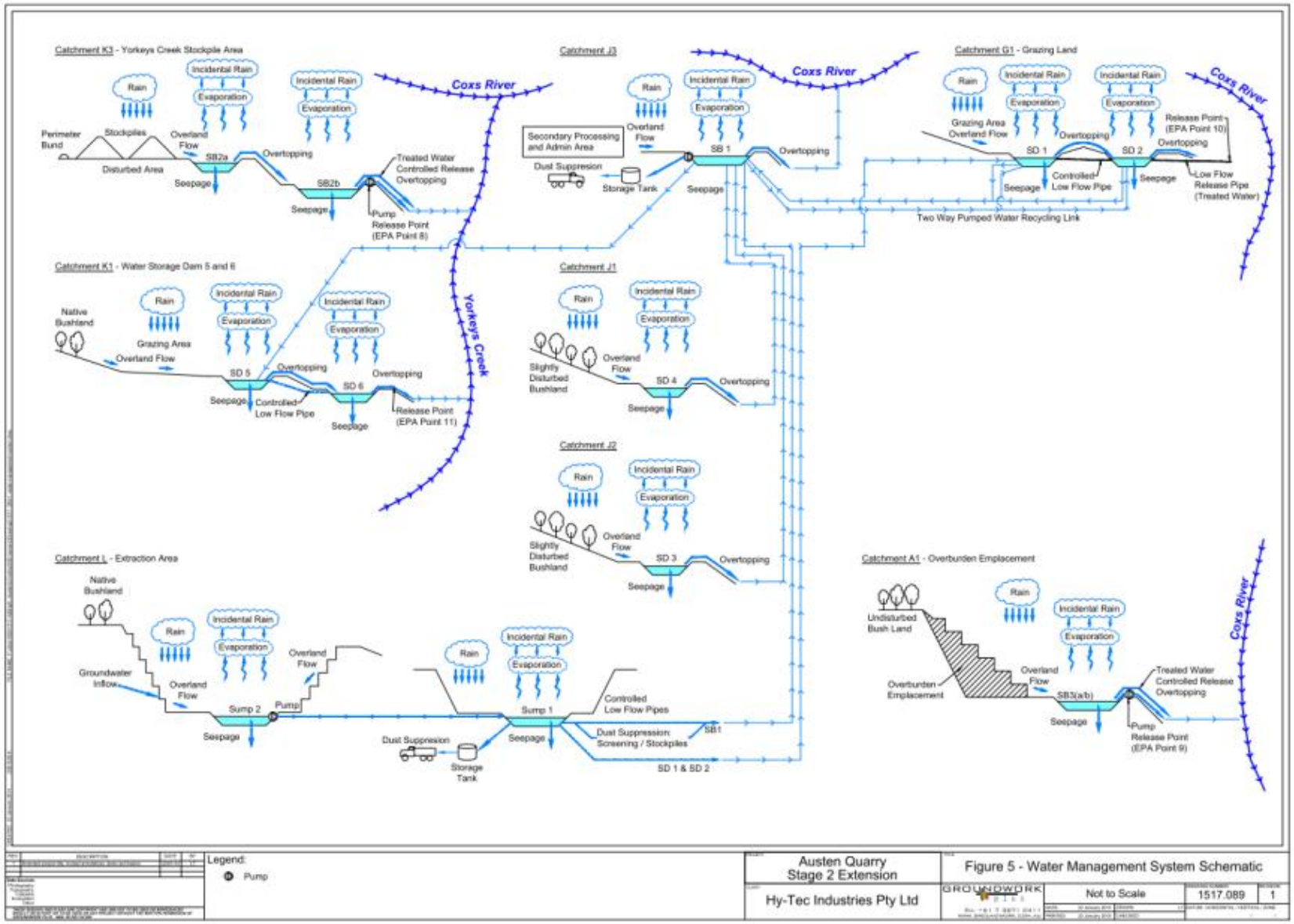


Figure 5-2 Water management diagram for the Stage 2 extension (Groundwater plus 2014)

5.2 ONGOING WATER MANAGEMENT CONSIDERATIONS

Stormwater runoff from the existing overburden emplacement is currently discharged to sediment basin SB3a. SB3a has a storage deficit of 3.2 ML, required to adequately store and treat runoff from the overburden emplacement catchment. Stormwater runoff from the proposed Stage 2 overburden emplacement area would be treated within a proposed new sediment basin (SB3b) to be built downstream of the overburden emplacement area footprint. SB3b would be constructed with a minimum storage capacity of 12.3ML within 6 months of the approval of development consent. SB3a would be retained as a basin fore-bay until such time as overburden emplacement development progresses over this.

The surface water management and discharge assessment of Groundwork Plus (2014) also identified that SB1, SB2b and SD5 had storage deficits of 5 ML, 1.2 ML and 18.8 ML, respectively, required to adequately store and treat runoff from their respective catchments (Groundwork Plus 2014). The storage capacity would be increased at SB2b (to 4.5ML) to provide the minimum settlement and storage requirements with an additional allowance to account for water below effective pumping level. An additional diversion weir would be constructed between SD5 and SD6 such that except under exceptional circumstances (e.g. prolonged drought), overflow from SD5 would flow directly to Yorkeys Creek. This would increase the capacity available to accept water from SB1 significantly and increase the effective water storage and sediment storage capacity of SB1.

The ability to increase the storage capacity of SB1 is limited by restrictions in the available area, basin depth and basin wall height (R W Corkery 2014). These factors make it inappropriate to increase the storage capacity of SB1 to the volume recommended in the Surface Water Management and Discharge Assessment (Groundwork plus 2014). As an alternative, the Applicant would install a pipe outlet with control valve which would enable the operator to control discharge from SB1. In conjunction with the added capacity provided by SD2 and SD6 (12ML greater than minimum storage capacity requirements), this should provide for greater control over the frequency and volume of discharges from SB1.

An important component of the quarry water management system is, and would continue to be the ability to discharge water from the various sediment basins and storage dams. In accordance with a Water Management Plan (WMP), which would be updated for the Site following the issue of development consent, the Applicant would apply procedures for the treatment and discharge of water. Subject to review and approval as part of the Site WMP, these procedures would provide for the following.

- A flocculating agent (NALCO 8187.154) would be regularly applied to the sediment basins and storage dams for which controlled discharges are predicted.
- Discharge of water would be undertaken either:
  - on the sediment basin reaching the identified minimum water settlement and sediment storage capacity; or
  - once the water level in the water storage reaching a nominated level, e.g. 2m from the level of the discharge outlet of SB1; and
  - as soon as practical after a significant rainfall / runoff event resulting in the above.

It is noted that the Applicant would preferentially discharge water to one or more of the other storages on the Site. Discharge to the Coxs River or Yorkeys Creek would only occur when there is insufficient capacity within other Site water storages.

- On discharge of water to the Coxs River or Yorkeys Creek, a sample of the water would be taken to record the pH, electrical conductivity, total suspended solids, biological oxygen demand and total petroleum hydrocarbons. The Applicant would report any non-compliance with the Site EPL to the EPA in accordance with the POEO Act.

5.3 HYDROLOGICAL MODELLING AND SITE WATER BALANCE

A water balance model was prepared to analyse the frequency and volume of water stored, transferred and discharged from the site as part of the Surface Water Management and Discharge Assessment (Groundwork plus 2014). The model assessed potential discharges under dry (15th percentile) and wet (90th percentile) rainfall scenarios. The water balance model also incorporated dewatering of groundwater seepage from the extraction area based on the groundwater hydrogeology investigations conducted by Ground Doctor Pty Ltd (2014).

5.3.1 Extraction Area

No uncontrolled discharges would occur from the extraction area sumps. The average rate of dewatering from the extraction area would vary between 0 and 1.13 ML/day, this being below the capacity of the existing dewatering infrastructure, which would cater for up to 1.9 ML/day.

5.3.2 Storage Dams 1 and 2

The water balance model indicates that there would be no uncontrolled discharges from SD1 and SD2, which would receive and treat water from the extraction area.

Controlled discharge of water would be required following significant rainfall events to retain sufficient capacity within the water storages to accept water from the extraction area and runoff from the upslope catchments. Groundwork Plus (2014) predicts that the annual volume of controlled discharge to the Coxs River would vary between 7.5ML and 21.8ML under dry weather (15th percentile rainfall), and 37.2ML and 73.5ML under wet weather (90th percentile rainfall) conditions. Treatment and discharge would be undertaken as soon as practical following each rainfall / runoff event.

The total volume of controlled discharge would be reduced further by constructing a clean water diversion around SD2. This would reduce the total discharge volume requirement to between 1.9ML and 126.3ML under dry weather (15th percentile rainfall), and 29.2ML and 65.5ML under wet weather (90th percentile rainfall) conditions annually.

5.3.3 Sediment Basin 1

Assuming the transfer of water from SB1 to SD6 and SD2 to maintain the minimum 2m (2.34ML) freeboard within the basin, Groundwork Plus (2014) predicts up to five uncontrolled discharges of a combined 10.1ML under dry weather (15th percentile rainfall) conditions and six uncontrolled discharges of a combined 46.9ML under wet weather (90th percentile rainfall) conditions. This is a significant reduction from a predicted 10 discharges of 38ML (under dry conditions) and 23 discharges of 102.3ML (under wet conditions) predicted without the implementation of water transfer between SB1 and SD6 / SD2. t

Groundwork Plus (2014) also modelled the performance of SB1 if the capacity was increased to 11ML in order to provide for water settlement and sediment storage capacity for a 5-day 95th percentile rainfall event. The modelling predicted this would result in 24 uncontrolled discharges totalling 60.1ML under dry weather (15th percentile rainfall) conditions and

22 uncontrolled discharges totalling 97ML under wet weather (90th percentile rainfall) conditions[1]. The implementation of this option to increase the capacity of SB1, notwithstanding the constraints nominated in Section 6.2, would provide little overall benefit.

5.3.4 Storage Dams 5 and 6

Excess water from SB1 is proposed to be received by SD6, with overflows from SD5 proposed to be diverted into Yorkeys Creek via a proposed new diversion weir under all but exceptional circumstances. The water balance model indicates that there would be up to 26 uncontrolled discharges under the dry weather scenario (8.7 ML per annum) and 22 uncontrolled discharges under the wet weather scenario (4.9 ML per annum) following the new configuration. The modelling predicted that the frequency and volume of uncontrolled discharges from SD6 would be significantly reduced using the SD5 diversion weir configuration.

5.3.5 Sediment Basin 2b

Between 13 and 22 controlled discharges would occur from SB2b per year, totalling 9.9 to 21.5 ML per annum under dry and wet weather scenarios respectively according to the water balance model. There would be no uncontrolled discharge under the dry weather scenario and eight uncontrolled discharges (1.2 ML per annum) under the wet weather scenario.

5.3.6 Sediment Basin 3b

Based on the construction of a 12.3ML capacity structure, Groundwork Plus (2014) predicts between 17 and 22 controlled discharges totalling less than 65ML annually. Under dry weather (15th percentile rainfall) conditions there would be no uncontrolled discharges, however, a single 3 day discharge of 1.4ML is predicted under prolonged wet weather (90th percentile rainfall) conditions. It is noted that this is as expected when considering the guidance provided by *Table 6.1* of DECC (2008).

5.4 DISCHARGE WATER QUALITY

Water quality objectives (WQO's) were generated through consideration of relevant guidelines and baseline data in the Surface Water Management and Discharge Assessment (Groundwork plus 2014). The potential for these WQO's to be exceeded at each of the potential discharge locations was also assessed.

Groundwork Plus (2014) note that the levels of EC (<770 µS/cm) and pH (<8.7) of the water that would be discharged would pose no genuine risk to the environmental values of the receiving waters (R W Corkery 2014). These values are near the upper values recorded by Cardno in the Coxs River (Section 4.6). Discharge values are therefore likely to be within the range of the receiving aquatic environment.

Groundwork Plus (2014) indicates that the likely concentrations of metals are reflective of the local geology and would be associated with the suspended sediment contained within the water, i.e. not from introduced sources. The suspended sediment levels would generally comply with the WQO (30mg/L), thereby limiting the total amount of these metals discharged. Furthermore, the required dilution to achieve compliance is low (at most 8:1) and would be provided almost immediately on release to the Coxs River (given discharge would almost

[1] The active transfer of water between SB1 and other storage dams was not included in this scenario given the sediment basin would be constructed to the design requirements of Landcom (2004).

certainly occur during or following periods of higher rainfall when flows in the river are likely to be higher) (R W Corkery 2014).

Groundwork Plus (2014) consider the elevated nutrient levels (TN, TP an NH_4) likely to be associated with organic matter (e.g. manures, top-soil erosion) contained within the TSS component of discharge. While without sufficient dilution, these could result in nuisance algal problems, the fact that TSS concentrations are likely to be complied with suggests the overall accumulation of these nutrients would remain low. Furthermore, discharge is most likely to occur during or following significant rainfall events and as such base flows in the river would quickly dilute the nutrient concentrations such that the noted algal bloom formation would not occur (R W Corkery 2014).

Turbidity could pose some risk to the receiving waters environmental values as aquatic ecosystems, recreational use and drinking water. It is noted, however, that with flocculation of the water contained within the storages, the turbidity of the water is likely to be significantly reduced prior to controlled discharge. Under conditions of uncontrolled discharge, during or following a significant rainfall event, the flow within the receiving waters is likely to be higher, resulting in higher suspended sediment loads and therefore elevated turbidity (R W Corkery 2014).

In accordance with the recommendations of Groundwork Plus (2014), and until a reference background level for the receiving waters is established, the Applicant would undertake sampling and analysis of water upstream and downstream of the discharge point at the time of discharge to demonstrate minimal or no impact on receiving water quality (R W Corkery 2014).

6. ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

6.1 INTRODUCTION

In this section, the potential direct, indirect and cumulative impacts on aquatic habitats, quality of water, aquatic biota including GDEs and threatened aquatic species that may arise during the development, operation, decommissioning and rehabilitation phases of the Proposal are described. The assessment of potential impacts on aquatic ecology arising from the Project is based on:

- The description of the Project presented in **Section 1.2**;
- The description of the existing biophysical environment of surface water and GDEs presented in **Sections 3.6** and **4**, respectively;
- Assessment of potential impacts on terrestrial ecology (Niche 2014), surface water (Groundwork Plus, 2014) and groundwater (Ground Doctor 2013).

The potential impacts associated with the development, operation, decommissioning and rehabilitation phases and measures that could be used to avoid, minimise and manage such impacts are described in **Sections 6.2**-**6.4**, respectively. The potential impacts on the Macquarie Perch that may occur in the Application Area are addressed in **Section 6.5**. The potential for cumulative impacts on aquatic ecology is discussed in **Section 6.6**.

6.2 DEVELOPMENT PHASE

6.2.1 Proposed Activities

The Proposal involves extension of existing activities at the Site and would therefore not require extensive additional development works. The development activities considered for the Stage 2 extension are:

- Modification of existing haul roads and internal access roads into the Stage 2 extraction and overburden emplacement areas;
- Extension of the extraction area within the designated Stage 2 area;
- Extension of the overburden emplacement within the designated Stage 2 area; and
- Modification of existing water management infrastructure and construction of the SB 3b sediment basin.

Site development activities would take place in a progressive manner throughout the Stage 2 extension, as outlined in the documentation supporting the Stage 2 application (Corkery 2013).

6.2.2 Potential Impacts

The following impacts could potentially occur during the site development phase.

- Runoff from areas that have been cleared of vegetation and where soils and sediments have been disturbed or stockpiled during extension of the Stage 2 extraction and overburden emplacement areas discharging into watercourses;
- The upgrade and extension of the existing access tracks to and around the extraction and overburden emplacement areas has the potential to increase soil erosion/sedimentation;

- Runoff from cleared areas and stockpiles of soil could transfer soil, sequestered nutrients, organic matter and contaminants into the watercourses;
- An increase in the sediment load of watercourses could, in turn, alter the nature of the benthic substratum, smother some aquatic habitats and increase turbidity levels, with the latter potentially decreasing the amount of light available for photosynthesis by aquatic plants, clogging the gills and feeding apparatus of aquatic fauna and reducing the visual acuity of some predators;
- Dust mobilised from the site could impact on local aquatic ecosystems through increased sediment input to creeks and/or through reduced primary productivity of riparian vegetation; and
- Accidental release of lubricating oils, hydraulic fluids and fuel from construction equipment could result in the input of toxic hydrocarbons into the streams and their drainage lines.

The likelihood of site development impacts occurring depends on the proximity of those works to the Coxs River and associated drainage lines, as well as the effectiveness of water management and treatment before discharge. Development activities are unlikely to have any detectable direct impact on the Coxs River as this is separated from the Stage 2 extraction and overburden emplacement areas. Direct development impacts are more likely to be observed along the Coxs River South Catchment drainage line or directly downstream of licenced discharge points before substantial dilution occurs.

Should sediment plumes form, they would be dispersed downstream, with rate of dispersion depending on the prevailing flow. The aquatic flora and fauna that occur in the watercourses within and adjacent to the Application Area would be fairly tolerant of increases in sediment load as these occur during periodic rainfall events. Temporary, localised increases in sediment load that may arise during general construction works are therefore unlikely to have any significant effects on aquatic habitats or associated biota, providing appropriate mitigation measures are implemented.

6.2.3 Avoidance, Mitigation and Management Measures

Impacts associated with construction works in the vicinity of watercourses could be minimised by:

- Limiting the area of riparian zone and aquatic habitat disturbed where feasible and reasonable, particularly in the vicinity of the Coxs River South Catchment;
- Developing and implementing a Sediment and Erosion Control Plan for the Stage 2 Extension or reviewing the existing plan for adequacy with respect to protection of aquatic habitats and biota immediately downstream of the construction area;
- Adhering to recommendations outlined in the Surface Water Management and Discharge Assessment, including development of storage and transfer infrastructure in the most appropriate and feasible manner for the control and treatment of water on site;
- Maintaining a bunded area for storage of fuels, oils, refuelling and appropriate maintenance of vehicles and mechanical plant;
- Minimising direct access to the Coxs River and its drainages by construction vehicles and mechanical plant;
- Prohibiting re-fuelling, washing and maintenance of vehicles and plant within 30 m the Coxs River and its drainage lines, where feasible and reasonable;

- Reporting spillages to the appropriate officer and immediately deploying spill containment kits to restrict their spread into or within drainage lines; and
- Dust suppression activities that involve water sprayed from a truck over exposed hardstand surfaces of the site including the processing area, Quarry Access Road and various stockpile areas.

The Erosion and Sediment Control Plan should be prepared in accordance with Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries (DECC 2008) and should include a description of the erosion sediment control structures that are to be used to minimise soil erosion and the potential for the transport of sediment to downstream waters. Temporary erosion and sediment control measures such as sediment fences, sandbag weirs, temporary drains, and temporary silt traps should be installed prior to any construction works. Maintenance of erosion and sediment controls and adaptive management should be performed throughout the life of the project to ensure they continue to function effectively.

Erosion and sediment control, monitoring and maintenance commitments are outlined in The Surface Water Management and Discharge Assessment (Groundwork plus 2014) and are summarised in Section 4.11.4.2 and 4.11.4.3 of the EIS (R W Corkery 2014).

Construction works undertaken in the vicinity of watercourses should be done in accordance with the NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management (See **Section 2.2.2**) (NSW DPI 2013). These indicate that:

- Riparian buffer zones should be established and maintained in or adjacent to Type 1 or 2 Habitat (i.e. those freshwater fish habitats considered to be highly or moderately sensitive) or Class 1-3 waterways (i.e. those containing major, moderate or minimal fish habitat). These waterway types were primarily restricted to the Coxs River and Yorkeys Creek and to a lesser extent the tributaries immediately upstream of the Coxs River;
- Riparian buffer zones should be designed to maintain lateral connectivity between aquatic and riparian habitat;
- The width of the riparian buffer zone should be based on the habitat type and waterway class, with buffer zones of 100 m, 50 m and 10-50 m being applicable respectively to highly sensitive freshwater fish habitats (Type 1) or waterways containing major fish habitat (Class 1), moderately sensitive freshwater fish habitats (Type 2) or waterways containing moderate fish habitat (Class 2), and minimally sensitive fish habitats (Type 3) or waterways containing minimal fish habitat (Class 3/4) (refer to **Table 4-4**);
- Existing riparian vegetation should be retained in an undamaged state where possible and disturbed areas should be revegetated with local native species and monitored to ensure revegetation is successful; and
- If rehabilitation is required this should include native instream vegetation and snags, where appropriate.

If pipeline or access track crossings need to be constructed over watercourses this should be done in accordance with the requirements outlined in Chapter 4 of the NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management (NSW DPI 2013).

6.2.4 Assessment of Likely Impacts

Activities undertaken during the development phase are largely an extension of existing activities and are being completed in an already disturbed environment. These activities are

unlikely to cause significant impacts on existing aquatic habitats, aquatic flora or aquatic fauna, provided that appropriate measures to avoid, minimise and manage impacts are implemented.

6.3 OPERATION PHASE

6.3.1 Proposed Activities

The operation phase would involve continued resource extraction and placement of overburden in order to produce for sale and despatch no more than 1.1 million tpa of rhyolite. The proposed production rate does not exceed the currently approved rate however, an overall increase in operational activity over that undertaken since Quarry operations commenced in 2005 is likely based on anticipated future demand. The life of the Quarry would be extended from March 2020 until 2050. The additional operation phase activities considered for the Stage 2 extraction area include:

- General operational impacts, including continued and potentially increased use of existing roadways and stockpile sites within the Application Area;
- Rhyolite extraction within the Stage 2 extraction area using conventional drill and blast, load and haul methods;
- Placement of overburden within the Stage 2 overburden emplacement;
- Dewatering of the extraction area;
- Retention and operational use associated with the Stage 2 extension; and
- Discharge of water additional to the storage capacity of Quarry water storages from Licenced Discharge Points (LDPs).

6.3.2 Potential Impacts

6.3.2.1 Resource Extraction and Overburden Emplacement

Extraction of rhyolite and the emplacement of the overburden would result in the direct removal and overfilling of some aquatic habitat from 1st and 2nd order waterways in the upper reaches of the Coxs River North and South Catchment respectively. A spatial assessment of the Quarry footprint at July 2013 indicated that approximately 924 m of mapped 1st and 2nd order drainages within the Coxs River North and South catchments had been disturbed. Development of the Stage 2 extraction and overburden emplacement may in the following impacts to aquatic ecology:

- Loss of a further total length of 810 m of aquatic habitat from mapped 1st and 2nd order drainages within the Coxs River North and South Catchments, this being associated with extension of the extraction area (100 m) and overburden emplacement (710 m);
- Loss of any aquatic flora and fauna resident within the aforementioned drainages;
- Eroded soil and contaminants in runoff arising from the overburden emplacement area, could have detrimental impacts on aquatic flora and fauna; and
- Dust mobilised from the Quarry could impact on local aquatic ecosystems through increased sediment input to creeks and reduced primary productivity of aquatic and riparian vegetation.

6.3.2.2 Dewatering

The proposed Stage 2 Extension would increase the area of disturbance by 25.7 ha (15.8 ha and 9.9 ha for the extension of the Stage 2 extraction area and overburden emplacement respectively). The Stage 2 extraction area is expected to reach a depth of 685 m AHD, approximately 60 m deeper than the current extraction area floor (745 m AHD) and 50 m deeper than the footings of the primary crushing station (735 m AHD). The groundwater level within the extraction area is approximately 730 m AHD (Ground Doctor 2014), which is approximately 45 m above the proposed depth of the Stage 2 extraction area. Dewatering of inflowing groundwater would therefore be required for the Stage 2 extraction area. The act of dewatering would result in a one-off loss of water from the fractured rock groundwater storage and a permanent lowering of the groundwater table within the extended Quarry and aquifers in the immediate vicinity (Ground Doctor 2014). The small reduction to local groundwater storage resultant from the Stage 2 Extension would not result in significant impacts to the River Oak riparian forest along Coxs River, identified by Niche (2014) as the only locally occurring surface GDE.

The change in hydrogeology as a result of the Stage 2 extraction could result in impacts to subsurface GDEs, if present, due to a localised loss of available habitat. The extent of the groundwater drawdown is anticipated to be restricted to the rhyolite hosted aquifer of ridges immediately surrounding the extraction and overburden emplacement areas due to the low average permeability of the aquifer. The predicted lateral spread of drawdown indicates that impacts to groundwater would be negligible at a distance of approximately 225 m from all sides of the excavation (Ground Doctor 2014). In a worst case scenario that drawdown extends further than 225 m, local drains, e.g. the Coxs River and incised gullies of the surrounding topography would act as barriers to groundwater drawdown further afield and would prevent impacts on aquifers west of Yorkeys Creek, north and east of the Coxs River and south of several incised gullies of the Coxs River South Catchment (Ground Doctor 2014).

Based on the evidence of groundwater drawdown presented in Ground Doctor (2014), standing water levels within the extraction area would remain higher than those within the surrounding water courses (including Yorkeys Creek and Coxs River), with a hydraulic gradient still maintained towards these water courses. The potential for groundwater to continue to discharge into the surrounding areas due to this gradient would help to maintain pre-development conditions and significant changes to the current site water balance are not expected. Therefore, potential impacts to subsurface GDEs due to groundwater drawdown would be very limited in spatial extent.

Due to the minimal groundwater drawdown predicted in the surrounding area, impacts to base flows of the larger river systems (Coxs River and Yorkeys Creek) from dewatering are expected to be nil to negligible as a percentage of their total discharge Anticipated impacts to resident in-stream flora and fauna in these watercourses are also expected to be minimal given the assessment by Niche (2014) that seasonal flows and storm surges during high rainfall events are far more deterministic of the condition of this vegetation than base flows of groundwater. A reduction in the contribution of groundwater base flows to the overall volume of water within those gullies within the predicted cone of depression, i.e. 225m from the perimeter of the extraction area, may occur. Referencing Niche (2014) again, none of the vegetation communities mapped within these gullies displays groundwater dependence and so this minor reduction in base flows would not impact on this vegetation.

Base flow to waterways would be maintained in all other areas by groundwater mounded within ridges that are not expected to be impacted by dewatering, for example, the northeast-

southwest trending ridge between the Quarry and the Coxs River and the ridge separating the Yorkeys Creek and Coxs River North Catchment.

6.3.2.3 Water Retention and Operational Use

Additional water may be retained within the extraction area sumps due to the increased catchment size of the extraction area. Additional water would also be retained in the SB3b sediment dam due to a proposed increase in volume (although as an operational requirement, this water would be regularly discharged following treatment to restore the required water settlement capacity). Other storage and sediment dams may also be expanded in response to sizing recommendations. A greater level of water management is also likely to require additional water transfers through pipelines. Some additional water may also be required for operational processes, such as dust suppression over a greater area of disturbed land for the Stage 2 extraction area.

Retention and operational use of water may result in the following impacts to aquatic ecology and groundwater dependent ecosystems:

- Reduced runoff and environmental water available to downstream aquatic ecosystems. This would potentially occur in small drainages of the North and South Catchment ;
- Changes to the flow regime in the south catchment tributary from changes to water management and increased basin volume of the SB3b dam;
- Reduced groundwater quality through movement of contaminated water from on-site into the underlying aquifer; and
- Elevated erosion at pipe outlet points associated with increased operational use and transfers.

6.3.2.4 Water Discharge

Groundwater seepage and water retained on Site from runoff would need to be discharged when there is an excess supply. This may result in the following potential impacts to the receiving aquatic environment:

- Release of sediment laden water into the aquatic environment downstream of LDPs leading to detrimental effects on aquatic flora and fauna;
- Release of water containing other aquatic contaminants into the aquatic environment downstream of LDPs leading to detrimental effects on aquatic flora and fauna; and
- Increased erosion around the LDPs, leading to detrimental effects on aquatic flora and fauna.

6.3.2.5 Groundwater Quality

Various extraction activities during the Stage 2 operational phase have the potential to impact on the quality of water retained on the Site.

- The residues of explosives, typically nitrate and other compounds of nitrogen, have the potential to contaminate water with in the vicinity of the blasting activities. Elevated nitrogen levels within an aquatic environment reduce oxygen levels of the water and can result in nuisance algal blooms.

- Fuel and oils could also potentially contaminate water within the Site if spilled during refuelling or maintenance of excavation machinery or inappropriately stored. Hydrocarbon products, in high concentration, are toxic to aquatic biota and may adversely impact on the surface or subsurface aquatic environment.

6.3.3 Avoidance, Mitigation and Management Measures

6.3.3.1 Resource Extraction and Overburden Emplacement

The aquatic habitat of the upper reaches of the Coxs River North and South catchment tributaries is minimal in extent and is unlikely support substantial aquatic life considering its position in the catchment (i.e. upland 1st and 2nd order watercourses). High quality aquatic habitat exists in the local area along the Coxs River, Yorkeys Creek and other large named tributaries feeding into the Coxs River in relatively close proximity to the Application Area. Impacts on aquatic ecology associated with removal of the 810 m of 1st and 2nd order streams within the Stage 2 extension area are therefore considered to be minimal on a regional scale. No specific measures are available to avoid the loss of aquatic habitat, flora and fauna from the upper reaches of the North and South Catchment tributary. Mitigation and management measures proposed include:

- Minimising the area of the catchment that is disturbed, where feasible and reasonable;
- Diverting clean water around the active disturbance area;
- Capture and treatment of runoff;
- Discharge of treated water to maintain environmental flows, where feasible and reasonable;
- Adherence to the Erosion and Sediment Control Plan;
- Active and appropriate decommissioning and rehabilitation actions, as discussed in **Section 6.4**; and
- Dust suppression activities.

6.3.3.2 Dewatering

Review, diligent implementation and continued improvement of the Water Management Plan (WMP) is recommended to mitigate potential impacts associated with dewatering on the receiving aquatic environment. This document would be coupled with a site water balance dictating the volume of water anticipated, rates of production and retention/discharge planning. The information required to construct these documents has been largely developed through the Surface Water Management and Discharge Assessment (Groundwork plus 2014) and Groundwater Assessment (Ground Doctor 2014).

Monitoring of the volume and quality of water removed from the Quarry should be implemented to ensure groundwater inflows are occurring in accordance with predictions. In the event that groundwater inflow rates become significantly greater than those predicted, a more detailed, quantitative investigation would be required to determine its source and potential impact on surrounding surface and groundwater dependent ecosystems. Baseline data to support any such investigation is recommended. Consultation with the NSW Office of Water would also be required in this situation and an amendment to the existing water licence would need to be obtained under the NSW Water Management Act (2000), as outlined under the NSW Aquifer Interference Policy.

Monitoring of the total discharge of Yorkeys Creek in relation to local rainfall patterns, with sufficient baseline data collection, would allow early detection of any flow reduction associated with the mine dewatering. Baseline monitoring of riparian vegetation along Yorkeys Creek, immediately west of the Quarry would also provide valuable information on this known GDE that could be used to assess any potential future impacts.

6.3.3.3 Water Retention and Operational Use

Water management during the operational phase would be governed by the WMP and site water balance, with strict application of these documents being the primary mitigation measure proposed. This would assist in minimising potential impacts associated with water retention and operational use through:

- Separation of potential sources of contaminants from potential aquatic receptors;
- Maintenance of appropriate wet weather storage; and
- Appropriate offtake depth at water pumping sites and scour protection at pipe outlet points.

Recommendations for appropriate and effective water management of this nature have been detailed in the Surface Water Management and Discharge Assessment (Groundwork plus 2014).

6.3.3.4 Water Discharge

Water discharge would occur in accordance with the conditions specified in the Environmental Protection Licence 12323. This licence specifies a concentration limit of 10 mg/L for Oil and Grease, 30 mg/L for total suspended solids and a pH range limit between 6.5 and 8.5. Requirements for monitoring of water quality during discharge and on a routine basis are also specified under the licence.

Analysis of potential impacts on ecosystem protection (aquatic plants, fish and other flora and fauna) from discharges of water was undertaken by Groundwork Plus (2014). The analysis suggested that there would be minimal impact from most contaminants to the ecological values of the receiving waters. It was stated that elevated nutrient levels in discharge water could result in nuisance algal problems. Nutrient concentration (TN, TP and NH_4), while potentially exceeding locally derived water quality objectives, would remain low and likely to be immediately diluted on release, i.e. during high rainfall events when discharge was likely. Furthermore, evidence of limited water sampling and analysis from dams within the local setting indicates that nutrient concentrations discharging to the Coxs River and Yorkeys Creek would have elevated nutrient concentrations as a consequence of pasture improvement / fertilisation practices and effects of livestock (manure, etc.)

Groundwork Plus (2014) also notes that while elevated turbidity may pose some risk to the ecological values of receiving waters during discharges, treatment by settlement and flocculation prior to discharge would significantly reduce this risk. Furthermore, in the event of an uncontrolled discharge, during or following significant rainfall, Groundwork Plus (2014) suggest that turbidity levels would already be elevated in receiving waters due to the natural mobilisation of sediments experienced during flood events. Based on these predictions, potential impacts to the aquatic ecosystem of the receiving waters due to the discharge of on-site water would likely be minimal.

The likely volume of water to be discharged to Yorkeys Creek and the Coxs River on each occasion is insignificant when considered against the total volume of water flowing past the

Austen Quarry each day. Furthermore, in the pre-extraction setting, this water would flow to these watercourses with the Proposal simply providing for a delay in the delivery of this water. Consequently, these discharges would almost certainly have no effect on the geomorphology or ecology of the watercourses which are subject to significant variations in flow due to seasonal variation and storm surges.

The impact of the discharge of water to the receiving environment can be minimised by ensuring the conditions of the licence are met. In addition to this the following specific measures should be implemented:

- Appropriate sizing, management and maintenance of water storages to ensure discharges are within the specified limits;
- Management of water within the on-site storages to ensure sufficient freeboard is available to accommodate normal wet weather events and prevent uncontrolled discharge to the environment, where feasible and reasonable; and
- Ensure discharge points are constructed to prevent excess erosion and in particular, to prevent potential overflow and undermining of water control structures that could lead to catastrophic failure of retention basins.

6.3.3.5 Groundwater Quality

Given that the activities (i.e. blasting, excavation) within the extraction area would be a continuation of those currently in operation, the Proposal is not expected to increase the risk of contamination of the groundwater aquifer. Furthermore, contamination of local groundwater by water containing hydrocarbons or elevated nitrate concentration is highly unlikely due to:

- the hydraulic gradient described by Ground Doctor (2014) which provides for preferential in-flow, not out-flow from the extraction area to groundwater; and
- the characteristic low porosity (0.7%) of the rhyolite and its resistance to fracturing which reduces the permeability of the strata.

Notwithstanding this, recommendations to manage Stage 2 extraction activities with regards to the elimination or minimisation of potential impacts to groundwater quality have been detailed in the groundwater assessment prepared by Ground Doctor (2014). The Applicant has committed to undertaking monitoring of groundwater with water quality analysis to be undertaken periodically to confirm no contamination of local groundwater.

6.3.4 Assessment of Likely Impacts

Loss of aquatic habitat from the upper catchments of small waterways associated with extension of the overburden emplacement is considered to be a minor and localised impact. Appropriate water management associated with dewatering, retention, operational use, discharge and groundwater quality will largely mitigate potential impacts on receiving aquatic ecosystems. It is therefore considered that the operation phase of the Proposal would not cause significant impacts on aquatic habitats, aquatic flora or aquatic fauna, provided that appropriate measures to avoid, minimise and manage impacts are implemented.

6.4 DECOMMISSIONING AND REHABILITATION PHASE

6.4.1 Proposed Activities

This would be a progressive activity that would include final landform construction, revegetation and decommissioning of the Site. Decommissioning would require removal of all processing plant and ancillary infrastructure, including concrete pads (unless required for a future land use). Final landform construction would involve re-profiling of the remaining landform to produce a landform which best confirms with the surrounding topography (R.W. Corkery 2013). All water management infrastructure would be removed, except for the vegetated bund along Coxs River and all storage dams and sediment basins.

A layer of weathered overburden would be placed over the final extraction area floor to create a water holding substratum with soil placed over this to establish vegetation. The final sump within the extraction area would likely accumulate rainfall runoff and some groundwater discharge. As the proposed final land use is for passive biodiversity conservation, there is no need to retain a water holding / watering point within the extraction area domain and overburden would be used to backfill the sump before soil is respread and revegetation with endemic grass and tree species is undertaken. Should some low intensity grazing form a component of the final land use in this area, the sump may be retained to provide a water source for stock.

The overburden emplacement would be constructed as a shaped and revegetated landform with a maximum elevation of 810 m AHD. This would be designed to blend with the surrounding landforms.

6.4.2 Potential impacts

6.4.2.1 Erosion and runoff

Potential impacts include:

- Erosion of the final landform of the overburden emplacement and extraction area;
- Runoff containing sediments and contaminants such as fertilisers and herbicides associated with the rehabilitation works enters watercourses during rainfall events; and
- The use of a bitumen spray on the wall of the extraction area to improve visual amenity may impact on surface and groundwater aquatic ecosystems.

6.4.2.2 Regeneration of landscape features that impact aquatic ecosystems

The construction of new landscape features, such as riparian vegetation and the geomorphology of drainage swales and dams during rehabilitation could impact on aquatic ecosystems if they are inappropriate for the local landform. This could lead to slumping and/or increased erosion/mass wasting and associated impacts to downstream aquatic ecosystems.

6.4.3 Avoidance, Mitigation and Management Measures

6.4.3.1 Erosion and Runoff

Avoidance, mitigation and management actions for potential erosion runoff and dust include:

- Preparing and implementing the Rehabilitation Management and Erosion and Sediment Control Plans;
- Stabilisation of all earthworks, drainage lines and disturbed areas in the short to medium term;
- Minimising the areas of exposed surfaces that would otherwise be potential sources of aquatic contaminants and windblown dust; and
- Ultimately creating a stable and safe landform with minimal erosion.

The overburden emplacement would have a concave profile equivalent to the surrounding topography to allow runoff to drain and would include appropriately designed surface water control structures to minimise the risk of erosion and sedimentation. Runoff from rehabilitated areas would be directed to a sediment basin for treatment prior to discharge until such time as a stable groundcover is established.

6.4.3.2 Landscape Features

A Rehabilitation Management Plan would be prepared and implemented to mitigate potential impacts to landscape features. Restoration and rehabilitation of land would be done progressively through the creation of a stable final landform, soil substrate quality and appropriate native vegetative cover suitable for passive biodiversity conservation and agricultural productivity.

6.4.4 Assessment of Likely Impacts

Activities undertaken during the decommissioning and rehabilitation phase are unlikely to cause significant impacts on aquatic habitats, aquatic flora or aquatic fauna, provided that appropriate measures to avoid, minimise and manage impacts are implemented.

6.5 IMPACT ON THREATENED SPECIES AND KEY THREATENING PROCESSES

An assessment of the significance of impacts on Macquarie Perch has been prepared in accordance with the Threatened Species Assessment Guideline – The Assessment of Significance (DECC NSW 2007). These guidelines specify the important factors that must be considered when assessing potential impacts on threatened species, populations or ecological communities listed under Schedules 4, 4A and 5 of the FM Act. The factors are outlined in Section 2.1.1.

6.5.1 Assessment of Significance for Macquarie Perch

(a) Is the proposed quarry extension likely to have an adverse effect on the life cycle of Macquarie Perch that would result in a risk of extinction of a viable local population of the species?

Macquarie Perch are found in rivers and lakes, but particularly the upper reaches of rivers and their tributaries. This species prefers clear water and deep, rocky holes with lots of cover in

the form of aquatic vegetation, large boulders, debris and overhanging banks (DSEWPAC 2010). They spawn in spring or summer and lay their eggs in shallow, fast-flowing water over stones and gravel in shallow upland streams or flowing parts of rivers.

The life cycle of Macquarie Perch could be affected if the development, operation, decommissioning and/or rehabilitation phases of the Stage 2 Extension resulted in loss or modification of its habitat or reduced the quality of the water downstream of the Proposal. The Application Area itself does not contain habitat that would be suitable for Macquarie Perch, although the Coxs River in the local vicinity and downstream is known habitat for this species. Water quality impacts from the Proposal are unlikely to extend downstream provided that appropriate mitigation measures are implemented.

(b) Is the habitat of Macquarie Perch likely to be (i) removed or modified, (ii) become fragmented or isolated from other areas of habitats by the proposed quarry extension and (iii), if so how important is the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species?

The upper tributaries of the Coxs River North and South catchments within the Application Area do not contain suitable spawning or residential habitat for Macquarie Perch.

(c) Is the proposed quarry extension likely to have an adverse direct or indirect effect on critical habitat?

Critical habitat for this species has not been declared under the *FM Act*.

(d) Is the proposed quarry extension consistent with the objectives or actions of a recovery plan or threat abatement plan?

There is no recovery plan or threat abatement plan for this species at present.

(e) Does the proposed quarry extension constitute or is it part of a key threatening process or is it likely to result in the operation of, or increase the impact of, a key threatening process?

Alteration of natural flow regimes and degradation of riparian vegetation are both listed as KTPs although it is considered unlikely that these processes would be accelerated as a result of Proposal.

Conclusion

It is unlikely that the Proposal would have a significant effect on known Macquarie Perch populations within the Coxs River downstream of the Application Area. There is, however, a potential that the cumulative impacts of extractive industries within the upper Coxs River could have an impact on this species with respect to water quality and hydrological pressures, although the Proposal is considered to be a small component of the overall cumulative potential impact.

6.5.2 Key Threatening Processes

Key Threatening Processes for the aquatic environment have been identified under state and federal legislation that may be amplified through activities of the Proposal. These include:

- Novel biota and their impact on biodiversity;

Considering that no additional water transfers are proposed, aquatic pest species found in the catchment are unlikely to be introduced into new habitats and amplification of this KTP is therefore considered highly unlikely.

- Degradation of native riparian vegetation along New South Wales watercourses;

There is a potential that native riparian vegetation could be degraded if altered groundwater dynamics associated with dewatering of the extraction area restrict water to these communities. However, the likelihood of this being significant and widespread is low, as groundwater impacts expected to occur at a localised level only.

- Instream structures and other mechanisms that alter natural flows;

There is likely to be some alteration of the natural flow of water in the Coxs River North and South catchments associated with expansion of the extraction area and overburden emplacement. Additionally, some instream structures may affect the natural flow of water, for example sediment basins. No work is proposed to occur on the major waterways around the Application Area (Yorkeys Creek or the Coxs River).

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.

Minor impacts of this nature may be observed within the Coxs River North and South catchments. In the case of sediment basins, these structures are considered a necessary measure to prevent sediment impacts downstream. Impacts are again expected to be minor considering appropriate mitigation measures are implemented. Any waterway crossings proposed for construction or modification should be assessed according to the criteria outlined in the NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management.

6.6 CUMULATIVE IMPACTS

The term cumulative impacts refers to the total impact on the environment in a defined area that results from incremental direct and indirect impacts of the Proposal combined with past, present, and reasonably foreseeable future actions.

Significant development of extractive industries is occurring within the upper Coxs River catchment in relation to coal mining and associated power generation. The Proposal contributes to the cumulative water quality and hydrological pressures on the Coxs River system through the disturbance of the pre-existing natural surface water and groundwater environment.

7. CONCLUSIONS

The information available indicates the Proposal would not have any significant impacts on aquatic habitats, aquatic flora or aquatic fauna, provided that appropriate measures to avoid, minimise and manage impacts associated with the development, operation, rehabilitation and decommissioning phases of the Proposal are implemented. Diligence in on-site water management practices, particularly the management of water storages to accommodate for unpredictable weather events, is required to avoid impacts on aquatic ecosystem receptors that are already under pressure from anthropogenic land use and industry in the upper and mid-catchment of the Coxs River.

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Austen Quarry Stage 2 Extension Project

APPENDIX A
DETAILED METHODS DESCRIPTION

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Aquatic Habitat Assessment

The aquatic habitat at each site was assessed using the NSW AUSRIVAS method described by Turak *et al*. 2004. This involved recording information on site location and access, site boundaries, topography, water level, shading, riparian vegetation, macrophytes, width and depth, water quality and land use as well as providing sketches of the site from both plan and cross-sectional views. Attributes of the habitats sampled, including substratum and general habitat features (e.g. detritus cover, snags and trailing bank vegetation), were also recorded.

Aquatic habitat was also assessed using a modified version of the Riparian, Channel and Environmental (RCE) method (Chessman *et al.* 1997). This assessment involved evaluation and scoring of characteristics of adjacent land, the condition of riverbanks, channel and bed of the watercourse, and degree of disturbance evident at each site. The characteristics and scoring system for this process are outlined in **Appendix B**.

The quality of aquatic habitat for sustaining fish populations was classified according to the NSW DPI Policy and Guidelines for Fish Habitat Conservation and Management (2013) as described in **Section 2.2.2** and outlined in **Appendix B**. Barriers to fish passage that were observed within or near each site were also recorded.

A comprehensive photographic record of each site was made. Photographs were taken near the top of the site looking downstream, near the middle of the site looking upstream, near the middle of the site looking downstream, and near the bottom of the site looking upstream.

Water Quality

At each site, two replicate measurements of dissolved oxygen (DO), electrical conductivity (EC), oxidation-reduction potential (ORP), pH, temperature and turbidity of the water were taken from just below the surface of the water using a fully calibrated multi-sensor water quality probe. Total carbonate alkalinity at each site was measured using a field titration kit. The EC, DO, pH and turbidity measures were compared with the ANZECC/ARMCANZ (2000) default trigger values for slightly disturbed upland rivers in south-east Australia as outlined in **Table 8-1**.

Table 8-1 ANZECC/ARMCANZ (2000) default trigger values for south east Australian upland rivers

Parameter	Trigger value	Comments
DO	90-110%	Daytime measurements
pH	6.5-8 units	
EC	30-350 µS/cm	High values in NSW
Turbidity	2-25 NTU	Higher in high flow

The ANZECC/ARMCANZ (2000) trigger values are indicators of concentrations below which there is a risk of adverse biological effects. These values are not designed to be used as a definitive reference from which an environmental problem is inferred if they are exceeded. Rather, they are designed to be used in conjunction with professional judgement, to provide an initial assessment of the waterway (ANZECC/ARMCANZ 2000).

Turbidity data was adjusted to account for negative values by increasing all data by the largest negative value (-0.7). Negative values were recorded when the water sampled was clearer than the zero reference solution to which the probe was calibrated.

AUSRIVAS Aquatic Macroinvertebrate Sampling

At each site, the aquatic macroinvertebrates associated with pool edge and riffle habitat were sampled using the NSW AUSRIVAS Rapid Biological Assessment method (Turak *et al*. 2004). Samples were collected with dip nets (250 µm mesh) from a 10 m length of pool edge habitat. Each sample was rinsed from the net onto a white sorting tray from which live animals were picked using forceps and pipettes. Animals were extracted for a minimum period of forty minutes and maximum period of one hour according to the NSW live sort protocol (Turak *et al*. 2004). Care was taken to collect cryptic and fast moving animals in addition to those that are conspicuous or slow. The animals collected at each site would be placed into a labelled jar containing 70% alcohol.

In the laboratory, each sample was sorted under a binocular microscope (at 40 X magnification), macroinvertebrates were removed and identified to family level, except for Oligochaeta and Polychaeta (to class), Ostracoda (to subclass), Nematoda and Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Dragonfly larvae were identified to family level and individuals of the genus Petaluridae, Gomphomacromiidae or Austrocorduliidae which contain threatened species were identified to species level, if possible. Identifications were confirmed using standard references. The animals belonging to each taxon identified (i.e. family or coarser taxonomic level) were counted. In the case of AUSRIVAS samples, only up to ten animals of each family were counted, in accordance with the AUSRIVAS protocol. Data on taxa abundance derived from the AUSRIVAS live-pick method is not appropriate for analysis and therefore, only presence/absence was reported.

The identification of a randomly chosen 10% of the samples was verified by a second experienced scientist. After confirmation of sample identifications, samples were stored in 70% alcohol in containers appropriate for long-term storage.

The data obtained from AUSRIVAS samples were analysed using the autumn or spring AUSRIVAS predictive models for edge habitats in New South Wales (Coysh et al. 2000). These models generate a number of indices, including:

- OE50Taxa Score - The ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50 % probability of occurrence. OE50 taxa values range from 0 to 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands derived from OE50Taxa scores which indicate the level of impairment of the assemblage, with bands being graded as follows:
  - Band X = Richer invertebrate assemblage than reference condition (greater than 1.17);
  - Band A = Equivalent to reference condition (0.82 to 1.17);
  - Band B = Sites below reference condition (0.47 to 0.81);
  - Band C = Sites well below reference condition (0.12 to 0.46);
  - Band D = Impoverished (equal to or less than 0.11).

The revised SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was also used to determine the “environmental quality” of sites on the basis of the presence or absence of families of macroinvertebrates. This method

assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their responses to chemical pollutants. The sum of all grade numbers for a site was divided by the total number of families recorded at that site to calculate the SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site.

Fish

Fish occurring in the watercourses were sampled using a back-pack electrofisher (model LR-24 Smith-Root). Backpack electrofishing is a commonly used, non-destructive sampling method that is useful for collecting fish in shallow freshwater pools and riffles. The back-pack electrofisher was operated around the edge of pools and in riffles. Fish stunned by the electrofisher were collected in a scoop net and then placed in a container filled with aerated stream water for handling. At the end of sampling of each site, all the fish caught were identified, counted and any abnormalities noted, before being released as quickly as practicably possible. Native species were released unharmed. Non-native species were humanely disposed of, as per NSW DPI guidelines. All fish captured and their fates were reported to DPI and the Director General's Ethics Committee as per the conditions of our permit to sample fish.

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Austen Quarry Stage 2 Extension Project

APPENDIX B

AQUATIC HABITAT CLASSIFICATION CRITERIA

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A. Modified version of the RCE inventory (Chessman *et al.* 1997)

Descriptor and category	Score
1. Land use pattern beyond the immediate riparian zone	
Undisturbed native vegetation	4
Mixed native vegetation and pasture/exotics	3
Mainly pasture, crops or pine plantation	2
Urban	1
2. Width of riparian strip of woody vegetation	
More than 30 m	4
Between 5 and 30 m	3
Less than 5 m	2
No woody vegetation	1
3. Completeness of riparian strip of woody vegetation	
Riparian strip without breaks in vegetation	4
Breaks at intervals of more than 50 m	3
Breaks at intervals of 10 - 50 m	2
Breaks at intervals of less than 10 m	1
4. Vegetation of riparian zone within 10 m of channel	
Native tree and shrub species	4
Mixed native and exotic trees and shrubs	3
Exotic trees and shrubs	2
Exotic grasses / weeds only	1
5. Stream bank structure	
Banks fully stabilised by trees, shrubs etc.	4
Banks firm but held mainly by grass and herbs	3
Banks loose, partly held by sparse grass etc.	2
Banks unstable, mainly loose sand or soil	1
6. Bank undercutting	
None, or restricted by tree roots	4
Only on curves and at constrictions	3
Frequent along all parts of stream	2
Severe, bank collapses common	1
7. Channel form	
Deep: width / depth ratio < 7:1	4
Medium: width / depth ratio 8:1 to 15:1	3
Shallow: width / depth ratio > 15:1	2
Artificial: concrete or excavated channel	1

Descriptor and category	Score
8. Riffle / pool sequence	
Frequent alternation of riffles and pools	4
Long pools with infrequent short riffles	3
Natural channel without riffle / pool sequence	2
Artificial channel; no riffle / pool sequence	1
9. Retention devices in stream	
Many large boulders and/or debris dams	4
Rocks / logs present; limited damming effect	3
Rocks / logs present, but unstable, no damming	2
Stream with few or no rocks / logs	1
10. Channel sediment accumulations	
Little or no accumulation of loose sediments	4
Some gravel bars but little sand or silt	3
Bars of sand and silt common	2
Braiding by loose sediment	1
11. Stream bottom	
Mainly clean stones with obvious interstices	4
Mainly stones with some cover of algae / silt	3
Bottom heavily silted but stable	2
Bottom mainly loose and mobile sediment	1
12. Stream detritus	
Mainly unsilted wood, bark, leaves	4
Some wood, leaves etc. with much fine detritus	3
Mainly fine detritus mixed with sediment	2
Little or no organic detritus	1
13. Aquatic vegetation	
Little or no macrophyte or algal growth	4
Substantial algal growth; few macrophytes	3
Substantial macrophyte growth; little algae	2
Substantial macrophyte and algal growth	1

B. NSW DPI fish habitat assessment criteria (DPI 2013)

Type	Characteristics of waterway type
Type 1 - Highly sensitive key fish habitat:	▪ Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 millimetres in two dimensions, snags greater than 300 millimetres in diameter or three metres in length, or native aquatic plants. ▪ Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the *FM Act.* ▪ Mound springs.
Type 2 – Moderately sensitive key fish habitat:	▪ Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in Type 1. ▪ Weir pools and dams up to full supply level where the weir or dam is across a natural waterway.
Type 3 – Minimally sensitive key fish habitat may include:	▪ Coastal and freshwater habitats not included in Types 1 or 2. ▪ Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.
N/A – Not considered key fish habitat[2]	▪ First and second order gaining streams (based on the Strahler method of stream ordering). ▪ Farm dams on first and second order streams or unmapped gullies. ▪ Agricultural and urban drains. ▪ Urban or other artificial ponds (e.g. evaporation basins, aquaculture ponds). ▪ Sections of stream that have been concrete-lined or piped (not including a waterway crossing). ▪ Canal estates.

[2] Note that if any of these habitats are found to be habitat of a listed threatened species, population or ecological community or 'critical habitat', then they would be considered 'key fish habitat' for the purposes of Tables 1 and 2 and these policies and guidelines

C. Classification of waterways for fish passage (NSW DPI 2013)

Classification	Characteristics of waterway type	Minimum recommended crossing type	Additional design information
Class 1 – Major fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.	Bridge, arch structure or tunnel.	Bridges are preferred to arch structures.
Class 2 – Moderate fish habitat	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and 2 habitats present.	Bridge, arch structure, culvert or ford [3].	Bridges are preferred to arch structures, box culverts and fords (in that order).
Class 3 – Minimal fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other Class 1 - three fish habitats.	Culvert[4] or ford.	Box culverts are preferred to fords and pipe culverts (in that order).
Class 4 – Unlikely fish habitat	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Culvert[5], causeway or ford.	Culverts and fords are preferred to causeways (in that order).

[3] High priority given to the 'High Flow Design' procedures presented for the design of these culverts—refer to the "Design Considerations" section of Fairfull and Witheridge (2003).
[4] Minimum culvert design using the 'Low Flow Design' procedures; however, 'High Flow Design' and 'Medium Flow Design' should be given priority where affordable—refer to the "Design Considerations" section of Fairfull and Witheridge (2003).
[5] Fish friendly waterway crossing designs possibly unwarranted. Fish passage requirements should be confirmed with NSW DPI.

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Austen Quarry Stage 2 Extension Project

APPENDIX C
WATER QUALITY DATA

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Water quality data collected September 2013

	Coxs River South (Site 11)		Quarry Treatment (Site 1)		North Catchment (Site 2)		North Tributary (Site NC1)	
Replicate No.	1	2	1	2	1	2	1	2
Depth (m)	0.1	0.15	0.2	0.2	0.3	0.1	0.05	0.1
Temperature (0C)	12.16	12.16	13.17	13.14	13.02	13.01	12.44	12
Conductivity (µS/cm)	310	309	298	297	319	317	94	95
pH	7.78	7.76	7.49	7.6	7.75	7.72	7.91	7.49
ORP (mV)	89.1	89.4	58.6	56.8	96.1	87.1	55.8	59.8
DO (%sat'n)	88.9	89.1	90.1	90.2	92	91.4	73	74.7
DO (mg/L)	9.53	9.55	9.46	9.45	9.5	9.62	7.81	8.03
Turbidity (ntu)	20.6	20.4	15.4	15.1	8.6	8.8	151.6	122.5
Turbidity (ntu)	20.7	20.4	15.2	15.2	8.5	12.7	147.9	121.8
Turbidity (ntu)	20.6	20.4	15.5	15	8.7	10.8	150.3	121.7
Alkalinity	55	-	70	-	65	-	N/A	-

Water quality data collected September 2013 (cont.)

	Glenroy Cottages (Site 5)		Quarry Control (Site 7)		Duddawarra (Site 9)		South Tributary (Site SC1)	
Replicate No.	1	2	1	2	1	2	1	2
Depth (m)	0.1	0.1	0.4	0.2	0.2	0.2	0.1	0.1
Temperature (0C)	14.28	14.48	11.91	11.93	13.19	13.21	12.17	12.44
Conductivity (µS/cm)	216	208	285	285	331	330	674	678
pH	7.81	7.73	7.57	7.55	8	7.85	7.66	7.91
ORP (mV)	81.3	80.2	116.3	114.3	76.1	78.5	86.4	73.5
DO (%sat'n)	92.1	87.8	89	89.3	90	90.2	74	86.8
DO (mg/L)	9.43	8.94	9.61	9.63	9.44	9.46	7.92	9.36
Turbidity (ntu)	51.4	53.2	21.3	21	5.9	6.1	1.7	1.3
Turbidity (ntu)	51	52.1	21.5	20.9	6	6.2	1.8	1.3
Turbidity (ntu)	50.7	51.9	21.6	20.8	5.9	6.3	1.8	1.4
Alkalinity	55	-	65	-	75	-	N/A	-

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Austen Quarry Stage 2 Extension Project

APPENDIX D
BIOLOGICAL DATA

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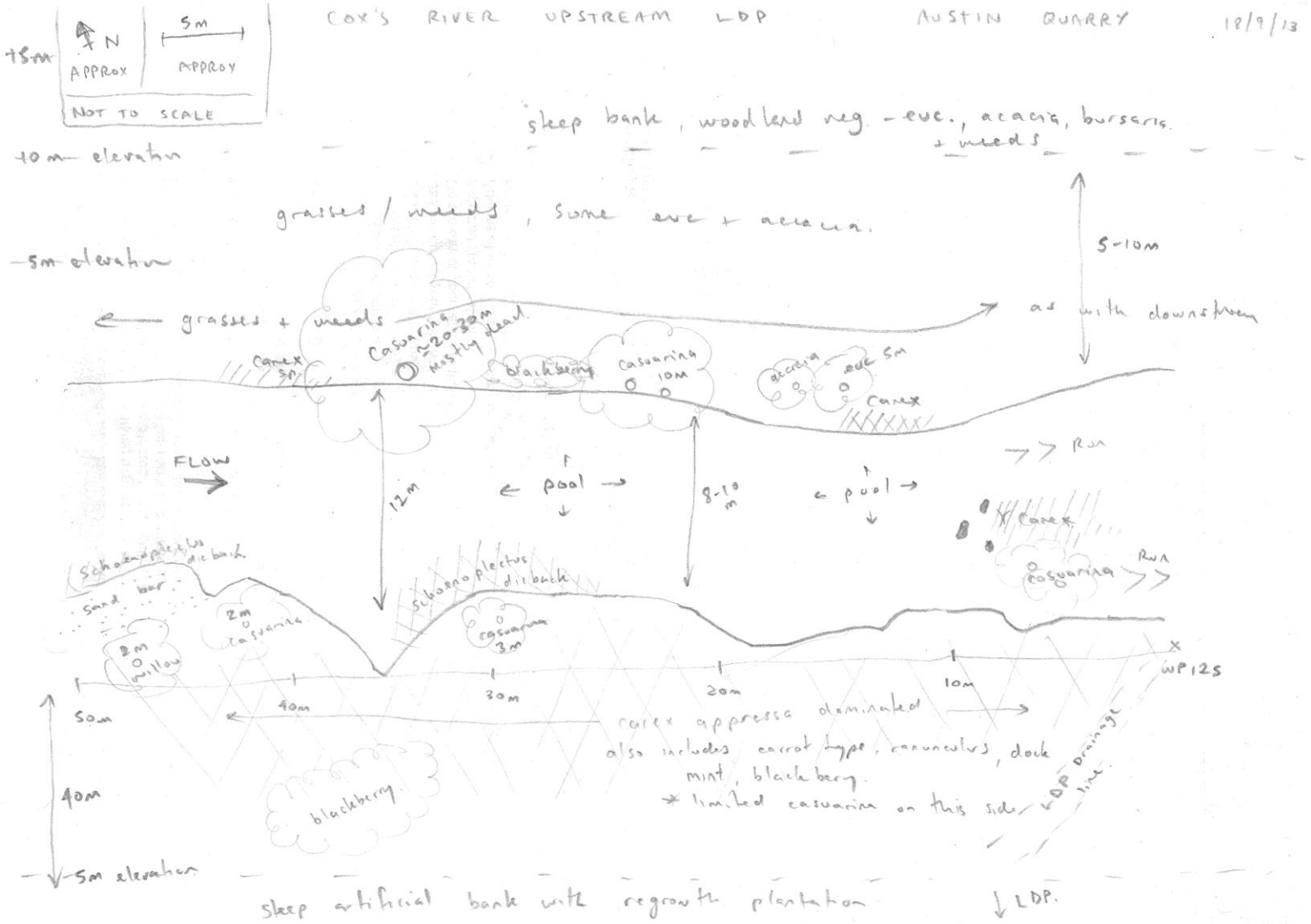
A. Aquatic macroinvertebrate data from sampling completed in September 2013

Site No.	1	1	2	2	11	11	5	5	7	7	9	9
Habitat	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**
Hydridae					X							
Dugesiidae						X	X				X	X
Nematoda							X					
Corbiculidae/ Sphaeriidae	X	X	X		X	X			X		X	X
Physidae			X		X	X		X		X		
Oligochaeta	X	X	X		X	X	X	X	X	X	X	X
Cladocera					X		X				X	
Copepoda		X	X		X		X		X		X	
Ostracoda			X		X						X	
Atyidae	X		X		X		X		X		X	
Parastacidae			X							X		X
Araneae	X								X			
Hydracarina	X	X						X			X	X
Hypogastruridae	X	X	X	X		X		X	X	X	X	
Entomobryidae	X		X								X	
Caenidae		X	X	X	X		X	X			X	X
Baetidae	X	X	X	X	X	X	X	X	X	X	X	X
Oniscigastridae	X		X		X				X		X	
Leptophlebiidae	X	X	X	X	X	X	X	X	X	X	X	X
Diphlebiidae		X										
Gomphidae		X	X	X		X	X			X		X
Telephlebiidae	X	X				X		X				X
Gripopterygiidae	X	X		X	X	X	X		X	X	X	X

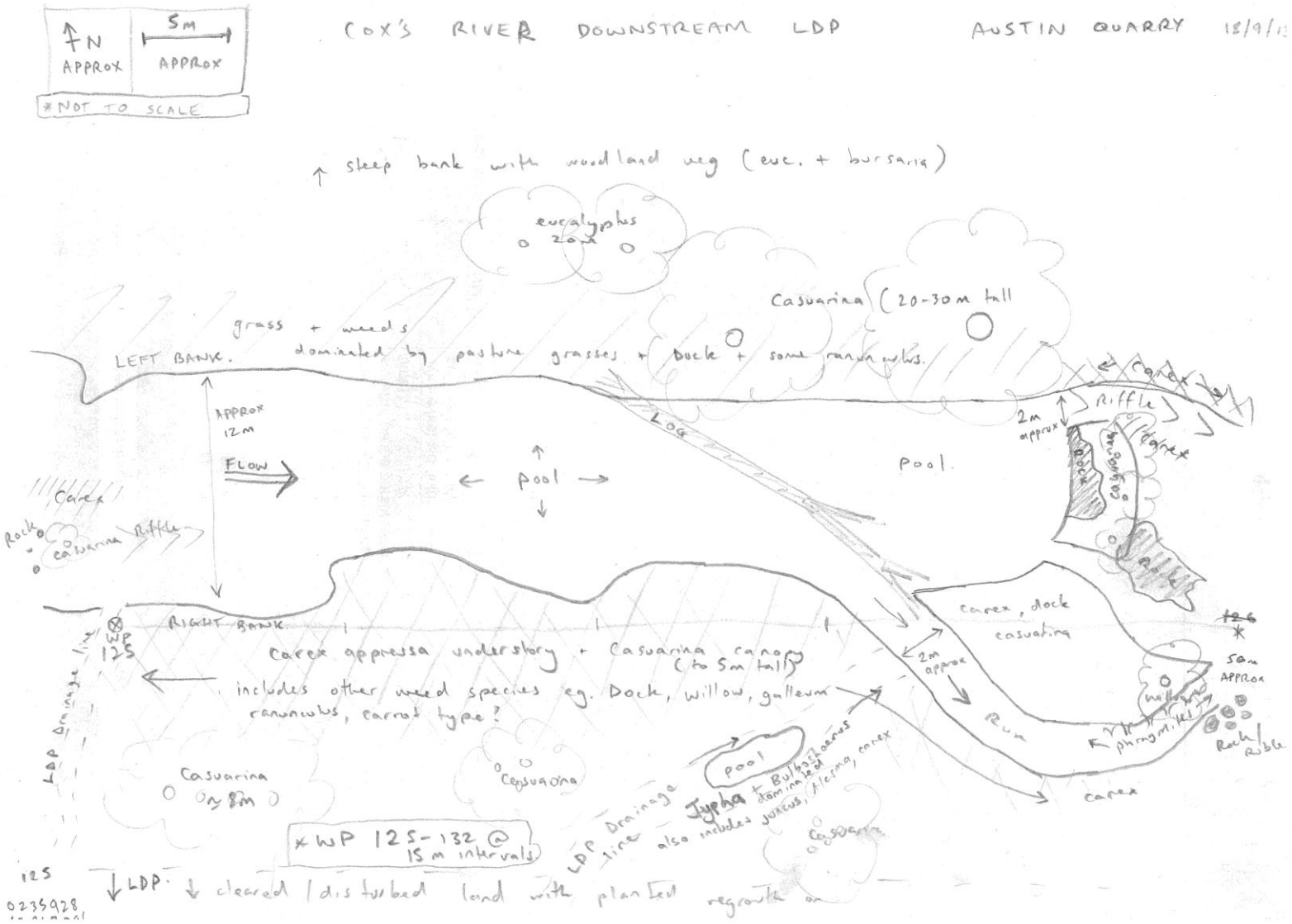
Site No.	1	1	2	2	11	11	5	5	7	7	9	9
Habitat	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**
Aphididae				X								
Veliidae			X		X				X	X	X	
Gerridae			X		X		X					
Gelastocoridae									X		X	
Corixidae	X	X	X		X		X	X	X		X	X
Notonectidae					X		X				X	
Corydalidae				X		X				X		
Sialidae					X							
Dytiscidae	X		X								X	
Hydrophilidae							X	X	X		X	
Hydraenidae									X		X	
Scirtidae									X		X	
Elmidae		X		X					X	X	X	X
Psephenidae				X		X					X	X
Dixidae									X		X	
Chironomidae/ Chironominae	X	X	X	X	X	X	X	X		X	X	X
Chironomidae/ Orthocladiinae		X	X	X	X	X		X		X	X	X
Chironomidae/ Tanypodinae	X		X	X	X		X				X	
Ceratopogonidae	X		X	X	X					X	X	X
Simuliidae	X	X	X	X	X	X		X		X		X
Tipulidae	X	X	X	X	X	X		X	X	X	X	X
Empididae		X								X		
Hydrobiosidae	X	X		X		X		X	X	X	X	X

Site No.	1	1	2	2	11	11	5	5	7	7	9	9
Habitat	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**
Hydroptilidae						X		X			X	X
Philopotamidae		X				X		X		X	X	X
Hydropsychidae		X		X		X	X	X		X		X
Ecnomidae	X		X			X	X			X	X	
Conoesucidae	X	X						X		X		X
Philorheithridae	X	X	X								X	X
Calamoceratidae									X		X	
Leptoceridae	X	X	X	X	X	X	X	X	X	X	X	X
Pyralidae									X			

B. Site map of riparian vegetation upstream of the LDP at the secondary processing area



C. Site map of riparian vegetation downstream of the LDP at the secondary processing area



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Austen Quarry Stage 2 Extension Project

APPENDIX E

MONITORING SITES FROM 2006-2011

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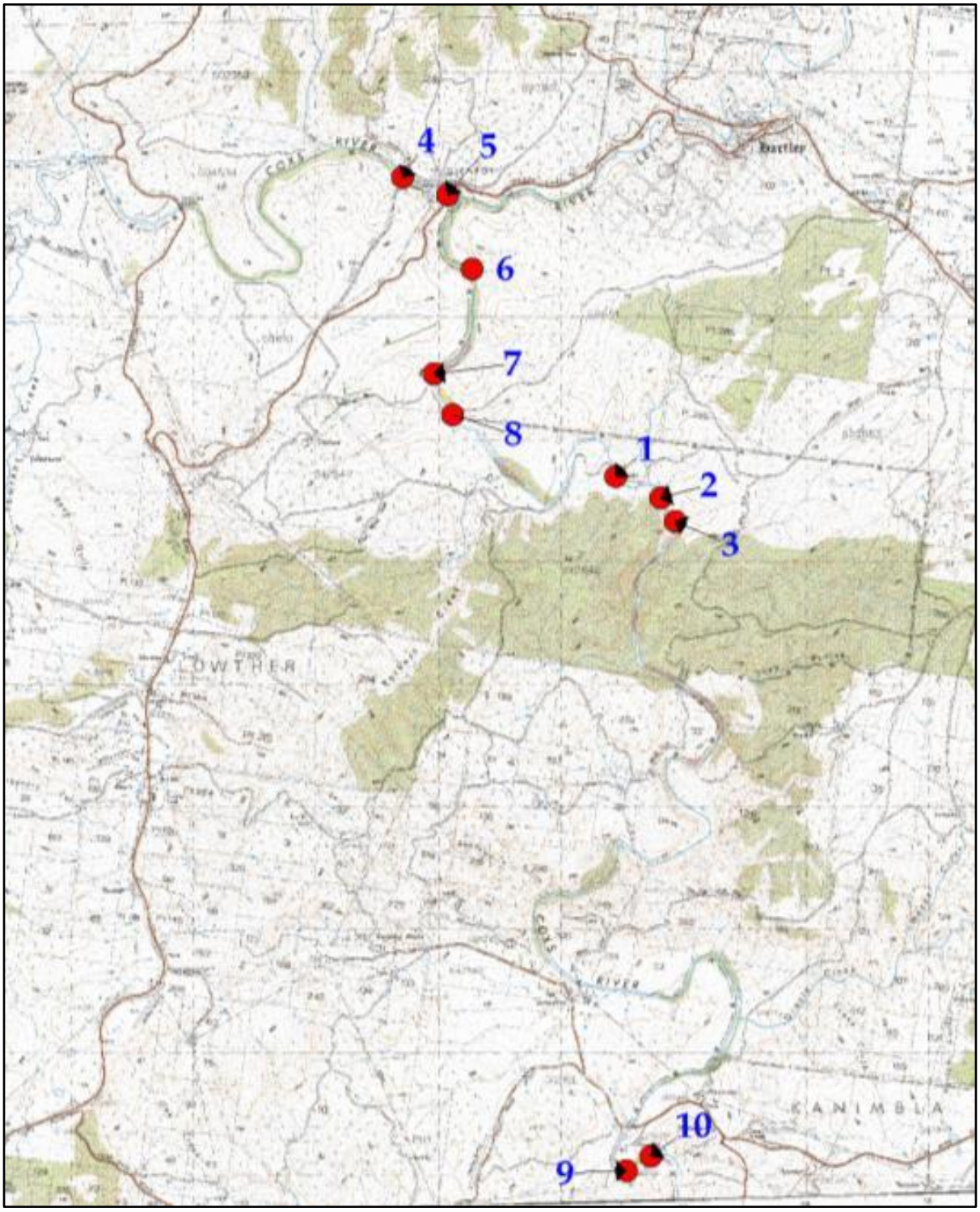
C. Monitoring sites from sampling years 2006 – 2011



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