WESTERN COAL SERVICES PROJECT

AQUATIC ECOLOGY ASSESSMENT

Wood Ducks on Cooks Dam

REPORT PREPARED FOR
Centennial Coal

MARINE POLLUTION RESEARCH PTY LTD
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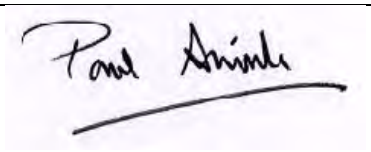
MPR APPROVAL: PAUL ANINK	 11 March 2013

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EXECUTIVE SUMMARY

This report describes and assesses the value of the current aquatic ecology of Wangcol Creek and Coxs River above and below the confluence in relation to the Western Coal Services Project:

- The Coxs River at the junction of Wangcol Creek plus Wangcol Creek and its sub-catchment tributaries (Neubecks Creek, Huon Gully and Lamberts Gully) are listed as "key fish habitat" under the FMA.
- Whilst there are no threatened aquatic species as listed under the NSW FMA or Commonwealth EPBC and none are expected, both Wangcol Creek and Coxs River support native fish and provide fish passage upstream past the site.
- Both waterways are accordingly classified as Class 2 “Moderate Fish Habitat” under the DPI Fisheries’ stream classification scheme.
- There are no surface aquatic ecosystems that are totally or substantially dependent on groundwater (GDEs) in Wangcol Creek or within the sub-catchment drainages through or in the vicinity of the upgrade site.
- Whilst Wangcol Creek provides suitable habitat for a variety of aquatic plants, fish and aquatic macroinvertebrates, the habitat values are compromised by low habitat diversity including lack of riparian vegetation and bank instability.
- Neubecks Creek is directly connected to Wangcol Creek and provides some aquatic habitat in the lower confluence section but there is little or no semi-permanent aquatic habitat further upstream.
- The upper catchments of Wangcol Creek, Lamberts Gully and Huon Gully are located in native woodlands but there is insufficient catchment area to provide semi-permanent aquatic habitat. The value in these upper sub-catchment areas is the supply of good quality catchment runoff for Wangcol Creek.
- However, this function of the upper sub-catchment drainages is compromised by the lack of separation between upper sub-catchment runoff water and process water management structures within the middle and lower sub-catchments. This includes the runoff from both Huon and Lamberts Gullies through the present Western Coal Services site.
- Assessment of the Neubecks Creek/Wangcol Creek and Coxs River study area aquatic ecology over the three baseline seasonal surveys between Autumn 2011 and Autumn 2012 indicates that overall variation in stream macroinvertebrate biodiversity can be attributed to a mixture of overall low habitat diversity and integrity, compromised sub-catchment runoff water discharge and licensed discharge impact.

The present site surface water management for protection of aquatic ecological values of the receiving waters includes internal drainage to control ponds and extensive water re-use facilities for dust suppression and the coal washery. However, parts of the site water management control system are linked to the Lamberts Gully stormwater collection and diversion system and parts of the stormwater diversion system are linked back into the system of site water management dams that eventually discharge via the licensed discharge point LDP006.

Potential construction impacts on aquatic ecology arising from the proposed Western Coal Services Project are generally related to site stormwater control and control of stockpile water runoff associated with site construction works at the Springvale Coal Services Site. Operational impacts are also generally related to control of site process waters and diversion of stormwater around the site and include the legacy problems already identified for the present site. The remaining project components, being the existing private haul roads, overland conveyors and the Kerosene Vale site are benign and are not being modified by the proposed project.

The potential construction and existing and potential operational impacts on adjacent aquatic habitats can be satisfactorily managed and mitigated via construction and operational Environmental Management Plans (EMPs). These provide the management measures for control, storage and treatment of site waters and set out the proposed mitigation measures that will be used to both minimise potential impacts from operations of the proposed upgrade plus reduce the overall site impact on surface water drainage and surface water quality to the creek and river.

The proposal also incorporates mitigation measures that have a direct benefit for the aquatic ecology of Lamberts Gully and Wangcol Creek east of the site:

- Riparian and stream bank improvements for Lamberts Gully and along Wangcol Creek that will address current habitat diversity problems and improve the water quality of stormwater draining from Lamberts Gully to the creek.

It is concluded that the proposed upgrade works coupled with improved site water management measures and creek plus river riparian and stream bank stabilisation and vegetation management measures will result in an overall improvement of water quality and aquatic habitat condition for the benefit of the aquatic biota residing in the creek adjacent to the site and for fish passage past the site.

The proposed works would maintain and improve the Key Fish Habitat and Class 2 features of Wangcol Creek and of the Coxs River below the confluence, and the proposed riparian and stream bank stabilisation and revegetation measures are in line with the Hawkesbury-Nepean Catchment Management Authority Action Plan 2007-2016 for the upper Coxs River catchment.

The environmental outcomes of the Western Coal Services Project construction, operation and remediation programs will be specified in an Environmental Management Strategy (EMS) that will incorporate all aspects of environmental control including aquatic ecology. An aquatic ecology monitoring program incorporating the base-line data from the present study will be undertaken as part of the EMS and will use a guiding set of criteria and protocols to establish if additional mitigation measures would be required. These would be specified in Trigger Action Response Plans (TARPs) contained in the EMS.

1 INTRODUCTION

Centennial Coal (Centennial) has developed a long-term strategy for its future operations in the Western Coalfield, that centres on the transport and processing of coal from Springvale Coal Mine and Angus Place Colliery, and may involve coal supplies from other areas (Figure 1).

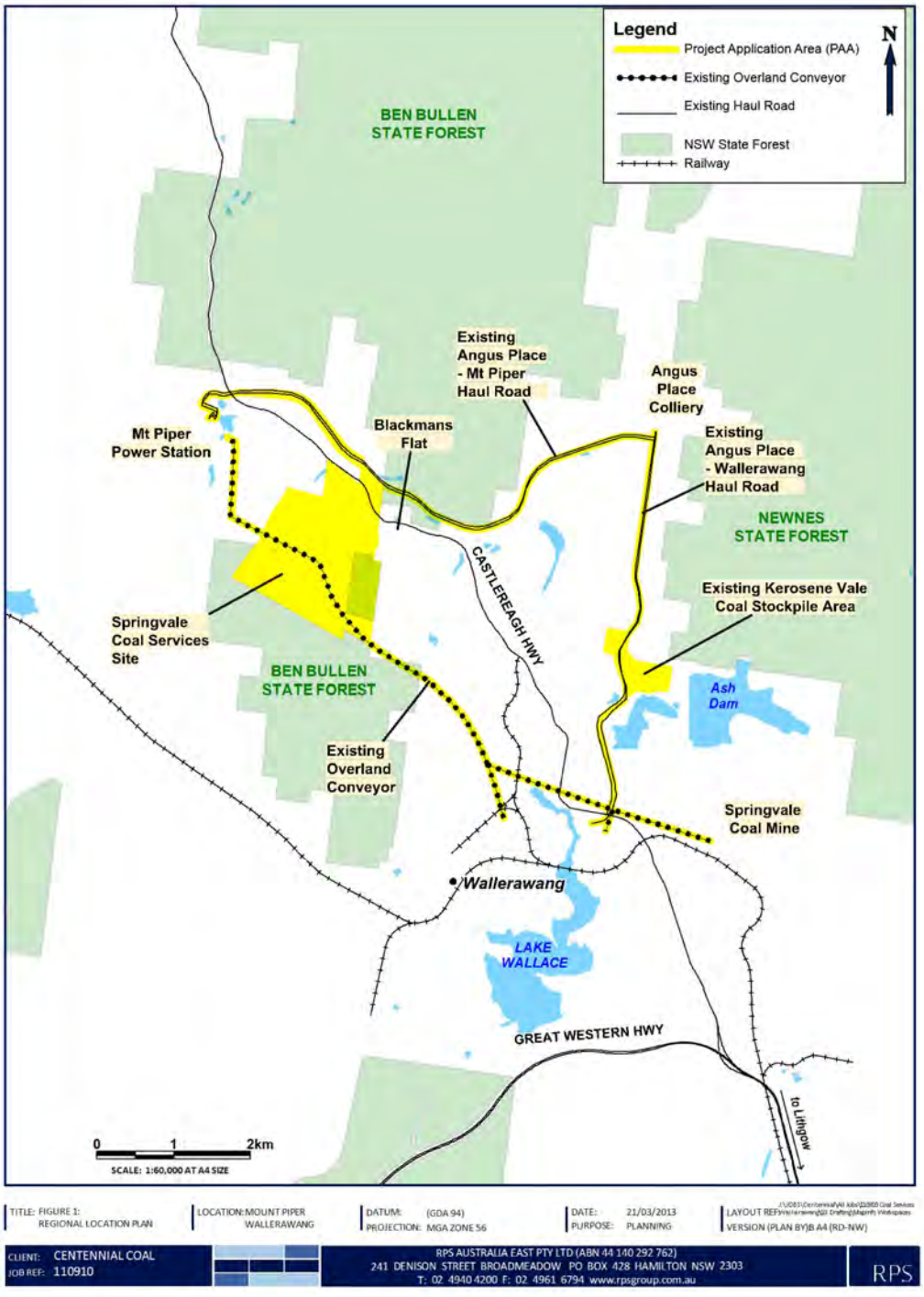

Figure 1 Regional Location Plan

Springvale Mine and Angus Place Colliery currently supply coal to the Wallerawang and Mount Piper Power Stations with some coal available for export via the Lidsdale Siding rail loading facility at Wallerawang:

- Unprocessed coal from Angus Place is transported directly to the Power Stations via trucks using dedicated haul roads. Angus Place currently has no access to Lidsdale Siding.
- Run of Mine coal from Springvale Mine is transported by overland conveyor to a coal processing and handling site located at the Springvale Coal Services Site (formerly known as Western Main Mine) off the Castlereagh Highway, adjacent to the now closed Lamberts Gully open cut mine near Blackmans Flat (Figure 1). Coal is then delivered via overland conveyors to the power stations. Reject/tailings from the coal washing are emplaced onsite.
- The Overland Conveyor 2 (OL2) is used to send coal back from the Washery to Lidsdale Siding.

The main purposes of the Western Coal Services Project are to develop suitable infrastructure to enable flexibility to supply both domestic and export markets from nominated mines within the Western Coalfield and to integrate into one approval the access, processing and distribution of coal from Springvale Mine, Angus Place Colliery, Lamberts Gully Open Cut and the Western Coal Services Site.

The proposed upgrade to the Springvale Coal Services Site will enable a total of 7.0 Mtpa of coal to be processed on site, making up to 6.3 Mtpa of product coal available for export if the whole export component is washed. The delivery capacity of the overland conveyor system to Lidsdale Siding will be 6.3 tpa which can be used for both processed and unprocessed coal.

The key construction elements of the Project are shown in Figure 2 and are described as follows:

- Upgrading the existing Washery at the Springvale Coal Services Site by constructing additional processing infrastructure adjacent to the existing facility, which is capable of processing a combined total of 7.0Mtpa.
- Provision for sufficient reject disposal capacity for a 25 year life.
- Increasing the rate and utilisation of the return side of existing overland conveyor system to enable up to 6.3 Mtpa to be delivered to Lidsdale Siding.

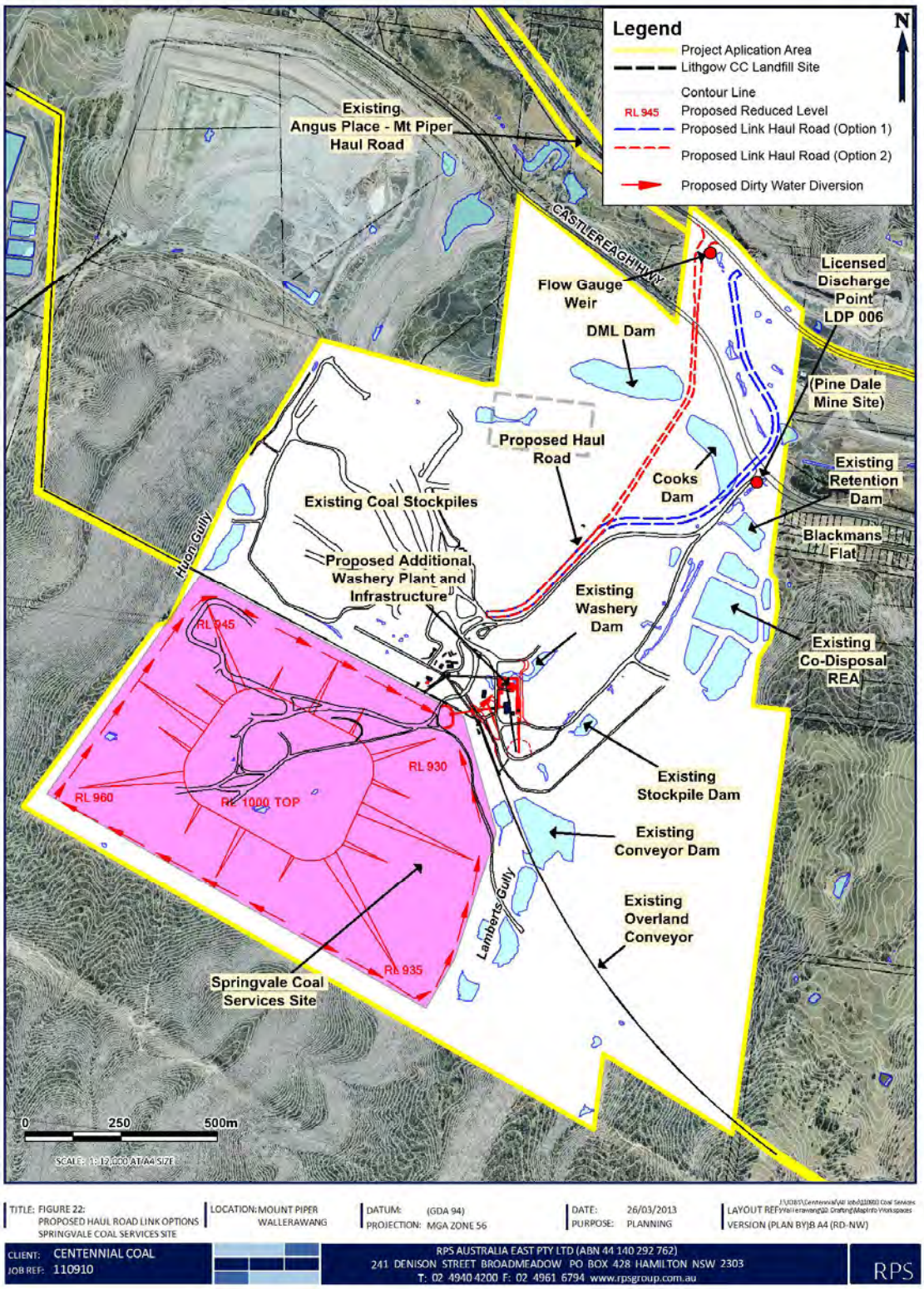

Figure 2 Layout Plan - Western Coal Services Project

- Construction of additional conveyors and transfer points and other coal handling requirements to cater for the upgraded Washery facility.
- Construction of a private haul road linking the Springvale Coal Services site with the existing private haul road from Angus Place Colliery to Mount Piper Power Station. This private road will cross a section of the existing Pine Dale Mine operation and over the Castlereagh Highway.

1.1 Aquatic Study Aims and Objectives

The NSW Department of Planning & Infrastructure (DoPI) issued Director General's Requirements (DGRs) on 6 November 2012, which required, *inter alia* the assessment of the potential impact of the project on aquatic ecology. Marine Pollution Research Pty Ltd (MPR) was commissioned to undertake this assessment.

The DGRs provide the overall requirements for the preparation of the Environmental Assessment and these are summarised in Section 1.3 below. In terms of overall study aims to meet the aquatic ecology assessment requirements, this report endeavours to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the aquatic habitats within the study area?
- Which of the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Is there fish passage between the site sub-catchment drainage lines, Wangcol Creek and Coxs River?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?
- Are there aquatic Groundwater Dependent Ecosystems (aquatic GDEs) in the study area?

1.2 Relevant Legislation & Guidelines

With regard to the assessment of aquatic ecology impact, a prime task is to determine whether there are any listed species or endangered ecological communities (EECs) in the study area or in areas that could be impacted by the proposal. Species and EECs are listed under the NSW *Fisheries Management Act 1994* (FMA) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC).

Assessment for Threatened Aquatic Species and for Aquatic Biodiversity are undertaken against the DEC *Draft Guidelines for Threatened Species under Part 3A of the EP&A Act 1979* and the NSW DPI Fisheries *Policy and Guidelines - Aquatic Habitat Management and Fish Conservation* respectively, as specified in the DGRs.

One of the objectives of the Fisheries Management Act 1994 is to 'conserve key fish habitats (KFH)' - those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. Accordingly, the aquatic ecology impact assessment needs to show how *Key Fish Habitats* are to be conserved or, if they are to be impacted, how these impacts can be minimised, mitigated or offset as per the DPI Fisheries' Guidelines (NSW Fisheries 1999a,b).

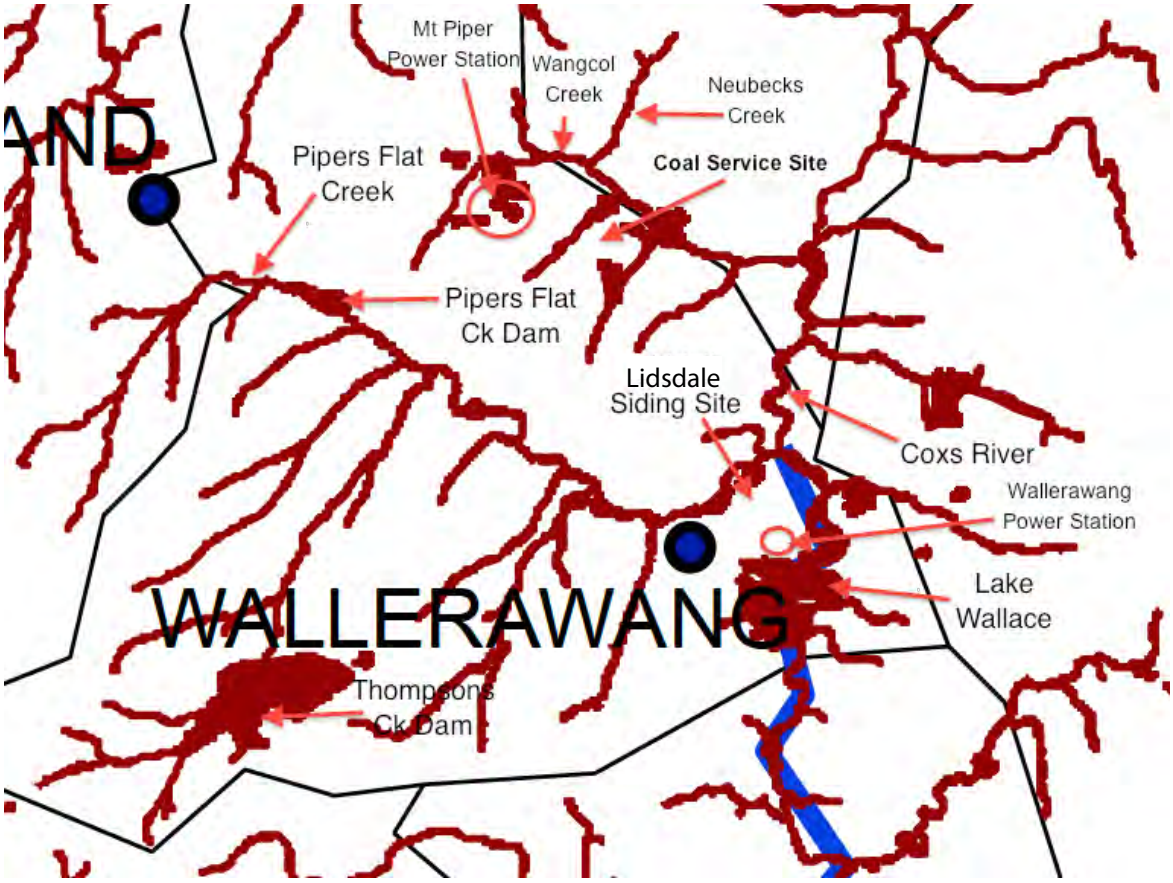

Figure 3 Portion of the DPI (Fisheries) Lithgow LGA Key Fish Habitat (KFH) Map DPI

DPI Fisheries has produced a series of KFH maps based on LGA boundaries and a portion of the Lithgow Regional KFH map is shown below as Figure 3. This map indicates that Coxs River, Wangcol Creek plus the two sub-catchment drainages to Wangcol Creek from the Western Coal Services Site are defined as KFH (shown in red).

Fisheries' guidelines also provide a Fish Habitat Classification Scheme (NSW Fisheries 1999b, see also Table 9), and the results of the baseline studies within the KFHs defined above are used to provide site-specific fish habitat classifications of streams within the study area.

Aquatic ecosystems include aquatic biota or assemblages that are groundwater dependent, and protection of potential Groundwater Dependent Ecosystems (GDEs) is set out in the NSW State Groundwater Dependent Ecosystem Policy (2002). Aquatic GDEs need to be identified using the eight-step rapid assessment (DLWC 2002), with specific potential aquatic GDEs including base-flow dependent GDEs, wetland GDEs and aquifer/cave GDEs. Terrestrial GDEs (i.e., those that are not associated with aquatic biota) are considered separately in the Terrestrial Ecological Assessment.

Where relevant, the following additional guidelines have been taken into account when assessing the Western Coal Services Project impacts and mitigation for aquatic ecology (see Section 5 for full citations):

- DEC/DPI (2005) *Draft Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act)*.
- OEH Website based *Survey and Assessment guidelines*. http://www.environment.nsw.gov.au/threatenedspecies/surveymethodsfauna.htm #1).
- AMBS (2011) *Survey guidelines for Australia's threatened fish*
- DLWC (2002) *NSW State Groundwater Dependent Ecosystem Policy*
- NSW Fisheries (1999a) *Policy & Guidelines - Aquatic Habitat Management and Fish Conservation*
- NSW Fisheries (1999b) *Policy & Guidelines - Fish Friendly Waterway Crossings*.
- Rutherford et al (2000) *A Rehabilitation Manual for Australian Streams*.

1.3 Compliance with DGRs

Table 1 summarises compliance with the DGRs in relation to aquatic ecology assessment.

Table 1 Compliance of Aquatic Ecology Report with DGRs

Agency	Requirement	Response	Report Sections
DP&I General Requirements	Description of existing environment using sufficient baseline data.	Streamhealth assessment in Wangcol Ck & Coxs R. up and downstream of confluence, including three seasonal surveys undertaken as per AusRivAS methods.	2.1 methods 5 results
DP&I General Requirements	Assessment of potential impacts and cumulative impacts as per relevant guidelines.	Assessment against guidelines as listed in Section 1.3 below.	6 Impact Assessment
DP&I General Requirements	Avoidance, minimisation, mitigation, offsets and contingency plans.	Assessed against guidelines as listed in Section 1.3 below.	6 Impact Assessment
DP&I Key Issue Biodiversity	Detailed assessment of potential impacts on aquatic threatened species or populations and habitats.	There are no listed aquatic threatened species or EECs and none are expected.	3 databases, 5.4, 5.5 & 5.6 study results
DP&I Key Issue Biodiversity	Detailed description of measures to avoid or mitigate impacts on biodiversity.	Assessed against guidelines as listed in Section 1.3 below.	6 Impact Assessment

1.4 Literature Review and Database Searches

Relevant aquatic ecology information has been sought from ecological studies conducted at the subject site and in the broader upper Coxs River catchment, generally from assessments of major developments and infrastructure projects. Relevant fish data, including records of threatened aquatic species listed under FMA were obtained from a search of records on the DPI (Fisheries) and the Australia Museum databases. The online search tool for aquatic species listed under the EPBC Act was also consulted.

With regard to the Springvale Coal Services site and the immediate Wangcol Creek sub-catchment of the upper Coxs River, there have been a number of major project assessments that have been consulted for aquatic ecological information. Whilst several of these studies provided general information on aquatic habitats none undertook any surveys for aquatic biota or for habitat assessment:

IEC (2006) Lambert Gully Mining Extension EA provides historic information on the hydrology and groundwater relationships of the Springvale Coal Services site and notes that the area in the immediate and surrounding vicinity of the Application Area has a long history of underground and open cut mining and associated infrastructure and power generation and associated facilities. It describes the (now closed) Lamberts Gully operation (located in the Future Rejects Emplacement Area) which mined an area of remnant shallow coal, and the interrelationships of the site to the Mount Piper Power Station and ash disposal facility and the proposed Lithgow Council Waste Disposal Facility, both of which require local open cut mining voids as part of their operation.

The report also provided a description of the interaction of groundwater with surface water expressions for the Springvale Coal Services site and a description of the Springvale Coal Services water management system incorporating clean and dirty water systems. Since that time, and following review by GHD (2009), further separation of clean and dirty water systems have been undertaken, and more are proposed as a part of the present proposal (see the Western Coal Services Project Surface Water Assessment Report RPS 2013).

Geolyse (2006) provide a summary assessment of an earlier EIS and other reports for the establishment of a waste management facility for Lithgow City Council utilising existing voids within the Springvale Coal Services site. The site is located on the Old Western Main Colliery site, and has been the subject of previous underground and open cut mining operations. The northern part of the site contains a void: the result of previous mining operations. A dam, known as the DML Dam, is located in the north-eastern part of the site. Whilst much of the site is devoid of vegetation, there is an area of stockpiled overburden directly south of the void and the dam, which is surrounded by an area of remnant vegetation and some areas of rehabilitation planting.

GHD (2007) provided an integrated Lambert Gully Mine rehabilitation plan plus a revised surface water management plan for the rehabilitation works that expanded on the system described by IEC (2006) and GHD (2009) provided a revised Surface Water management Plan for the Springvale Coal Services Site.

SKM (2010) compiled an EA for the possible use of Springvale Coal Services voids in the Future Rejects Emplacement Area and in the lower Huon Gully for Mount Piper Power Station (Delta Power) ash placement. Whilst the report does not provide any specific aquatic ecology assessment, it does make some comments about remnant wetland and riparian vegetation in the area of remnant vegetation in the Future Rejects Emplacement Area (i.e., part of the Lambert Gully West sub-catchment - see Figure 4):

- Remnant vegetation at the site also includes numerous small and one large ephemeral drainage line and an ephemeral wetland at the south-western edge of the largest remnant patch. These areas provide refuge, foraging and breeding habitat for amphibians, and provide an important water source for other fauna.
- The ephemeral wetland and creek line with associated pond provide foraging, breeding and refuge habitat for frogs at the site. Two species (common eastern froglet and red-groined toadlet) were detected at the ephemeral wetland during the survey, and it is likely others encountered by Ecotone during their 1996 survey also occur at the study area. The ephemeral wetland is in particularly good condition, with abundant littoral vegetation and apparently good water quality. Both habitats offer abundant adjacent terrestrial and riparian refuge.

RW Corkery and Co (2010) produced the Pine Dale Coal Mine Yarraboldy Extension EA and ecological assessment was undertaken by Ecotone (2010). The report did not include any sampling of Wangcol Creek and noted that the aquatic habitats present in the study area included only two artificial wetlands: one excavated dam and one small shallow wetland, which has formed behind a wall constructed across a gully. No running streams, water flow channels or vegetation recognisable as riparian vegetation occurred in the study area. A fish survey was not conducted on the subject site as Ecotone (2010) reasoned that due to the artificial nature of the water bodies, and the distance from natural bodies of water, it was considered unlikely that the wetlands on the site would support native fish. They also noted that limited wetland vegetation was associated with the two wetlands on the site with only a small number of wetland-dependent vertebrate species (four species of frogs and one waterbird) detected using the wetland habitats.

The Hawkesbury Nepean Catchment Management Authority (HNCMA) has assessed the upper Coxs River aquatic and riparian habitats as part of their River Health Strategy (HNCMA 2007). The upper catchment river was found to be under “severe and immediate threat from riparian weed invasion and coarse sediment as a result of erosion, which creates a severe downstream impact”. HNCMA (2007) recommended that the most effective land management strategy for the Upper Coxs River catchment is riparian revegetation.

GHD (2012) provided an assessment of Springvale Coal Service's water quality data from LDP006 and Wangcol Creek up and downstream sites. The downstream monitoring location has data dating back to January 2000 with monthly data for a limited suite of parameters from November 2007 and monthly data for a full suite of parameters since July 2010. The upstream site corresponded to the Office of Water flow gauge and a full 24 month sampling data set was not yet available at the time of report preparation. An interim set of Site Specific Trigger Values (SSTV) was established using the existing data. The assessment showed that some parameters exceed the SSTVs at the downstream monitoring location including EC, aluminium, iron, manganese, nickel and zinc. The report recommended that the monitoring program be continued and that the SSTV's be reassessed once a full 24 month data base is established for the upstream reference site. The report also recommended that Centennial Coal consider installing an additional two monitoring stations downstream of LDP006 at 400 and 800 m and that these sites be sampled for Ni, Zn and Mn to further delineate the size of the downstream mixing zone. This is in addition to ongoing site water management improvements to reduce levels of Ni, Zn and Mn. The Surface Water Management Report for the Western Coal Services Project prepared by RPS (2013) provides an update on this report

MPR (2010) and Cardno Ecology Lab (2010) provided reviews of available aquatic ecological information for the upper Cox River above Lake Wallace and for the Coxs River between Lake Wallace and Lyell respectively:

- Battaglia et al (2005) undertook studies of the riffle macroinvertebrate assemblages in Wangcol Creek and two streams un-impacted by coal mining (Megalong and Jocks Creeks) and found that the Wangcol Creek macroinvertebrate assemblage was less diverse and less abundant than in the reference streams. They used reciprocal transplant studies to show that the toxicity for the macroinvertebrate assemblages was primarily due to adverse water quality (low pH and dissolved metals) rather than sediment quality.
- TEL (2007) undertook electrofishing and macroinvertebrate surveys in two creeks within the upper Coxs River catchment; Kangaroo Creek and Sawyers Swamp Creek and in Marrangaroo Creek, which flows to the Coxs River below Lake Wallace.
- Cardno Ecology Lab has been undertaking fish and macroinvertebrate surveys in the Coxs River between Lakes Wallace and Lyell since 2005.

- MPR has undertaken seasonal macroinvertebrate and fish trapping studies at multiple sites in Coxs River, Kangaroo Creek, Wangcol Creek, Pipers Flat Creek and Springvale Creek since 2010.

With respect to macroinvertebrate communities, there is limited publically available information for the river and creeks above Lake Wallace prior to the commencement of the MPR seasonal surveys in 2010. TEL (2007) noted that the macroinvertebrate fauna of Sawyers Swamp Creek was dominated by pollution tolerant taxa such as midge flies (sub-families Chironominae and Tanypodinae) and biting midge larvae (family Ceratopogonidae), whereas locations in two other creeks showed higher proportions of pollution sensitive taxa: caddis-flies (family Leptoceridae) and mayflies (family Leptophlebiidae) in Marrangaroo Creek and dragonflies (family Telephlebiidae) and stone-flies (family Gripopterygidae) in Kangaroo Creek.

With respect to the fish fauna of the upper Coxs River, both the main artificial impoundments on the upper Coxs River (Lake Wallace and Lake Lyell) have no fishways and they represent impassable barriers to most fish species (Gehrke and Harris 1996). Nevertheless, Lake Wallace and the upper Coxs River catchments do support several native and a number of introduced fish species:

- The native flathead gudgeon and the introduced brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), mosquito fish and carp (*Cyprinus carpio*) have all been reported previously from Lake Wallace (Jones et al 1994).
- The two trout species plus the native Australian bass (*Macquaria novemaculeata*) have been stocked in Lake Wallace and Coxs River (NSW Fisheries 2003).
- TEL (2007) found a small number of mountain Galaxias in Sawyers Swamp Creek and there were no fish recorded from Kangaroo Creek. Three introduced species were recorded in Marrangaroo Creek; brown trout, rainbow trout, and gambusia. Although there is inhibited fish passage between Marrangaroo Creek and the study area upstream of Lake Wallace, there is passage to the lower end of the study area below Lake Wallace dam.

The following threatened species or populations listed under the FMA and EPBC Act are relevant to the assessment:

- Macquarie perch (*Macquaria australasica*) are listed as Endangered under both the NSW *Fisheries management Act 1994* (FM Act) and the EPBC Act. Whilst Macquarie perch have been reported from the Coxs River below Lake Lyell, they

have not been found in the upper river and, owing to the impassable Coxs River impoundments, these species are not expected to occur.

- Australian grayling (*Prototroctes maraena*) are listed as Vulnerable under the EPBC Act. Whilst Australian Grayling are known from high altitude rivers on the Australian east coast it is also severely impacted by impoundments, and has not been recorded in the Coxs River above or below the impoundments.
- The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: 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. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 5). Considering these observations, and taking into account the habitat requirements for this species it is concluded that the aquatic habitats available in the lower Pipers Creek and Coxs River above Lake Wallace do not provide suitable habitat for Adams Emerald Dragonfly and none have been located in the aquatic ecology sites studied seasonally in the upper Coxs River since at least 2007.

In summary, no threatened aquatic plants, fish or macroinvertebrate species or populations listed, under the threatened species provisions of the Commonwealth EPBC Act or under the threatened species provisions of the NSW FMA have been found or are likely to occur in the upper Coxs River catchment above Lake Wallace.

1.5 Description of the Study Area

Whilst the project area is defined as indicated in Figure 2 above, the actual study area for consideration of aquatic ecological impacts needs to include the complete sub-catchments for the project area with regard to assessment of aquatic habitat, fish passage and habitat connectivity. Figure 4 provides a portion of the available topographic information (from lite.maps.nsw.gov.au) showing the two main sub-catchments that drain waters from the Western Coal Services site:

Huon Gully:

- The western sub-catchment known locally as Huon Gully rises on the northern flank of Mount Piper and drains through part of the Ben Bullen State Forest then along the western flank of the South-west rejects emplacement area to drains into a constructed dam just below the Mount Piper Coal Conveyor line.

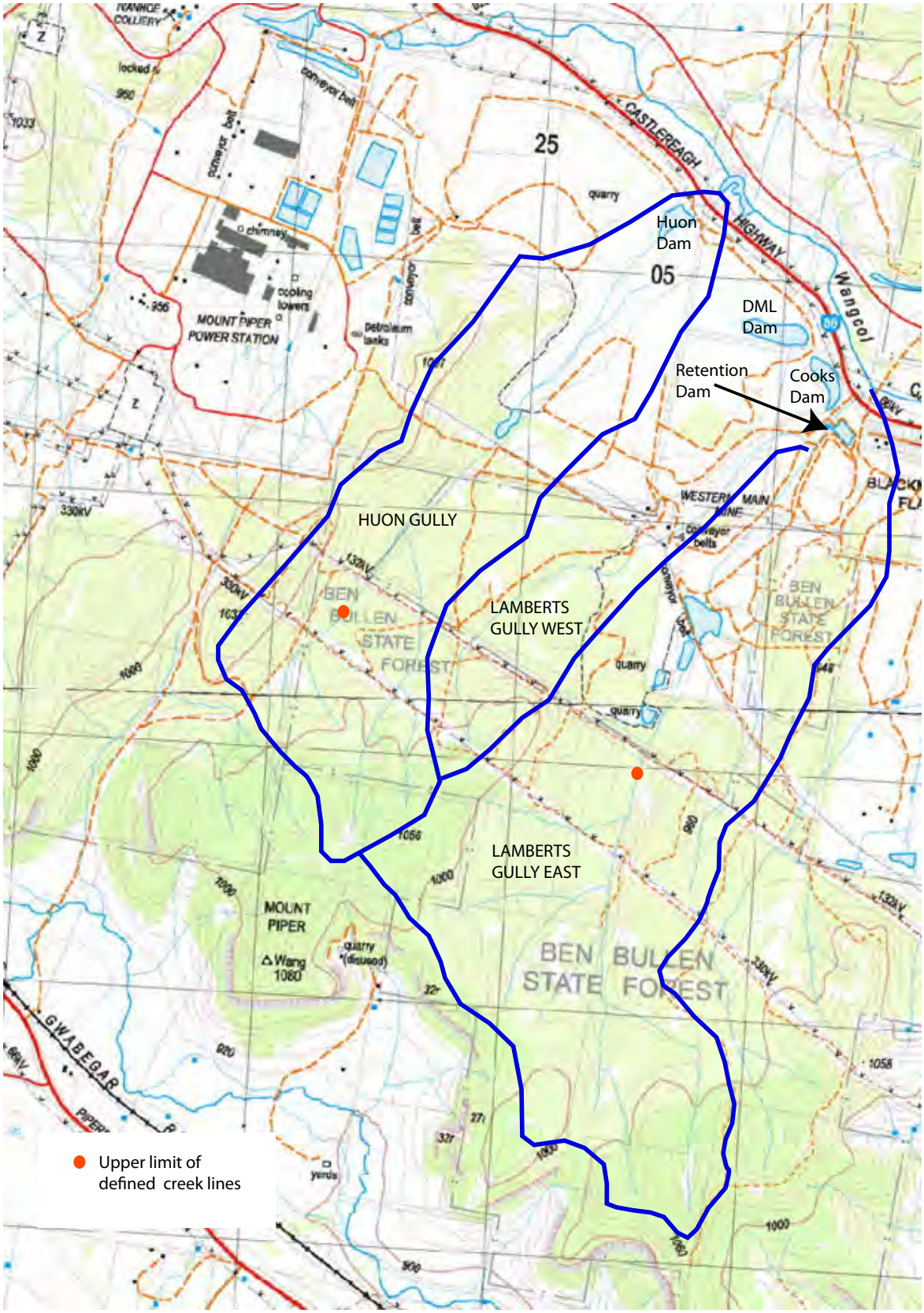

Figure 4 Huon and Lambert Gully sub-catchments showing present upper limits of defined creek structure (NSW Government www/lite.maps.nsw.gov.au web site).

- A portion of the upper sub-catchment has been subsumed into the south-east rejects emplacement area. Prior to entering the Coal Services site this dam collects both natural creek drainage and road drainage from the conveyor service road and from service roads for two high tension electricity easements. The Huon Gully within the Springvale Coal Services land contains settlement ponds that blend upper catchment drainage water with settled site water and the overflow from the settlement dams flows out of the property and through land controlled by Delta Electricity to Huon Dam. Overflow from Huon Dam drains to Wangcol Creek.

Lamberts Gully:

The eastern sub-catchment known locally as Lambert Gully rises on the south-eastern escarpment of Mount Piper. There were originally two main upper sub-catchments for Lamberts Gully. These are designated on Figure 4 as "West Lamberts Gully" and "East Lamberts Gully". West Lamberts Gully has been subject to mining operations since open cut mining begun in 1940 (see Main EIS report Section 2.4.1):

- The lower West Lamberts Gully sub-catchment" below the Pit A REA area now contains the washery plus the Washery Sediment Pond (to the north-east of the existing coal washery), and this dam drains north east to a final settlement dam (adjacent to the existing co-disposal area), before being piped into the lower Eastern Lambert Gully drainage.
- Much of the upper section of West Lamberts Gully has been lost to the Lambert's Gully mine works which have now become the Pit A Rejects Emplacement Area (REA) and that now forms part of the proposed REA south of the overland conveyor (Figure 2). Residual drainage from the small remaining forested upper western sub-catchment area is diverted along the electricity high tension easement service road into a small dam on the remaining (Eastern) Lamberts Gully sub-catchment.
- The Eastern Lamberts Gully sub-catchment (now referred to as simply Lamberts Gully) has a series of inline dams constructed within the Springvale Coal Services site that collect the natural drainage from the forested upper sub-catchment located to the south of the site within Ben Bullen State Forest, plus drainage from service roads for the two electricity high tension lines to the south of the site and drainage from service roads within the Springvale Coal Services site. The drainage from these upper sedimentation ponds then flows through a number of water quality control structures that also take the drainage from the existing washery pond. The drainage from the Washery Sediment Pond is piped to Cooks Dam (Figure 2).

- Water from the Retention Pond may be combined with water from Cooks Dam prior to discharge at LDP006, which is located on the original Lamberts Gully drainage line above the culvert under the Castlereagh Highway.
- Drainage from Lamberts Gully flows through LDP006 into Wangcol Creek.

Wangcol Creek from the LDP006 confluence to the confluence with Coxs River (some 2.4km downstream) is a constructed drainage more or less within the original creek alignment (Figure 5). Wangcol Creek flows from the northwest to the southeast, generally parallel to various rehabilitation areas before entering the Coxs River at the Blue Lake (which was the original Commonwealth Open Cut Mine final void). The course of Wangcol Creek was redirected to accommodate the operation of a number of small, shallow open cuts operated by various government agencies during the early 1950s to overcome severe coal shortages in the immediate post-war years. Whilst there have been slight variations in the geometry of the creek banks since the late 1950s to accommodate later developments, the creek banks have progressively stabilised from the presence of naturally established native grasses and trees, including eucalypts.

The Coxs River is a major tributary to the Hawkesbury-Nepean River system and is part of the Sydney Water Catchment Area. It originates in the Blue Mountains Range around 23km north of Lithgow at an elevation of 1060m Australian Height Datum (AHD), and the average annual rainfall for the study area is 760mm. From the headwaters, the river flows in a southerly direction before heading east at the Wild Dog Mountain Range towards the Nepean River, east of the Blue Mountains. There are three large impoundments along the length of Coxs River; Lake Wallace within the study area, Lake Lyell some 12km downstream from Lake Wallace and Lake Burragorang (Warragamba dam), just above the confluence with the Nepean River.

The upper 5km of Coxs River catchment within the study area is in Ben Bullen State Forest, which gives way to cleared valley floors bordered by vegetated slopes at Angus Place. The remainder of the upper Coxs River study area has been subjected to extensive agricultural and industrial activity and most of the river reaches are highly degraded.

1.5.1 Summary of present study area drainages

In summary, the three upper catchment drainages that flow through the Springvale Coal Services site provide more or less intact upper catchment ephemeral aquatic habitat within the Ben Bullen State Forest above the site, and then all three creek lines become integral to the surface water management for the site (or for Delta Electricity site water management) with inclusion of various in-line water quality treatment measures prior to

discharge to the series of dams established at the northern side of the site, just above the Wangcol Creek floodplain. These combined water treatment facilities mean that there is little or no suitable fish passage from Coxs River/Wangcol Creek up into the lower catchments of the drainages, and no natural drainage aquatic habitats available on either the Springvale Coal Services or Delta Electricity sites.

Eventual discharge of Huon Gully to Wangcol Creek now only occurs via the possibility of dam overflow discharges from Huon Dam (which is now part of Delta Electricity's water management system), and discharge of the two Lamberts Gully sub-catchment treated water drainages to Wangcol Creek is via the Licensed Discharge Point LDP006 below the Retention Pond. DML and Cooks Dams discharge above the current location of the LDP006 point.

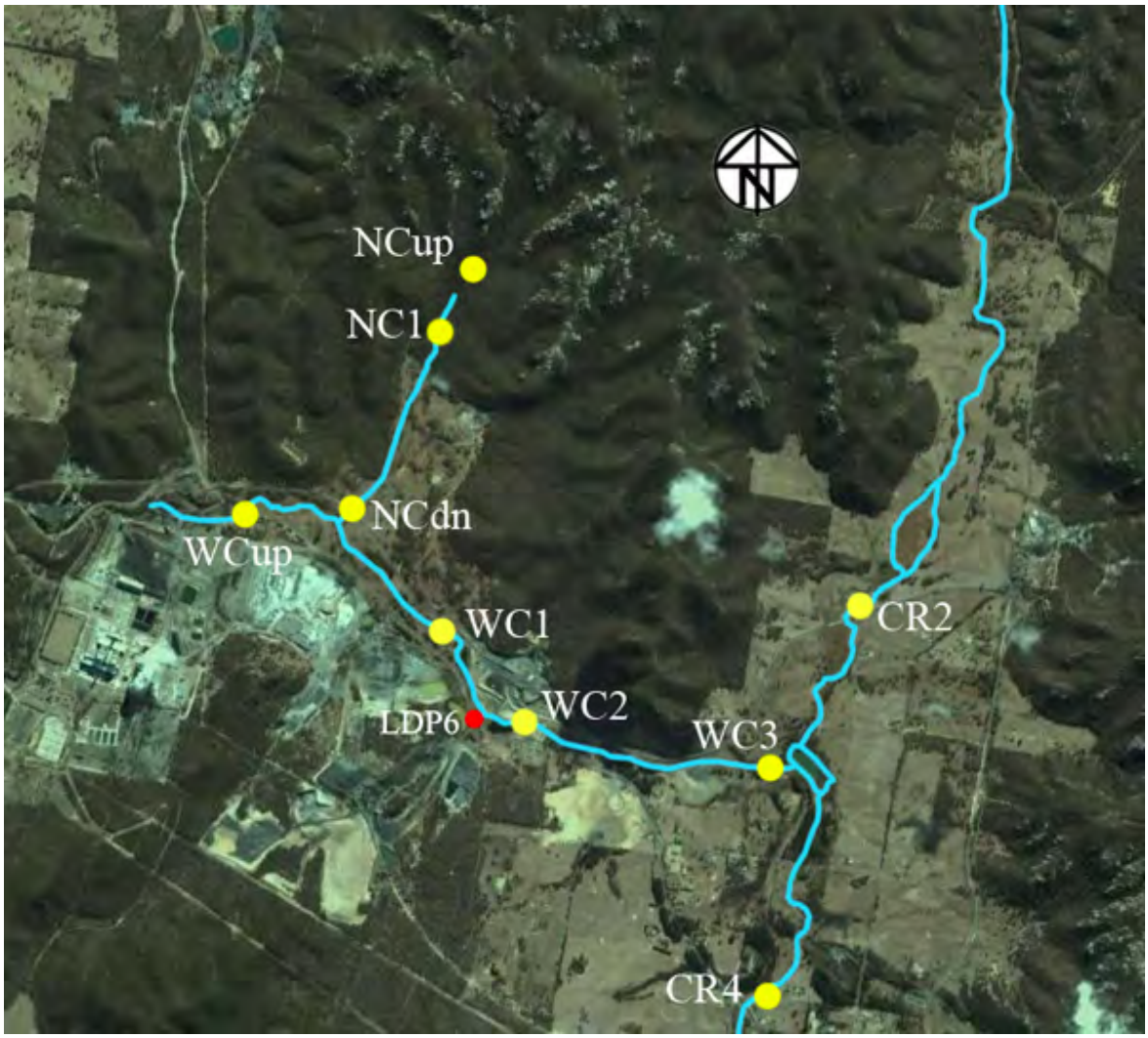

Figure 5 Stream Sampling Sites for assessment of Western Coal Services Project area receiving waters Aquatic Ecology

2 STUDY & ASSESSMENT METHODS

2.1 Study Design and Study Elements

The study aims and objectives are outlined in Section 1.2 above and the adopted sampling methodology to achieve the study aims incorporated the following sampling tasks:

- Sampling the aquatic macroinvertebrate fauna of suitable creek habitats twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June 15 and 'spring' is defined as September 15 to December 15.
- Depth profiles of basic water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Recording of changes in site riparian and aquatic habitat condition and of aquatic plant distribution within the study areas at each sampling time.
- Estimation of fish occurrence by a combination of overnight or short-term bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released wherever possible.

The adopted study design to achieve these objectives uses in-stream sites within Neubecks Creek, Wangcol Creek sites up and down-stream of LDP006, and additional sites in the receiving waters of Wangcol Creek and the Coxs River. Figure 5 shows site locations for the Autumn 2011, Spring 2011 and Autumn 2012 sampling periods.

2.2 Aquatic Macroinvertebrate Sampling

The aquatic macroinvertebrate assemblages are determined using the standardised AusRivAS sampling protocol (Turak et al 1999, Turak et al 2004, Chessman 2003b), which provides a number of definitions of sites, and of habitats within sites, for selection of sampling locations:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater"
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum". However, "sampling riffles where the substratum consists predominantly of large boulders may be difficult and may not produce

reliable results".

- Edge habitat is "an area along the creek with little or no current".

Ideally, AusRivAS recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site. In practice, given that the creek sub-catchments are often dry or have no flow with consequent isolated pools, it was decided that pool 'edge' samples would comprise the main sampling unit, as riffle samples could not be guaranteed for all sites at all sample times.

Macroinvertebrate assemblages are sampled using a 250 μm mesh dip net over as many aquatic 'edge' habitat types as can be located within each of the pools along the defined stream reach. Net samples are then placed into white sorting trays for in situ live sorting. Live sorting (picking) is undertaken for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations are made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms are collected and added to the dip net samples.

Specimens for which positive identifications can be made in the field - especially the rarer specimens (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopt a 'sampling with replacement' policy. Notwithstanding this procedure, for most taxa that can be positively identified in the field, at least one of each of the field identified taxa are retained as a representative of that taxa for that sampling event. For all other macroinvertebrate taxa where field identifications are not definitive, specimens are retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies).

All retained specimens are placed in sample jars preserved in 70% ethanol for subsequent laboratory identification. Sample jars are labelled and paper laundry tags are inserted noting the sample site, sample date and sample collector/picker initials.

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes. The following taxonomic guides have been found to be the most useful; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999) & Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars. Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed. At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies. Following this procedure, and if there have been anomalies, an additional 10% of the remaining samples are chosen and the QA/QC re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.1 Macroinvertebrate data evaluation

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL (Stream Invertebrate Grade Number Average Level) score. SIGNAL is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus

(Chessman 2003a). Whilst site SIGNAL scores are graded into the following generalised categories (Chessman *et al*. 1997), in practice the SIGNAL scores are used to provide relative assessments within site and across seasons:

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

Once individual taxa SIGNAL indices have been applied, site SIGNAL scores are calculated as the mean of the individual taxa SIGNAL indices. For coherent groups of sites (e.g., all sites within a stream/river or all dam sites within a catchment), combined stream or habitat type (dams) scores can be calculated in the same way from the combined taxa for the stream/habitat types. Site and stream/habitat SIGNAL scores can then be compared across each survey and between surveys.

2.3 Field Sampling Methods for Fish and other Vertebrates

At each macroinvertebrate sampling site four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified in situ and released. Any fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released. Fish specimens that become deceased during the sample process are retained with macroinvertebrate samples, and identified using Allen et all (2002) and McDowall (1996). Any fish retained that are not positively identified are sent to the Australian Museum for confirmation of species identification. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted, with fish species-name only noted if positively identified.

For each survey, tadpoles and frogs (amphibians) are noted in the results but tadpoles are not kept or identified (see the Terrestrial Fauna report for details of amphibians). Notes are also kept of the presence of reptiles, turtles, aquatic birds and bats that directly utilise the aquatic habitats. Sightings and searches for possible platypus burrows and Australian water rat tracks are made at suitable river and creek locations, preferably at dusk to detect the emergence and activity of these aquatic animals. Reports of amphibians, reptiles, birds and mammals are provided to the Terrestrial Fauna team for incorporation into their assessments where required.

2.4 Stream Condition, Aquatic Plants and Field Water Quality

A standardised description of aquatic and riparian site condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997). The index is compiled by rating each RCE descriptor (13 in total) a score between 0 and 4, then summing the scores to reach a maximum possible score of 52. Scores are then expressed as a percentage.

The aquatic edge sampling for macroinvertebrates includes the assessment of aquatic plants (macrophytes) within the site length and within the greater study area.

A submersible Yeo-Kal 911 water quality data logger was used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. Where possible depth profiles of water quality are made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.).

2.5 Aquatic Groundwater Dependent Ecosystems (GDEs)

The Aquatic Ecology study included inspections for Aquatic Groundwater Dependent Ecosystems (Aquatic GDEs) within the study area, as required under the DGRs Key Issue for *Biodiversity*). Aquatic GDEs include all aquatic biota of aquatic habitats that are dependent (or substantially dependent) on baseflow for their continued existence, and this definition does not include ephemeral aquatic habitats that depend on sporadic surface water flow.

The search for possible surface expressed aquatic GDEs was based on analysis of current aerial photography, on available topographic information, on discussions with the project groundwater experts and on field stream walk-over assessments.

3 AQUATIC ECOLOGY OF THE STUDY AREA

As noted in Section 1.5 the Western Coal Services Project study area comprises three upper sub-catchment drainages above the site, highly modified drainages through the site and the receiving waters of Wangcol Creek and Coxs River below the site. The aquatic habitats of these drainages are described in Section 3.1 and Section 3.2 provides the results of aquatic studies on the receiving waters of Wangcol Creek and Coxs River above and below the Springvale Coal Services LDP006. Annexures A and B provide the full data sets for the surveys undertaken in Autumn and Spring 2011 and Autumn 2012.

3.1 Descriptions of the Study Area Sub-Catchment Drainages

Walk over surveys were undertaken of the upper sub-catchment drainages to Wangcol Creek from the Springvale Coal Services site during the Spring and Autumn 2011 field surveys. The following summary descriptions are based on these surveys.

3.1.1 Huon Gully and Lamberts Gully Upper Catchments

The study area upper catchment within the Ben Bullen State Forest comprises a set of gently sloping drainages north from the Mount Piper escarpment towards Wangcol Creek. The upper Huon Gully and the East plus West Lamberts Gully sub-catchments are broad open forest swales with little or no defined aquatic attributes until at least the first (southernmost) electricity high tension wires easement (Figures 6 and 7).

From the first electricity easement to the second (northerly) easement, the sub-catchment drainages continue as broad grassy swales with occasional short narrow shallow drains within the broad grassy swale that may hold water for short periods after rain (Figures 8 and 9). Where these swale drainages cross the electricity easements there may also be some additional but temporary ponding of water following rainfall (Figures 10 and 11). There are no semi-permanent aquatic habitats and no indications of emergent vegetation that could indicate swampy meadow habitats.

Below the southern electricity easement both the Huon Gully and Lambert Gully sub-catchments steepen a little and there are more defined ‘V’ shaped drainage lines plus some short ephemeral incised pool sections constrained by accumulated sediments or rocks plus debris. These drainage features are ephemeral with bare accumulated sand and litter substrata, and no emergent plants to indicate any retained sub-surface waters. Runoff is likely to be swift with little or no significant long-tail flow post rainfall (Figures 12 to 14). Both Huon Gully and Lamberts Gully are subsumed into historic and present site works within the Western Coal Services Project area and Figures15 to 23 provides several views of the constructed water management features through the site.

Figure 6 Broad woodland swale with no defined creek structure in Ben Bullen State Forest, Upper Huon Gully.

Figure 7 Broad woodland gully with small incised drainage in Ben Bullen State Forest, Upper Huon Gully, just upstream of lower electricity high-tension wire easement service track.

Figure 8 Broad woodland overland flow-path with no defined creek structure in Ben Bullen State Forest, Upper Lambert Gully – east sub-catchment.

Figure 9 Small ephemeral pond and incised drain just upstream of lower electricity high-tension wire easement service track, Upper Lambert Gully – east sub-catchment.

Figure 10 Pool above lower electricity high tension wire easement service track, Upper Huon Gully.

Figure 11 Small dam below lower electricity high tension wire easement service track - Lambert Gully west sub-catchment.

Figure 12 Better defined V shaped gully on Huon Gully below the lower electricity high tension line service track. The incised creek has a more cascade shape with rock and sediment constraints but little rain water retention capacity.

Figure 13 Temporary rain pool in Huon Gully below the lower electricity high tension line service track.

Figure 14 Overland undifferentiated drainage of upper Huon Gully located just upstream of the main conveyor line to Mount Piper Power Station. This drainage line flows to the first constructed sedimentation pond just below the conveyor line (see Figure 15).

Figure 15 Uppermost Springvale Coal Services constructed sedimentation pond on Huon Gully, located just below the conveyor line to Mount Piper Power Station.

Figure 16 Lamberts Gully – east sub-catchment undefined swale drainage in foreground, draining to uppermost Springvale Coal Services sedimentation pond.

Figure 17 Lower Section of Huon Gully draining to Huon Dam in the background

Figure 18 View looking down-slope showing an upper sedimentation dam in Lambert Gully with the conveyor dam in the background.

Figure 19 Lambert Gully drainage across a Springvale Coal Services road looking downstream.

Figure 20 Springvale Coal Services Stockpile Sediment Pond (see Figure 2 for location).

Figure 21 Lambert Gully drainage is in the foreground and is piped to the Retention Dam just out of the photo at the right (see Figure 22). Cooks Dam is in the background and the spillway can be seen at the left hand side of the embankment.

Figure 22 Retention Dam with inlet channel at the lower left corner and the outlet channel at the top left corner of the dam.

Figure 23 LDP006 at the lower end of Lamberts Gully looking downstream to the Castlereagh Highway culvert pond. The confluence with Wangcol Creek is at the other side of the highway.

3.1.2 Neubecks Creek

Neubecks Creek is the only other major sub-catchment drainage to Wangcol Creek and Annexures A and B provides three sets of seasonal photographs of the lower Neubecks Creek aquatic ecology sampling site.

Additional inspections of Neubecks Creek drainage channels were undertaken on the 29th and 30th May 2012, as surface water from the tailing limb of a 38mm rain event four days prior to the visit was prevalent throughout the lower catchment area:

- At the upstream limits of the inspection area there was surface water present in a broad and shallow swampy basin which supported a dense copse of tea-tree (see Figure 24). There was no surface flow within the vegetated swamp, and at the downstream end the broad valley basin drained into an incised, sunken erosion hole which at the time of inspection supported a large round pool to 1.5m depth (Figure 24). The pool water was clear and contained moderate amounts of filamentous green algae.
- Figures 25 and 26 compare channel areas between Spring 2011 and Autumn 2012 surveys for the upper sections of NC1 that were dry in 2011. For the Autumn 2012 survey the channel banks were actively eroding and unstable.
- There was surface flow from the downstream pool for approximately 100m, after which the flow became sub-surface in the sandy substrate (at the upstream end of NC1).
- The cleared broad valley below the forest (i.e., downstream from NC1) has no defined channel sections, and it is a broad shallow soak that spanned at least 50m in width. There was overland flow typical of a grassy swamp for around 200m, down to the track crossing.
- Downstream from the track crossing, channel incision resumed and at the time of inspection there were a series of deep, round pools connected by shallow sandy incised channel races. Pools within this section contained clear water and moderate to abundant amounts of filamentous green algae. There was continuous surface flow through to the confluence with Wangcol Creek.

It is concluded that these aquatic features are ephemeral and rapidly dry out after rain. This can be seen from inspection of the Spring 2011 survey photographs where the channel was dry and, as indicated by the active wombat hole within the main site pool, the channel is normally dry (see Figures 27 and 28 below).

Figure 24 Shallow surface water depression upstream from NC1, looking upstream (left) and lower end terminating (right).

Figure 25 Termination of swamp leading into the upstream end of the erosion hole (left) and looking upstream through the erosion channel (right).

Figure 26 Looking downstream from the upstream end of NC1 in Spring 2011 (left) and Autumn 2012 (right).

Figure 27 Broad channel area immediately below track crossing during Spring 2011 (left) and Autumn 2012 (right).

Figure 28 Large pool within channel area below track crossing during Spring 2011 (left) and Autumn 2012 (right). The dark spot in the middle of the left image is a wombat burrow.

3.2 Aquatic Flora and Fauna Assessment

There have been three seasonal sampling events to describe the aquatic flora and fauna of the Springvale Coal Services receiving waters (Wangcol Creek and Coxs River):

- Sampling for Autumn 2011 was undertaken between the 7th and 10th June 2011.
- Sampling for Spring 2011 was undertaken on 1st and 2nd November 2011.
- Sampling for Autumn 2012 was undertaken between the 28th and 31st May 2012.

Table 2 Western Coal Services Project Aquatic Ecology Monitoring Sites

Catchment	Site	Coordinates		Sample	Description
		E	N		
Coxs River	CR2	228691	6305324	2	Upstream of Wangcol Creek monitoring site in Cox's River at the haul road crossing, approximately 1km downstream of Angus Place LDPs.
	CR4	228348	6302775	2,3	Coxs River monitoring site located at Maddox Lane crossing, below Wangcol Creek and above Neubecks Creek confluences.
	CR5	228529	6300752	2,3	Downstream of Pipers Flat Creek on Cox's River, located at Main St crossing.
Wangcol Creek	WCup	224733	6305941	2	Upper Wangcol Creek monitoring site located above the confluence of Neubecks Creek at the Castlereagh Highway.
	WC1	226076	6305175	2	Wangcol Creek upstream site located approximately 700m upstream of LDP6.
	WC2	226732	6304547	2	Wangcol Creek downstream monitoring site located approximately 350m downstream of LDP6.
	WC3	228414	6304303	2	Lower Wangcol Creek site sampled around 250m upstream from the confluence with the Coxs River.
Neubecks Creek	NCdn	225480	6305993	2	Site sampled in Centennial property above the Haul Rd crossing in Neubecks Creek.
Note:	1 = Water Quality, Aquatic plants and RCE, 2 = 1 + Macroinvertebrates and fish, 3 = Overnight fish.				

The full results of these studies have been presented in two reports (MPR 2012a and MPR 2012b). There were four sites sampled in Wangcol Creek, one site that could be sampled in Neubecks Creek and three sites sampled in the Coxs River (see Figure 5 for site locations and Table 2 for sampling site descriptions and coordinates).

Annexure A and Annexure B provide field notes and site photographs of the sampled sites for survey.

Table 3 presents the mean daily flow rates recorded by NSW Office of Water gauging stations in the Coxs River (#212054 immediately downstream of CR5) and in Wangcol Creek (#212055 at WC1) for each seasonal survey.

Table 3 Seasonal Flow Rates

Season	Date	Flow (ML/day)	
		Coxs River	Wangcol Ck
Au11	7/06/11	9.6	0.75
Au11	8/06/11	9.2	0.74
Au11	9/06/11	9.1	0.69
Au11	10/06/11	8.8	0.66
Sp11	1/11/11	8.8	0.05
Sp11	2/01/11	7.3	0.06
Sp11	21/11/11	11.2	0.01
Sp11	22/11/11	17.3	1.5
Au12	28/05/12	19.8	2.1
Au12	29/05/12	16.7	1.9
Au12	30/05/12	15.3	1.7
Au12	31/05/12	15.7	1.5

The mean daily flow rates for Autumn 2012 were receding over the course of the survey period, and although the flow rates were generally higher than the previous two surveys the water levels and the overall pool dimensions for most sites have remained relatively consistent throughout the baseline survey period to date. Maximum depths for all sites ranged between 0.8m and 1.5m depth.

Also in Autumn 2012, the Coxs River water was clear at CR2 however the turbidity increased downstream from CR3 through to CR5. At CR4 there was a notable presence of a whitish-cream flocculant that was settled and smothering the substrate and submerged surfaces in the lower flow locations of the site pools. The flocculant was widespread at CR5 along the site pool edge areas but also suspended within the water column. The water clarity at Wangcol Creek upstream site WCup was very turbid when compared to sites downstream, which were clear to very clear throughout the length from WC1 and downstream through WC2 and WC3 to the Coxs River. Eventually the substance was sourced from Sawyers Swamp Creek, which enters the Coxs River between CR3 and CR4 (MPR2012b).

3.3 Aquatic Plants and Habitat Assessments

Table 4 details the occurrence of aquatic plants and emergent macrophytes for all seasonal surveys. A total of 12 macrophytes have been recorded from the wider Coxs River sampling area with 10 found in the Western Coal Services study area. Five of these were found in the Wangcol Creek sub-catchment and seven in the Cox River segment. Three of the macrophytes listed are introduced species; starwort *Callitriche stagnalis* and blue water speedwell (*Veronica anagallis-aquatica*) were only found in Pipers Creek, and jointed rush (*Juncus articulatus*) was found in all streams and was the most common macrophyte. This species has been recorded in increasing amounts of over consecutive surveys, from three sites in Autumn 2011 to five sites in Spring 2011, most likely as a result of sustained water levels particularly around the edges of pools.

Table 4 Study Area Macrophyte Occurrence

	Starwort *Callitriche spp*	*Carex appressa*	Tall Spikerush *Eleocharis sphacelata*	Spike Rush *Eleocharis spp*	Jointed Rush *Juncus articulatus*	Spiny Rush *Juncus spp*	Common Reed *Phragmites australis*	Curly Pondweed *Potamogeton crispus*	River Buttercup *Ranunculus inundatus*	River Clubrush *Schoenoplectus validus*	Cumbungi *Typha spp*	Blue Water Speedwell *Veronica anagallis-aquatica*	Charophytes
CR2			1		1			1			1		
WCup				1							1		
NCdn		1			1								
WC1		1			1								1
WC2			1		1						1		
WC3					1								1
CR4					1	1	1						1
CR5					1	1		1		1	1		

Cumbungi is the most commonly occurring macrophyte throughout the Coxs River sites, at times forming extensive stands along the river edges. However, as observed between consecutive surveys, cumbungi can undergo seasonal fluctuations due to die-back and is also subjected to scouring by flooding (such as that observed at CR5 during the period between Spring 2010 and Autumn 2011).

Site CR5 has consistently supported widespread and dense beds of curly pondweed (*Potamogeton crispus*) and to a lesser extent blunt pondweed along the site length deeper pool sections.

Extensive beds of charophytes (which are an algae and not true flowering plants) have been observed at the upstream Coxs River monitoring site CR4, in amongst common reed stands and the introduced jointed rush along the waters edge. At CR4 and WC1 they occurred in sufficient quantities to warrant sampling as part of the edge habitats.

Full results of the Autumn 2012 seasonal riparian and aquatic habitat condition as estimated by RCE (Riparian, Channel and Environment) analysis are shown in Table 5 with Autumn and Spring 2011 site totals included for comparison at the bottom. The seasonal RCE results have been expressed as percentages with higher percentages indicating better aquatic habitat condition.

Table 5 Comparison of RCE Results Autumn 2012 to 2011 Results

Category	CR2	CR4	CR5	WCup	WC1	WC2	WC3	NCdn
Land-use pattern beyond immediate riparian zone	2	2	2	2	2	2	2	3
Width of riparian strip-of woody vegetation	1	2	2	2	2	2	3	2
Completeness of riparian strip of woody vegetation	0	1	2	2	1	1	2	1
Vegetation of riparian zone within 10 m of channel	1	2	3	3	3	3	3	2
Stream bank structure	1.5	2	2	2	1	1	1.5	3
Bank undercutting	2	2	2	2	1	1	1.5	3
Channel form	4	4	3	3	3	3	4	4
Riffle/pool sequence	1	1.5	3	3	1	1	1	2
Retention devices in stream	1	2	3	3	0	0	0	1.5
Channel sediment accumulations	2	3	3	3	3	3	2	2
Stream bottom	1	3	2	2	2	2	2	1
Stream detritus	2	3	3	3	1	1	2	2
Aquatic vegetation	3	2	3	3.5	3	3	3.5	3.5
RCE Score	21.5	29.5	33.0	33.5	23.0	23.0	27.5	30.0
Autumn 2012 Site % Scores	41.3	56.7	63.5	64.4	44.2	44.2	52.9	57.7
Spring 2011 Site % Scores	42.3	56.7	63.5	63.5	45.2	44.2	53.8	58.7
Autumn 2011 Site % Scores	42.3	56.7	63.5		45.2	44.2		

RCE scores are generally poor to fair with low individual category scores due to all sites being surrounded by cleared agricultural lands and industrial areas, with very few sections of continuous riparian woody corridors.

The Autumn 2012 RCE scores were similar to the Autumn and Spring 2011 survey scores for all sites, and ranged between 41.3% at CR2 to 64.4% at WCup. For sites that showed variations over time, the main variations related to seasonal fluctuations in levels of filamentous green algae at the sites.

A search was made of the project and study areas for springs and wetlands that may have supported aquatic GDEs but none were found and, given the long history of mining, creek diversions and industrial land use undertaken in the Wangcol Creek and Coxs River study area, none are expected.

3.4 Field Water Quality Results

Table 6 Stream surface water quality Autumn 2011 to Autumn 2012

Site	Date	Time	Depth m	Temp °C	Cond µS/cm	Sal ppt	DO %sat	DO mg/l	pH Units	Turb ntu
Coxs River above Wangcol Creek Confluence										
CR2	09/06/11	15:46	0.2	5.38	749	0.35	72.4		8.41	2.8
CR2	01/11/11	15:37	0.1	15.77	939	0.47	95.9	8.6	8.27	13.9
CR2	29/05/12	16:01	0.1	7.69	542	0.29	92.2	9.7	7.99	2.9
Wangcol Creek above LDP006										
WCup	10/06/11	15:34	0.2	6.86	417	0.19	73.2		7.18	14
WCup	22/11/11	8:58	0.1	16.91	452	0.21	76.9	6.7	7.61	130.5
WCup	28/05/12	13:56	0.1	9.49	314	0.17	91.5	9.2	7.48	317
NCdn	10/06/11	14:17	0.1	7.67	84	0.02	71.7		6.82	7.5
NCdn	21/11/11	16:18	0.1	17.85	87	0.03	84.6	7.3	6.06	59.2
NCdn	29/05/12	14:30	0.1	9.53	61	0.05	89.4	9.0	6.33	6.1
WC1	07/06/11	9:19	0.1	4.2	420	0.18	79.1		8.11	3.4
WC1	10/06/11	15:21	0.1	7.14	253	0.1	71.7		7.19	7.5
WC1	21/11/11	13:56	0.2	19.4	516	0.25	97.8	8.2	7.10	8.2
WC1	30/05/12	10:51	0.1	6.66	283	0.16	95.5	10.3	7.33	3.1
Wangcol Creek below LDP006										
WC2	07/06/11	11:04	0.1	6.82	1577	0.81	80.5		7.42	4.5
WC2	21/11/11	10:42	0.1	18.62	2211	1.2	100.3	8.4	7.00	10.5
WC2	30/05/12	12:27	0.1	9.49	1451	0.75	92.1	9.2	7.14	2.4
WC3	21/11/11	12:18	0.1	19.06	2452	1.35	106.6	8.9	7.62	11.5
WC3	30/05/12	12:59	0.1	8.21	623	0.32	104.1	10.8	7.64	3.6
Coxs River below Wangcol Creek confluence										
CR4	08/06/11	15:51	0.1	6.38	930	0.46	76		8.02	5.3
CR4	01/11/11	18:16	0.1	19.82	853	0.43	101.2	8.4	7.99	5.9
CR4	30/05/12	15:11	0.1	8.57	640	0.33	90.9	9.3	7.15	11.6
CR5	07/06/11	12:56	0.2	7.23	860	0.42	83.9		8.47	3.7
CR5	02/11/11	12:39	0.1	19.51	764	0.38	171.2	14.2	8.67	15.2
CR5	28/05/12	15:05	0.1	9.62	700	0.36	98.2	9.8	7.14	27

Table 6 provides the site surface water quality data for the three surveys derived from the full survey reports. Site water quality results are summarised as follows:

- Generally there was no stratification occurring between surface and bottom readings, and for most of the sites the waters were generally well mixed.

- Surface water temperatures reflected seasonal conditions with cold water and even surface ice recorded during the Autumn 2011 survey.
- Surface water conductivity in the Coxs River above the Wangcol Creek confluence ranged from 540 µS/cm to 940 µS/cm.
- Surface water conductivity in Wangcol Creek above LDP006 ranged from 314 µS/cm to 516 µS/cm with Neubecks Creek contributions always lower (< 87 µS/cm.
- Conductivity in Wangcol Creek below LDP006 was generally elevated (623 to 2211 μS/cm).
- Conductivity at Coxs River sites downstream of Wangcol Creek were similar to upstream conductivity (630 µS/cm to 930 µS/cm). For all four surveys CR5 recorded the lowest conductivity readings compared to other Coxs River sites.
- Dissolved oxygen (DO) results for the study were mostly in the moderate to high range.
- Water pH was slightly acidic in Neubecks Creek, generally neutral to slightly alkaline in Wangcol Creek (both up and down stream of LDP006) and slightly more alkaline in Coxs River (both up and down stream of the confluence with Wangcol Creek).
- Generally water turbidity is low with ranges up to 27 NTU for all streams. The exception is site WCup that has had high turbidity readings over two seasons (Spring 11 and Autumn 12). There was also one spike in turbidity at site NCdn in Spring 2011).

3.5 Aquatic Macroinvertebrate and Fish Survey Results

The full results of taxonomic identifications of aquatic macroinvertebrates to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates, fish and reptiles over all seasonal surveys are provided in the published seasonal reports (MPR2012 and MPR 2013). Aquatic macroinvertebrate sampling results for the baseline survey may be summarised as follows:

- Over the term of the study period, a total of 19 macroinvertebrate samples were collected from the seven sites within the study area.
- A total of 58 macroinvertebrate taxa were recorded from the study area over the three baseline seasonal surveys (Autumn 2011 to Autumn 2012).
- The majority of the macroinvertebrate fauna were insects (39 taxa), with the remainder being 5 crustaceans, 5 molluscs (4 snails and 1 bivalve), and one each of the following taxa; a leech, water mite, seed shrimp and one freshwater worm.

- Over all seasonal surveys, the most commonly encountered taxa were caddis-fly family Leptoceridae and water boatmen family Corixidae, generally recorded from all sites.
- Other common taxa (occurring at 8 or more sites) included bloodworms from the sub-family Chironominae, all of the mayflies from the families Baetidae, Caenidae and Leptophlebiidae, diving beetle family Dytiscidae, caddis-fly family Hydroptilidae, freshwater shrimp family Atyidae, yabbies (family Parastacidae) and freshwater worms (class Oligochaeta).
- In terms of individual taxa SIGNAL grades, the most sensitive taxa were dragonfly family Telephlebiidae (SIGNAL value 9), which was recorded from WC1 and WC2 only. There were four SIGNAL 8 taxa; mayfly family Leptophlebiidae, stonefly family Gripopterygidae, and caddis fly families Philorheithridae and Hydrobiosidae. Each site recorded at least one of the SIGNAL 8 or 9 taxa.

Table 7 Seasonal Stream Macroinvertebrate Summary Statistics

Season	CR2	WCup	NCdn	WC1*	WC2	WC3	CR4	CR5
Site Diversity								
Au 2011	22	20		26	10		22	25
Sp 2011	27	12	26	25	17	22	24	27
Au 2012	23	19	22	17	20	15	20	23
Site SIGNAL Index								
Au 2011	4.65	3.89		4.22	3.75		4.14	4.00
Sp 2011	4.40	3.92	4.04	4.00	3.75	3.90	4.64	3.90
Au 2012	4.27	3.94	4.25	4.47	4.50	4.33	4.58	3.91

Note* Sites are ordered downstream from CR2 in Coxs River and WCup in Wangcol Creek, and LDP006 is located between sites WC1 and WC2. See Figure 5 for site relationships.

Table 7 provides summary statistics derived from the total study aquatic macroinvertebrate data, and shows the variation of site statistics in relation to LDP006, which is located between sites WC1 and WC2:

- The individual site macroinvertebrate diversity ranged between 12 taxa at WCup to 27 taxa at both CR2 (the upstream Coxs River site) and CR5 (the downstream Coxs River site).
- Upstream sites in both Coxs River and Wangcol Creek generally had greater diversities than sites immediately downstream of LDP006 or the

Wangcol Creek confluence, and mean site diversity over all three seasons in Wangcol Creek was greater upstream (mean 19.8 taxa per site) compared to downstream (mean 16.8 taxa per site). For Coxs River the diversity at the downstream site CR5 was the same or better than the upstream site CR2.

- Individual site SIGNAL scores ranged between 3.75 (severely impaired) at WC2 to 4.65 (moderately impaired) at CR2.
- For Wangcol Creek the upstream site WCup SIGNAL score was consistently lower than both the NCdn and WC1 scores, and the WC2 site (located below the LDP006 discharge) had scores lower than WCup for the first two surveys. However, on the comparison of overall stream mean SIGNAL values the Wangcol Creek downstream mean SIGNAL value was only marginally lower (4.05) than the upstream Wangcol Creek mean (4.07).
- Whilst Coxs River upstream to downstream study site mean diversity varied from 24 at CR2 to 22 at CR4 and 25 at CR5, the upstream to downstream study site mean SIGNAL varied from 4.44 at CR2 to 4.45 at CR4 and 3.94 at CR5. That is, whilst the lower site had overall greater taxa diversity than other sites the SIGNAL score was always the lowest.

Table 8 Fish and tadpoles recorded from study area Autumn 10 to Autumn 12

Common Name	*Species*	Site							
		CR2	WCup	NCdn	WC1	WC2	WC3	CR4	CR5
Flathead Gudgeon	*Philypnodon grandiceps*	√	√		√	√	√		√
Mountain Galaxias	*Galaxias olidus*	√			√	√	√		√
Eastern Gambusia*	*Gambusia holbrooki*		√		√	√	√	√	√
Brown Trout*	*Salmo trutta*								√
Goldfish*	*Carassius auratus*	√							√
Fish larvae			√						
Fish eggs					√	√			
Tadpoles		√	√					√	√

Note * Introduced species

Table 8 provides a listing of the fish reported from the upper Coxs River study area catchment through to Autumn 2012. There were five fish species; two native and three exotic pest species. Two other introduced species (carp and rainbow trout) have been

reported previously from the upper Coxs River but were not caught or observed, and Australian Bass, a native species previously reported as being stocked into Lake Wallace was also not caught or observed.

For the last (Autumn 2012) survey, mountain galaxias (*Galaxias olidus*) was found at all sites in Wangcol Creek except for WCup, juvenile gudgeons were recorded at site WC3 and fish eggs were retained in the macroinvertebrate samples at WC1 and WC2. There were also a number of dead or dying fish and yabbies collected or observed:

- A single large dead flathead gudgeon and a dead yabbie (*Cherax destructor*) were found at WC1 and a deformed mountain galaxias was also found at WC1. Both dead fish had scales missing.
- A dying mountain galaxias was found at WC2.

There were no threatened or protected invertebrate or vertebrate aquatic species (as listed under the FMA, TSC or EPBC Acts) caught or observed during the three baseline surveys, and none are expected. No platypus or Australian water rat were observed and there was no indication of occupation by either of these species within the study area.

3.6 Summary of Results

The site walkover surveys confirmed that upper sub-catchments for Neubecks Creek, Huon Gully and Lamberts Gully did not provide any permanent aquatic habitats in the form of pools, wetlands or swamps and there were only small narrow disconnected erosion drainages within broad drainage swales the supported woodlands or grassy meadows. Pools, when they did form, were most often associated with ponding upstream of formed tracks (bush tracks in Neubecks Creek and electricity line or coal conveyor line service tracks in Huon and Lamberts Gully).

The total upper catchment of Wangcol Creek drains to Mt Piper Power Station and is likely to be similar to the Huon and Lambert Gully upper catchments. All these drainages are ephemeral with flow confined to local rain periods and little if any flow following cessation of rainfall. All these upper catchment drainages flow into existing or old coal mining areas (or into the Mount Piper Power Station site in the case of upper Wangcol Creek).

The lower section of Neubecks Creek and Wangcol Creek below the Power Station are formed creeks with more permanent pools plus flow, and Wangcol Creek drains to Coxs River via a constructed drainage around old (historic) and active mine workings.

The middle and lower sections of Huon and Lamberts Gully have been subsumed into old mine workings with remaining sections currently included in active mine or ash placement water management plans for Springvale Coal Services and Delta Electricity. The upper catchment waters are collected into process water dams and sedimentation ponds that manage water quality for rehabilitation works and in the case of Lamberts Gully are eventually drained to Wangcol Creek via the LDP006 discharge. There are currently no natural aquatic habitats remaining in these two drainages and the only aquatic habitat is provided in the water management dams. All these dams are disconnected from Wangcol Creek via spillways and there is no fish passage available from Wangcol Creek up into these sub-catchment drainages.

Accordingly, the main relatively permanent aquatic habitat available in the total Wangcol Creek catchment is the lower section of Neubecks Creek at the confluence with Wangcol Creek and Wangcol Creek below Mount Piper Power Station/Castlereagh Highway. This waterway is sustained by drainage water from natural wooded upper sub-catchments that are all (apart from Neubecks Creek) diverted through Mount Piper Power Station, Delta Electricity Ash Placement site and Springvale Coal Services site.

As a consequence of these interrupted sub-catchment drainages the actual available water to sustain pools plus flow through Wangcol Creek may be compromised. Thus for instance, during the Autumn 2012 survey period, the month prior to the commencement of sampling was relatively dry, with a single days rainfall of 38mm, two days before sampling began. There was no flow at the upper site WCup (which has only had sluggish flow during the previous wetter sampling seasons), with some surface flow through the upper site WC1 and generally good flow for the remaining sites below LDP006 (sustained by the discharge). Thus, it would appear that a fair proportion of the Wangcol Creek flow is sustained by licensed discharges including the Springvale Coal Services LDP006 flow.

This combined flow is discharged to Coxs River and there are no substantial impediments to fish passage between Coxs River at the confluence and Wangcol Creek through to the Castlereagh Highway. The weir at the NOW Wangcol Creek water flow gauge station (below site WC1) only impedes fish passage at very low flows or during extended drought periods when there are also natural impediments downstream that also disconnect pools.

Assessment of the Neubecks Creek/Wangcol Creek and Coxs River study area aquatic ecology over the three baseline seasonal surveys between Autumn 2011 and Autumn

2012 indicates that the overall variation in stream macroinvertebrate biodiversity can be attributed to a mixture of site-specific and probable discharge impact:

- Individual SIGNAL site scores for all sites are in the moderately to severely impaired ranges, largely due to intrinsic low aquatic habitat diversity, as demonstrated by the overall low site RCE scores discussed in Section 3.4 above.
- However, consistent differences between scores for some adjacent sites point to additional factors. Thus for the two Wangcol Creek sites above the LDP006 discharge (WCup and WC1) that have similar physical water quality attributes, and the fact that site WCup has the best overall site habitat (RCE) score for the study area (64%) whilst site WC1 had the second lowest habitat score (45%) would point to an expectation of lower macroinvertebrate scores at the downstream site WC1. However the opposite is the case and there are consistent lower Diversity and SIGNAL scores for site WCup. Similarly, for the two downstream Coxs River sites CR4 and CR5, mean Diversity and SIGNAL scores at the lower site are also less than the upper site means. This would indicate other factors such as seepage from historic mine works or additional discharges from other sources could be confounding the results. In the case of site WCup the lack of sustaining water flow may also be a contributing factor to poor aquatic biodiversity.
- With regard to possible LDP006 impact the physical water quality data presented in Section 3.5 clearly indicates an impact is possible (e.g., mean conductivity for Wangcol Creek sites WCup and WC1 upstream is around 400 μS/cm and mean conductivity downstream of the LDP is elevated (mean around 1700μS/cm at WC2 and around 1500μS/cm at WC3). The macroinvertebrate summary Diversity statistics presented in Section 3.6 correlate with the water quality data in that site WC2 has the lowest mean site Diversity (15.1 taxa) – compared to 22.7 taxa at the upstream site WC1) and site WC3 has the second lowest mean site Diversity (16.8 taxa). There is a weaker but consistent correlation in the site mean SIGNAL scores with Wangcol Creek sites means as follows; WC1 upstream of LDP006 mean SIGNAL 4.23, WC2 350 m downstream mean SIGNAL score 4.00 and WC3 2.4km downstream mean SIGNAL score 4.05.
- For the Coxs River receiving waters the macroinvertebrate results are equivocal in terms of impact attribution. Site aquatic habitat condition shows an overall improvement downstream (from 41.3% RCE at CR2 to 63.5% at CR5) and physical water quality is similar between sites (e.g., mean conductivity between 700 and 800 μS/cm for all three sites). Whilst mean Diversity is similar for the three sites (21 to 22 taxa), mean SIGNAL Index deteriorates downstream (from 4.99 at CR2 to 3.94 at CR5).

3.7 Classification of Wangcol Creek and Coxs River

Notwithstanding the major impediments to fish passage from the lower Coxs River to the upper Coxs River presented by the combined dams over the Coxs River downstream of the Western Coal Services Project area there is still viable native fish aquatic habitat available in Wangcol Creek and good connectivity to Coxs River. There are suitable drought refuge pools available up- and downstream of the Springvale Coal Services site thus there remains a need for fish passage from Coxs River into and upstream Wangcol Creek. Accordingly Wangcol Creek from below the Castlereagh Highway to Coxs River confluence is classified Class 2 Moderate Fish Habitat under the NSW DPI (Fisheries) stream classification (Table 9).

Table 9 Fish Habitat Classification Scheme (NSW Fisheries (1999b)

Class 1 - Major fish habitat Large named permanently flowing stream, creek or river. Threatened species habitat or area of declared "critical habitat' under the threatened species provisions of the Act. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 2 - Moderate fish habitat Smaller named permanent or intermittent stream, creek or watercourse. Clearly defined drainage channels with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 3 - Minimal fish habitat Named or unnamed watercourse with intermittent flow, but has potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). None to minimal defined drainage channel. Semi- permanent pools, ponds, farm dams or wetlands nearby, or form in the watercourse after a rain event. Watercourse interconnects wetlands or stream habitat.
Class 4 - Unlikely fish habitat Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free standing water or pools after rain event finishes (e.g. dry gully, shallow floodplain depression with no permanent wetland aquatic flora present). No aquatic or wetland vegetation present.

Of the four main sub-catchment drainages to Wangcol Creek only one (Neubecks Creek) has uninterrupted connection from the upper catchment waters to Wangcol Creek. Whilst there is a connection from Wangcol Creek to the lower section of Neubecks Creek (at sample site NCdn) there have been no fish observed or caught at this site. However as the possibility of fish passage remains the lower section of Neubecks Creek in direct connection with Wangcol Creek is classified as Class 3 Minimal Fish Habitat.

The upper catchments of the four feeder drainages (upper Wangcol Creek, upper Neubecks Creek, Huon and Lamberts Gullies) are all located in more or less natural forested lands and have a valuable role in sustaining the fish and aquatic habitats of the lower catchment streams via contributions of rainfall waters. However, the upper catchments do not provide any meaningful aquatic habitat in their own right and they are classified as Class 4 Unlikely fish habitat.

The middle and lower sections of the three feeder drainages that are subsumed into mining or power generation associated sites could have been expected to provide some suitable semi-permanent aquatic habitat and may have been classified as Class 3 Minimal Fish Habitat, however, owing to the interruption of aquatic habitat function and fish passage for all three of these drainages they are classified as Class 4 Unlikely fish habitat.

If there were no major impoundments in the Coxs River, the upper Coxs River would need to be classified as a Major Fish habitat (Class 1) on the basis that threatened fish species could reach the upper catchment. However, given the number of impoundments that prevent native fish passage the classification for the Coxs River above Lake Wallace remains Class 2 Moderate fish habitat.

4 IMPACT ASSESSMENT & MITIGATION

4.1 Construction Impacts

The Western Coal Services Upgrade project description is detailed in Section 2.5 of the EIS (RPS 2013) and summarised in Section 1 of this report. The main features of the proposed upgrade that have the potential for direct impact on aquatic habitats is related to contaminated water runoff from the construction works into Wangcol Creek, and the main contaminant of concern arising from construction works is sediment in the form of high Total Suspended Solids (TSS) loads that could smother creek aquatic habitats and biota, or as turbidity that could inhibit photosynthesis of aquatic plants.

The main potential mechanisations of TSS and turbidity generation to Wangcol Creek from construction are as follows:

New and Upgrade Washery Plant

- Construction of facilities for the new washery plant and for upgrade of the existing washery will require earthworks for the preparation of a site for the new washery. These works have the potential for impacts on shallow groundwater quality and issues relating to overburden storage and surface water and sediment runoff control.

New Rejects Placement Area

- The proposed new reject emplacement area (REA) located south of the existing conveyor as shown on Figure 2 will rise from RL 930 at its lowest point in the north east corner to RL 1000. It will be approximately 1km long and approximately 700m wide. Site preparation will require additional road works to allow traffic to access the site and management of surface runoff from the site will require construction of a purpose built dirty water management system.. These works are located alongside Lamberts Gully with direct stormwater drainage to the Gully and will require careful management of sediment and stormwater control to prevent construction related contaminated waters and sediments from entering the gully.

Overland Conveyor Upgrade

- Increased utilisation of the existing overland conveyor may necessitate some strengthening of conveyor structures plus installation of additional control systems. This will necessitate additional access along the existing service tracks

plus possible earthworks at the sites where strengthening is required. Runoff from the service track and the conveyor line at the sites where these works are proposed has the potential for sediment transport into upper catchment drainages that eventually drain to Wangcol Creek.

New Haul Road Link

- There are currently two options for the proposed new hail road link from the Springvale Coal Services site to the existing Angus Place to Mount Piper Power Station haul road (see Figure 2). Both these options need to cross over Wangcol Creek and both will require extensive earthworks for road construction. There are potential direct impacts to Wangcol Creek aquatic biodiversity if fish passage or creek habitat and hydraulic functions are not suitable protected by provision of an adequately sized crossing and there are potential indirect impacts from sedimentation and smothering from the associate earthworks. These works will require suitable bunding to prevent TSS and turbidity entering the creek plus there will need to be suitable bridging to facilitate stormwater flow through Wangcol Creek as well as protecting the existing aquatic ecological habitats within the creek.
- The western option would cross Wangcol Creek in a section where the creek exists in a channelized fill section. The channel is stable at between 10 to 15 m wide and up to 1.5 m deep and generally incised to shale bedrock. There is little or no riparian or emergent vegetation. It is anticipated that some stream edge erosion protection would be required in the form of rock gabions. The design of the crossing would need to accommodate peak flows from flood events without adversely scouring the creek line downstream of the culvert and will need to ensure that the present fish passage attributes are protected or improved (see also NSW Fisheries 1999b).
- The eastern haul road crossing is in an area where the creek has been diverted around the original Wallerawang Colliery surface infrastructure (now Pine Dale Mine). The channel has been excavated into bedrock consisting of shales and sandstones. As with the eastern option, the creek would be crossed in a stable section and the design of the culvert beneath the new haul road would need to be designed to accommodate peak flows from flood events. It is also anticipated that some downstream erosion protection would be required to protect the creek from scour. As for the western option the design will need to ensure that the present fish passage attributes are protected or improved.
- Erosion controls would be installed as part of the construction program along with normal sediment containment systems such as ponds and silt control fencing. Once the road batters are formed they will be revegetated and stabilised.

The erosion and sedimentation controls would remain until the batters are considered stable and soil movement minimal.

- It will be necessary to excavate the topsoil and subsurface fill either side of the Wangcol Creek channel in order to provide a stable base for the new road embankment. The topsoil will be stockpiled away from the channel and protected by silt control fencing while the fill will be tested for suitability for use within the road embankment. Additional fill will be sourced from the old open cut areas at the Springvale Coal Services Site.
- All erosion and sedimentation controls will be designed and installed in accordance with a project Construction Surface Water Management Plan (CSWMP) and the Creek crossing will be designed to conform to the design guidelines for a Class 2 Moderate Fish Habitat as detailed in NSW Fisheries 1999b.

Upgraded Water Management System

- The upgraded washery and use of the new REA will increase the overall water demand of the site and this will necessitate an upgrade of the existing water management system. The main upgrading relates to the progressive separation of water from the Lamberts Gully drainage line, which flows through the site. At present this water passes through two dam structures, the Main Sediment Pond and the Retention Pond. It also receives treated overflow water from Cooks Dam and various smaller dam structures below the processing area.
- The upgrade would require construction of new channels, refurbishing existing channels and construction of additional pipe works.
- The design would also need to cater for Delta Electricity's proposed diversion of Huon Gully into Lamberts Gully upstream of the Springvale Coal Services Site.
- All these upgrades require extensive earthworks that will themselves require suitable bunding to prevent TSS and turbidity entering the creek downstream.

Provided the construction is managed in a manner that prevents contaminated waters (including turbid waters) reaching Wangcol Creek and that the haul road creek crossing does not interfere with creek hydraulic function or creek aquatic habitat diversity, there would be no construction impacts on the existing Wangcol Creek aquatic biodiversity. Further, the proposed upgrade of the water management system that has the aim of better separation of Lamberts (and Huon) Gully upper catchment runoff water from the Western Coal Services water management system has the potential to provide an improvement for aquatic biodiversity in Wangcol Creek.

Construction would be managed via a Construction Environmental Management Plan

(CEMP) that would include construction related stormwater diversion around the site and collection, storage and treatment of construction site related waters (including potentially contaminated groundwater from the excavations) - with possible discharge of treated waters to creek. There may need to be separate treatment streams for site construction surface stormwater and site groundwater collection and treatment. These measures would be outlined in Surface and Groundwater Water management reports and would be detailed in Construction Surface Water Management Plans (CSWMPs).

4.2 Operational Impacts

In addition to TSS and turbidity associated with site runoff, other potential contaminants of concern arise from operational site water runoff associated with coal dust and coal spillages from trucks) and hydrocarbon residues (fuel and oil spills). This will necessitate additional site works to ensure separation and treatment of site related runoff from diversion of catchment drainages plus other off-site related stormwater diversions around the site to Wangcol Creek. In addition, the current EPA licence review process for the Springvale Coal Services Site is providing the main mechanism for progressive improvements in overall site and diversion water quality. This process will continue and will result in positive impacts on Wangcol Creek by better control of licensed discharges and better provision of clean diversion waters to the creek.

4.3 Impacts during Rehabilitation Works

As outlined above there are a number of rehabilitation works planned to improve overall water management on and offsite, and there are also potential disturbance impacts on riparian and aquatic habitats from stabilisation works along the watercourses. The control of these impacts relate generally to prevention of disturbed soils reaching the water courses during storms via suitable silt fencing and stabilising new banks with staged planting including initial fast growth grasses that can hold banks until the slower growing native species have taken hold.

4.4 Cumulative Effects of the Proposal in Relation to Other Projects

There are a number of projects approved or underway within the overall Huon and Lambert Gully sub-catchment drainages to Wangcol Creek and there are expected to be managed with the intention to further improve the control of site process waters plus improve diversion of clean stormwaters to Wangcol Creek. The approved Pine Dale mining operation includes similar provisions for controlling site water runoff and diversion of stormwaters around the site. In summary, assessment of existing and

approved projects in the locality indicate that there will be no adverse cumulative effects on the aquatic ecology of Wangcol Creek or Coxs River arising. In fact proposed improvements to site water management associated with the various projects should have the effect of an overall improvement for Wangcol Creek aquatic biodiversity.

4.5 Mitigation Measures

The main mitigation strategy relies on the improvement of water quality leaving the site. This will be achieved by implementing mitigation strategies identified in the main EIS report and are likely to include a combination of the following works:

- Construct a combination of new channels, pipes and refurbished existing channels to provide passage of water from above the site to Wangcol Creek. The design would need to cater for Delta Electricity's proposed diversion of Huon Gully into Lamberts Gully upstream of the Springvale Coal Services Site.
- Undertake additional rehabilitation work within smaller sub-catchments and drainages that naturally flow towards the various channels that make up the Lamberts Gully drainage line
- Provide partial or complete bypass of the Main Sediment Pond and Retention Pond. At present the Main Sediment Pond controls runoff from a portion of the open cut rehabilitation area and this runoff needs to be redirected. Similarly, the Retention Pond receives some surface runoff from around the Co-Disposal REA as well as natural inflow from Lamberts Gully. These works will be staged in accordance with ongoing liaison with the EPA.
- The new REA will require an additional pollution control pond to be constructed to control runoff. This structure will have a capacity of approximately 15 ML and will be located on the north eastern corner of the reject emplacement. The dam will have a pipe connection to the existing Washery Sediment Pond, which is connected to Cooks Dam via a pipeline. This will enable treated stormwater from the new REA to be recycled back to the Washery via Cooks Dam.

The aquatic biodiversity of Wangcol Creek will also be improved by selected riparian planting for a distance of 100 m downstream of the proposed private haul road crossing, subject to land owner consent. This will not only compensate for the minor loss of aquatic macrophytes during the construction program but provide an improved aquatic habitat within the mixing zone below the current discharge point.

5 MONITORING & MANAGEMENT OF POSSIBLE IMPACTS

To ensure the environmental outcomes of the Western Coal Services Project construction, operation and remediation programs, an Environmental Management Strategy (EMS) will be developed to incorporate all aspects of environmental control including aquatic ecology. The EMS will outline a set of Environmental Management Plans (EMPs) that contain specific strategies to encourage and enhance the natural ecology within the designated site and rehabilitation areas. The success of these strategies are to be monitored on a periodic basis and the plans would be 'live' and modified as necessary to address any identified issues so that issues can be resolved and management measures can be implemented in a timely and professional manner. Management for aquatic ecology would form part of a *Flora and Fauna Management Plan* which will detail the basis for monitoring programs to be undertaken and these programs will build on monitoring studies already undertaken for this EA.

5.1 Aquatic Ecology Monitoring and Management Program

The aquatic ecology (stream health) monitoring program will incorporate the existing aquatic ecology study sites and data plus data from on-going studies to provide base-line data against which changes that may be attributable to construction or operation of the Springvale Coal Services facility can be measured. In order to provide successful management measures, aquatic ecology monitoring will be undertaken using a guiding set of criteria and protocols developed to establish the circumstances under which additional mitigation measures would be required, and these would be specified in Trigger Action Response Plans (TARPs). Thus, where perceptible impacts are noted through site monitoring activities, the following general procedure would be applied:

- Undertake additional investigations to ascertain the actual cause (site-related or other cause) of deteriorating aquatic conditions;
- If site related, notify relevant government authorities;
- Develop and implement a specific response plan to prevent further impacts, and
- Undertake remediation as required.

As set out in the TARPs, the response plans would be prepared on a case by case basis, with suggested short-term mitigation measures such as minor physical repair works, which could be implemented until such time that necessary long-term remediation works have been completed.

6 CONCLUSIONS

This report describes and assesses the value of the current aquatic ecology of the Wangcol Creek catchment and Coxs River above and below the confluence and assesses the consequences of the present site surface water management at Springvale Coal Services site for protection of aquatic ecological values of the receiving waters. Both waterways are designated Key Fish Habitat and are classified as Class 2 Moderate Fish Habitat under the DPI Fisheries' stream classification scheme.

The report addresses the potential construction and operational impacts on aquatic ecology arising from the proposed Western Coal Services Project upgrade and sets out the proposed mitigation measures that will be used to both minimise potential impacts from the proposed upgrade plus reduce the overall site impact on surface water drainage and surface water quality to the creek and river.

It is concluded that the proposed upgrade works coupled with improved site water management measures and creek riparian and stream bank stabilisation and vegetation management measures will result in an overall improvement of water quality and aquatic habitat condition for the benefit of the aquatic biota residing in the creek adjacent to the site and for fish passage past the site.

The proposed works would maintain and improve the Key Fish Habitat and Class 2 features of Wangcol Creek and of the Coxs River below the confluence, and the proposed riparian and stream bank stabilisation and revegetation measures are in line with the Hawkesbury-Nepean Catchment Management Authority Action Plan 2007-2016 for the upper Coxs River catchment.

The environmental outcomes of the Western Coal Services Project construction, operation and remediation programs will be specified in an Environmental Management Strategy (EMS) that will incorporate all aspects of environmental control including aquatic ecology. An aquatic ecology monitoring program incorporating the base-line data from the present study will be undertaken as part of the EMS and will use a guiding set of criteria and protocols to establish if additional mitigation measures would be required. These would be specified in Trigger Action Response Plans (TARPs) contained in the EMS.

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ANNEXURE A

AQUATIC ECOLOGY

SAMPLING FIELD NOTES,

SITE PHOTOGRAPHS

&

SAMPLING DATA

WESTERN COAL SERVICES UPGRADE PROJECT

AUTUMN 2011 TO AUTUMN 2012

Date	Site	Comments
9/6/11	CR2	Channel and site conditions similar to previous survey. Water clear, with flow throughout the site length. Maximum depth to 1.0m, though most of site less than 0.3-0.4m. Edge habitat consisting of edge grasses, detritus, submerged jointed rush (*Juncus articulatus*) and curly pondweed (*Potamogeton crispus*). Cumbungi (*Typha spp*) present on upstream side of road. Substrate mostly unconsolidated sandy sediments with finer muddy deposits in localised channel areas with lower flow, and at creek crossing. Banks undercut in some channel areas with evidence of ongoing erosion. Cattle access available throughout entire site length, with evidence of active usage along site length (stock nearby at sample time). Filamentous green algae abundant throughout site length.
8/6/11	CR4	Site sampled in same location as spring 2010; downstream from Maddox Lane culvert (access restricted upstream). Water levels and channel dimensions unchanged since spring 2010 survey. Water moderately clear and flowing through site length. Maximum creek depth to 1.0m. Edge habitats sampled included trailing bank vegetation and grasses, charophytes, jointed rush and detritus. Substrate a mix of cobbles and boulders, with varying amounts of sandy and muddy deposits in areas of lower flow. Algal mat smothering parts off pool substrate. Filamentous green algae present in moderate amounts.
7/6/11	CR5	Site conditions and pool dimensions similar to previous samples. Water clear and flowing throughout site length Indications of water levels to +3m to 3.5m above current water level. Maximum pool depths to 1.5m. Blackberry on eastern bank under bridge has been scoured out. Cumbungi stands throughout site length were also scoured out, and were in a state of die-back during the survey period. The edge habitats sampled similar to autumn 2010, and consisted of curly pondweed, logs, cumbungi, river clubrush (*Schoenoplectus validus*) and trailing bank vegetation. Substrate was mostly soft muddy sand within the pool area upstream of the bridge which extends into bedrock, boulder and cobble at the downstream end. Filamentous green algae smothering substrate and all submerged surfaces, making it difficult to locate areas free of algae to sample. Mat-like algae prevalent also. Three large fish (15cm to 25cm) observed briefly during sample process.

7/6/11	WC1	Wangcol Creek rock bar site sampled. Water level similar to previous samples. Water very clear, stream edges with thin layer of ice over water surface. Maximum depth 0.8m to 1m, though most of site less than 0.3m depth. The pool edge habitats sampled were identical to that previously sampled, and consisted of charophytes, submerged edge vegetation (grasses), detritus and undercut banks. Charophytes more prevalent than former sample occasions. Substrate flat bedrock with some gravel, sand and larger boulder fragments. Combination of silt and iron precipitate smothering substrate. Filamentous green algae present in moderate amounts.
7/6/11	WC2	Water level similar to previous sample occasions. Water very clear and flowing through site length. Maximum depth to 0.8m, average depth to 0.3m. Pool on northern bank discharging into creek at lower end of site. Edge habitats poor. Pool edge habitats similar to previous samples, consisting of detritus and undercut banks, and minimal amounts of trailing bank vegetation. Detritus mostly pine needles. No charophytes observed. Substrate flat bedrock with some gravel, sand and larger boulder fragments. Moderate amounts of silt smothering substrate, and iron precipitate smothering all submerged surfaces. Filamentous green algae present in sparse to moderate amounts. Very few animals retained in sampling.
10/6/11	NCdn	Site sampled in Centennial property above the Haul Rd crossing in Neubeck's Creek. Water clear and flowing through site length and downstream to confluence with Wangcol Creek. Maximum creek width 3m, average width 1m, maximum depth to 0.8m, average depth 0.3m. Site channel relatively straight, narrow and box-shaped. Riparian corridor consists of dense blackberry growth along site length, and single willow tree in site, with prolific grass growth along pool edges. Edge habitats sampled consisted of willow tree roots, detritus and trailing bank vegetation. The pool substrate was fine sand mostly firm, though there were some sections that contained softer finer sediments. Clay in channel bank walls. Minimal detritus on substrate, channel basin relatively free of plant matter. Filamentous green algae present in low to moderate amounts.

10/6/11	PFup	Site sampled in Pipers Flat Creek adjacent Lidsdale siding coal stockpile area. Water clear and flowing throughout site length. Maximum stream width to 5m, average width 1.5m, maximum depth 1.2m to 1.5m. Site length consists of a highly meandering channel, in which a series of deeper pools are intersected by shallow and constricted pseudo riffle zones most of which are created by willow roots. Banks steep and undercut. Riparian cover is high provided by the consistent and dense corridor of willow trees, which are growing on the channel banks and in creek channel. The edge habitats sampled include undercut banks, willow roots, blunt pondweed (*Potamogeton ochreatus*), detritus and trailing bank vegetation. Substrate consisted of soft muddy sediments in pool basins and firm sandy sediments with some larger rock fragments in the shallower fast flow areas. Filamentous green algae present in moderate amounts through site length.
10/6/11	PFdn	Large pool under rail bridge sampled at outflow point of LDP4 channel. Water clear and flowing throughout site length. Site consists of a narrower meandering channel 6-10m width, which broadens into a wide pool underneath the rail bridge, with a maximum width of 22m, average width 18m. Maximum pool depth estimated at 1.5m, average depth 1m. Willow trees form the dominant riparian tree along the site length, many of which have been recently toppled from a high flow event. Banks steep and undercut. Edge pool access restricted by blackberry, which is prominent throughout the site length banks. Edge habitats sampled include undercut banks, blunt pondweed, detritus and trailing bank vegetation. Substrate mostly construction rubble with sections of very soft fine mud and sand deposits. Layer of fine silt smothering most of the pool edge areas and areas of low flow. Entire pool substrate and submerged surfaces smothered in filamentous green algae, which was prevalent in sample contents. Most of site pool exposed to direct sunlight, with willow trees providing very little shade.

1/11/11	CR2	Site water levels and pool dimensions similar to previous surveys. Water clear and flowing throughout site length. Maximum depth to 0.8m. Some localised infilling and deepening of instream pools due to mobile sandy sediments prevalent throughout site length. The edge habitats sampled similar to previous occasions and consisted of edge grasses, detritus, submerged jointed rush, curly pondweed and in amongst cumbungi stands. Substrate consisting mostly of unconsolidated sandy sediments with finer muddy deposits in localised channel areas with lower flow and at creek crossing. Bank undercutting has increased in some channel areas with evidence of ongoing erosion. Cattle access available throughout entire site length, with stock using creek crossing during sampling. Filamentous green algae present in small to moderate amounts.
1/11/11	CR4	Site water levels and sample conditions similar to previous surveys. Water clear and flowing throughout site length. Maximum pool depths reaching between 1m and 1.2m. Sampled edge habitats included submerged bank vegetation including jointed rush, charophytes, detritus and undercut banks. Channel substrates made up of cobbles and boulders, with varying amounts of sandy and muddy deposits in areas of lower flow. Filamentous green algae abundant throughout site length.
2/11/11	CR5	Site water levels and pool dimensions similar to previous survey. Water clear and flowing throughout site length. Maximum site pool depth to 1.2m. Blackberry bushes have dies back significantly and willow trees along edge banks have been cut back and poisoned since previous sample. Filamentous green algae abundant, smothering all submerged surfaces, with clumps of algae floating downstream. The edge habitats sampled consisted of curly pondweed, logs, cumbungi, river clubrush and trailing bank vegetation. Substrate was mostly soft muddy sand within the pool area upstream of the bridge which extends into bedrock, boulder and cobble at the downstream end. Filamentous green algae smothering substrate and all submerged surfaces, making it difficult to locate areas free of algae to sample. Mat-like algae prevalent also. At least four large brown trout observed during sample process.

22/11/11	WCup	Upper Wangcol Creek site sampled in the roadside locations adjoining the up and downstream sides of the Castlereagh Highway (access restricted to channel locations up and downstream). Water very turbid with sluggish flow throughout site length. Maximum stream width to 8m, average width 3 to 4m, maximum depth 1 to 1.2m, average depth 0.6m. Site channel flat bottomed with steep banks. Edge habitats sampled include trailing bank vegetation, undercut banks and cumbungi. Substrate mostly soft sandy sediments with sections of firm clayey sediments, and a prominent layer of detritus. Filamentous green algae present in small amounts.
21/11/11	WC1	Site sample conditions, water levels and pool dimensions similar to previous sample occasions. Water clear and flowing throughout site length. Maximum depth 0.7m though most of site less than 0.3m depth. The edge habitats sampled were consistent with that encountered on previous sample occasions, and consisted of charophytes, jointed rush, detritus and undercut banks. Charophytes prevalent throughout the mid to lower site length. Substrate flat bedrock with some gravel, sand and larger boulder fragments. Combination of silt and iron precipitate smothering substrate. Filamentous green algae present in moderate amounts.
21/11/11	WC2	Water level slightly higher than previous sample occasions, inundating some previously exposed edge areas. Water very clear and flowing through site length, with a maximum depth of 0.8m. Edge habitat consisting jointed rush, detritus and undercut banks and of trailing bank vegetation. Detritus mostly pine needles and pine seed heads. Single charophyte and single cumbungi plant observed. Substrate flat bedrock with some gravel, sand and larger boulder fragments. Moderate amounts of silt smothering substrate, and mat-like algae (or iron precipitate?) smothering all submerged surfaces throughout site length. Filamentous green algae present moderate to abundant amounts. Very few animals retained in sampling. Mountain galaxiid observed on lower side of pipe culverts halfway between WC2 and WC3.

21/11/11	WC3	Lower Wangcol Creek site sampled around 250m upstream from the confluence with the Coxs River. Site length channel area similar to WC2; steep banks with flat bottomed channel consisting mostly of rock rubble, though WC3 with higher degree of meandering channel, and higher proportion of trailing bank vegetation, detritus and undercut banks. Downstream end of site leads into straight section of channel which is concrete reinforced at the downstream end (which terminates in a shallow cascade fish barrier around 125m above the confluence with Coxs River). Water very clear and flowing throughout site length. Maximum stream width to 6m, average width 3m, maximum site pool depth to 0.9m, average depth 0.3m. The edge habitats sampled included undercut banks, detritus and trailing bank vegetation. No macrophytes observed. Substrate flat rock rubble with some gravel, sand and larger boulder fragments. Moderate amounts of silt smothering substrate. Very little iron precipitate smothering submerged surfaces such as that encountered at WC2. Filamentous green algae present in small amounts.
21/11/11	NCup	Site located below confluence of main upper sub-catchment tributaries. Site drainage channel consisting of a broad swale; very shallow and indistinct with no incision into surrounding substrate. Channel would likely to be able to hold water for a very short time after rainfall, with limited retention capabilities due to shallowness of channel and sandy sediments. No indications of surface water expressions or any semi-permanent water storages. Site riparian corridor continuous along site length, consisting of native woodland.
21/11/11	NC1	Site drainage channel incised 1m to 2m into surrounding valley floodplain, some sections of channel walls with undercut banks. Channel very dry with terrestrial plants growing throughout, and as with the upper site NCup, there were no indications of surface water expressions or any semi-permanent water storages. Site riparian environment with continuous corridor along site length. Dense growths of blackberry along site channel, however beyond that the immediate riparian the vegetation is mostly native woodland.

21/11/11	NCdn	Lower Neubecks Creek site sampled in same location as per Autumn 2011. Water level around 5-10cm lower the previous sample, with site length consisting of the deeper pools (to 0.5m depth) intersected by very shallow (around 1-2cm depth) densely vegetated grassy areas. Water slight to moderate turbidity, with low flow through site length (lower flow than Autumn 2011). Very little open surface water at upstream end of site, with channel areas consisting of the inundated dense grassy areas. Edge habitats similar to Autumn 2011, which consisted of willow tree roots, detritus and trailing bank vegetation (mostly terrestrial grasses). The pool substrate was fine sand mostly firm, with some sections that contained softer finer sediments. Small amounts of detritus on substrate. Filamentous green algae present in small amounts.
22/11/11	PFup	Site pool dimensions, aquatic habitats and water levels similar to previous sample occasion. Water clear and flowing throughout site length. Maximum pool depth to 1.2m deep. Riparian willow trees and blackberry have grown back significantly since Autumn 2011 sample. The edge habitats sampled include undercut banks, willow roots, blunt pondweed, detritus and trailing bank vegetation. Substrate consisted mostly of soft muddy sediments in pool basins and firm sandy sediments with some larger rock fragments in the shallower fast flow areas. There was a prominent layer of willow leaf detritus in most of the pool areas. Filamentous green algae present in moderate amounts.
22/11/11	PFdn	General pool dimensions, water levels and habitat availability consistent with previous sample occasion. Water clear and flowing through site. Maximum depth to 1.2m, average depth 1.0m. All of the riparian willow trees on the downstream side of the railway crossing have been cut and poisoned since previous sample, leaving no riparian trees downstream from the railway crossing. Most of the pool edge areas access still restricted by blackberry bushes. Edge habitats sampled include undercut banks, blunt pondweed, detritus and trailing bank vegetation. Substrate consisting of rock rubble with sections of very soft fine mud and sand deposits. Cobble banks present in some channel areas. Entire pool substrate and submerged surfaces smothered in filamentous green algae.

Appendix Table A-2

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

	Descriptor																					
	Category		AU111	AU111	AU111	AU111	AU111	AU111	AU11	AU11	SP11	SP11	SP11	SP11	SP11	SP11	SP11	SP11	SP11	SP11	SP11	SP11
		Value	CR2	CR4	CR5	WC1	WC2	NCdn	PFup	PFdn	CR2	CR4	CR5	WCup	WC1	WC2	WC3	NCup	NC1	NCdn	PFup	PFdn
1	Land-use pattern beyond immediate riparian zone																					
	Undisturbed native vegetation	4																4				
	Mixed native vegetation and pasture/exotics	3						3											3.5	3		
	Mainly pasture, crops or pine plantation	2	2	2	2	2	2		2.5	2	2	2	2	2	2	2	2				2.5	2
	Urban, some vegetation	1																				
	Industrial, little vegetation	0																				
2	Width of riparian strip-of woody vegetation																					
	More than 30 m	4							4									4	4		4	
	Between 5 and 30 m	3															3					
	Less than 5 m	2		2	2	2	2	2		2.5		2	2	2	2	2				2		2
	No woody vegetation	1	1								1											
	No Vegetation	0																				
3	Completeness of riparian strip of woody vegetation																					
	Riparian strip without breaks in vegetation	4																4	4			
	Breaks at intervals of more than 50 m	3							3.5												3.5	
	Breaks at intervals of 10-50 m	2			2								2	2			2					
	Breaks at intervals of less than 10 m	1		1		1	1	1		1.5		1			1	1				1		1
	No riparian strip at all	0	0								0											
4	Vegetation of riparian zone within 10 m of channel																					
	Native tree and shrub species	4																4				
	Mixed native and exotic trees and shrubs	3			3	3	3		3				3	3	3	3	3		3		3	
	Exotic trees and shrubs	2		2				2		2.5		2								2		2.5
	Exotic grasses/weeds	1	1								1											
	No vegetation at all	0																				
5	Stream bank structure																					
	Banks fully stabilized by trees, shrubs, concrete	4																				
	Banks firm but held mainly by grass and herbs	3						3	3.5											3	3.5	
	Banks loose, partly held by sparse grass, rubble	2		2	2					2		2	2	2				2	2			2
	Banks unstable, mainly loose sand or soil	1	1.5			1	1				1.5				1	1	1.5					
	Banks actively eroding	0																				
6	Bank undercutting																					
	None, or restricted by tree roots or man-made	4																4				
	Only on curves and at constrictions	3						3												3		
	Frequent along all parts of stream	2	2	2	2				2	2	2	2	2	2					2		2	2
	Severe; bank collapses common	1				1	1								1	1	1.5					
	Total bank collapse	0																				
7	Channel form																					
	Deep; width:depth ratio less than 8:1	4	4	4				4	4		4	4					4		4	4	4	
	Medium; width:depth ratio 8:1 to 15:1	3			3	3	3			3.5			3	3	3	3						3.5
	Shallow; width:depth ratio greater than 15:1	2																2				
	Artificial; concrete or excavated channel< 8:1	1																				
	Artificial; concrete or excavated channel > 8:1	0																				
8	Riffle/pool sequence																					
	Frequent alternation of riffles and pools	4							4												4	
	Long pools with infrequent short riffles	3			3								3	3								
	Natural channel without riffle/pool sequence	2						2										2	2	2		
	Artificial channel; some riffle/pool sequence	1	1	1.5		1	1			1	1	1.5			1	1	1					1
	Artificial channel; no riffle/pool sequence	0																				
9	Retention devices in stream																					
	Many large boulders and/or debris dams	4																				
	Rocks/logs present; limited damming effect	3			3				3	3			3	3							3	3
	Rocks/logs present but unstable; no damming	2		2								2						2				
	Stream or channel with few or no rocks/logs	1	1					1.5			1								1.5	1.5		
	Artificial channel; no retention devices	0				0	0								0	0	0					
10	Channel sediment accumulations																					
	Little or no accumulation of loose sediments	4																				
	Some gravel bars but little sand or silt	3		3	3	3	3					3	3	3	3	3						
	Bars of sand and silt common	2	2					2	2.5	2.5	2						2	2	2	2	2.5	2.5
	Braiding by loose sediment	1																				
	Complete in-filled muddy channel	0																				
11	Stream bottom																					
	Mainly clean stones with obvious interstices	4																				
	Mainly stones with some cover of algae/silt	3		3					3	3		3									3	3
	Bottom heavily silted but stable	2			2	2	2						2	2	2	2	2					
	Bottom mainly loose and mobile sandy sediment	1	1					1			1							1	1	1		
	Bottom mainly loose and mobile muddy sediment	0																				
12	Stream detritus																					
	Mainly unsilted wood, bark, leaves	4																				
	Some wood, leaves, etc. with much fine detritus	3		3	3				3			3	3	3				3	3		3	
	Mainly fine detritus mixed with sediment	2	2					2		2	2						2			2		2
	Little or no organic detritus, mainly sandy	1				1	1								1	1						
	No organic detritus, mainly mud	0																				
13	Aquatic vegetation																					
	Little or no macrophyte or algal growth	4						4									4	4	4	4		
	Substantial algal growth; few macrophytes	3	3		3	3.5	3				3.5		3	3	3.5	3						
	Substantial macrophyte growth; little algal growth	2		2								2										
	Substantial macrophyte and algal growth	1							1	1											1	1
	Total cover of macrophytes plus algae	0																				
	RCE Score		21.5	29.5	33	23.5	23.0	30.5	39	28.5	22.0	29.5	33.0	33	23.5	23.0	28.0	38.0	36.0	30.5	39	27.5
	RCE %age		41.3	56.7	63.5	45.2	44.2	58.7	75.0	54.8	42.3	56.7	63.5	63.5	45.2	44.2	53.8	73.1	69.2	58.7	75.0	52.9

Appendix Table A-3 Site Field Water Quality Readings Autumn and Spring 2011												
Site	Date	Time	Depth	Temp	Cond	Sal	DO	DO	pH	Turb		
			M	°C	µS/cm	ppt	%sat	mg/l	Units	ntu		
CR2	9/06/11	15:46	0.2	5.38	749	0.35	72.4		8.41	2.8		
CR4	8/06/11	15:51	0.1	6.38	930	0.46	76.0		8.02	5.3		
CR5	7/06/11	12:56	0.2	7.23	860	0.42	83.9		8.47	3.7		
WCup	10/06/11	15:34	0.2	6.86	417	0.19	73.2		7.18	14.0		
WC1u	10/06/11	15:21	0.1	7.14	253	0.10	71.7		7.19	7.5		
WC1	7/06/11	9:19	0.1	4.20	420	0.18	79.1		8.11	3.4		
WC2	7/06/11	11:04	0.1	6.82	1577	0.81	80.5		7.42	4.5		
NCdn	10/06/11	14:17	0.1	7.67	84	0.02	71.7		6.82	7.5		
PFup	10/06/11	11:30	0.1	7.71	540	0.25	66.2		7.37	5.0		
PFdn	10/06/11	9:54	0.1	6.12	594	0.28	68.7		7.45	2.4		
CR2	1/11/11	15:37	0.1	15.77	939	0.47	95.9	8.6	8.27	13.9		
CR2	1/11/11	15:37	0.2	15.77	943	0.47	96.0	8.6	8.26	12.4		
CR4	1/11/11	18:16	0.1	19.82	853	0.43	101.2	8.4	7.99	5.9		
CR4	1/11/11	18:16	0.4	19.82	854	0.43	101.5	8.4	7.98	5.7		
CR5	2/11/11	12:39	0.1	19.51	764	0.38	171.2	14.2	8.67	15.2		
CR5	2/11/11	12:39	0.3	19.52	757	0.37	172.1	14.3	8.68	32.9		
WCup	22/11/11	8:58	0.1	16.91	452	0.21	76.9	6.7	7.61	130.5		
WCup	22/11/11	8:58	0.4	16.90	458	0.21	76.8	6.7	7.61	132.6		
WC1	21/11/11	13:56	0.2	19.40	516	0.25	97.8	8.2	7.10	8.2		
WC1	21/11/11	13:56	0.2	19.39	511	0.25	97.7	8.1	7.10	7.9		
WC2	21/11/11	10:42	0.1	18.62	2211	1.20	100.3	8.4	7.00	10.5		
WC3	21/11/11	12:18	0.1	19.06	2452	1.35	106.6	8.9	7.62	11.5		
NCdn	21/11/11	16:18	0.1	17.85	87	0.03	84.6	7.3	6.06	59.2		
NCdn	21/11/11	16:18	0.3	15.75	90	0.03	89.7	8.1	6.09	95.2		
PFup	22/11/11	8:10	0.2	17.42	609	0.30	40.6	3.5	7.07	11.3		
PFdn	22/11/11	7:29	0.1	17.07	648	0.32	48.2	4.2	7.14	6.8		
Note:	WCup and WC1u AU11 water quality readings recorded immediately above and below (respectively) of Neubecks confluence in Wangcol Creek											

Appendix Table A-4 Centennial West Aquatic Ecology Monitoring Macroinvertebrate & Fish Results - Autumn & Spring 2011

Phylum	Class	Sub-Class	Order	Sub-Order	Family	Sub-Family	Genus/spp	Common name	Life Stage L	Life Stage N	Life Stage A	9/06/11 CR2	8/06/11 CR4	7/06/11 CR5	7/06/11 WC1	7/06/11 WC2	10/06/11 NCdn	10/06/11 PFup	10/06/11 PFdn	1/11/11 CR2	1/11/11 CR4	2/11/11 CR5	22/11/11 WCup	21/11/11 WC1	21/11/11 WC2	21/11/11 WC3	21/11/11 NCdn	22/11/11 PFup	22/11/11 PFdn	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles	x		x		1		1	1	1	1		1		1	1	1	1		1	1	13	2
Arthropoda	Insecta		Coleoptera		Elmidae			Riffle Beetles	x		x									1									1	7
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles	x		x	1			1		1			1	1		1	1	1	1		1		10	4
Arthropoda	Insecta		Coleoptera		Hydraenidae			Scavenger Water Beetles			x																1		1	2	3
Arthropoda	Insecta		Coleoptera		Hydrophilidae			Scavenger Water Beetles	x		x			1												1	1		3	2
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles	x								1										1	1		3	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges	x											1		1	1	1	1	1		1		7	4
Arthropoda	Insecta		Diptera		Chaoboridae			Phantom Midges	x																					2	
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms	x			1		1	1		1	1	1	1		1		1	1	1	1	1	1	14	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae		Bloodworms	x			1		1	1		1	1	1	1	1	1				1	1		1	12	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1		1			1	1	1	1	1	1			1		1		1	11	4
Arthropoda	Insecta		Diptera		Dixidae			Mensicus Midges	x																		1			1	7
Arthropoda	Insecta		Diptera		Simuliidae			Black Flies	x			1	1	1	1		1	1	1	1	1	1								10	5
Arthropoda	Insecta		Diptera		Tipulidae			Crane Flies	x			1			1					1				1			1			5	5
Arthropoda	Insecta		Ephemoptera		Baetidae			Mayflies		x		1	1	1	1		1	1	1	1	1	1		1	1		1		1	14	5
Arthropoda	Insecta		Ephemoptera		Caenidae			Mayflies		x		1		1	1		1		1	1	1	1		1	1				1	11	4
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies		x		1	1	1	1		1		1	1		1	1	1	1		1	1	1	13	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Water Boatmen				1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	16	2
Arthropoda	Insecta		Hemiptera		Nepidae			Needle Bugs															1			1				2	3
Arthropoda	Insecta		Hemiptera		Notonectidae			Backswimmers					1		1		1			1			1	1	1	1	1			9	1
Arthropoda	Insecta		Hemiptera		Veliidae			Small Water Striders													1				1	1	1			4	3
Arthropoda	Insecta		Lepidoptera		Pyralidae			Moths	x			1	1								1									3	3
Arthropoda	Insecta		Megaloptera		Sialidae			Alderflies	x					1																1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Aeshnidae			Dragonflies	x														1			1	1		1	4	4
Arthropoda	Insecta		Odonata	Epiproctophora	Cordulephyidae			Dragonflies	x															1						1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Gomphidae			Dragonflies	x				1			1					1	1		1	1	1				7	5
Arthropoda	Insecta		Odonata	Epiproctophora	Hemicorduliidae			Dragonflies	x				1		1		1				1	1		1		1	1			9	5
Arthropoda	Insecta		Odonata	Epiproctophora	Libellulidae			Dragonflies	x						1	1														2	4
Arthropoda	Insecta		Odonata	Epiproctophora	Synthemistidae			Dragonflies	x																		1			1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae			Dragonflies	x												1						1			2	9
Arthropoda	Insecta		Odonata	Zygoptera	Coenagrionidae			Damselflies	x				1	1	1		1				1			1		1	1	1		9	2
Arthropoda	Insecta		Odonata	Zygoptera	Lestidae			Damselflies	x															1						1	1
Arthropoda	Insecta		Odonata	Zygoptera	Megapodagrionidae			Damselflies	x												1					1		1		3	5
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies	x						1					1	1			1	1	1			1	7	7
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies		x										1	1		1			1				4	8
Arthropoda	Insecta		Plecoptera		Notonemouridae			Stoneflies		x		1			1		1			1								1		5	6
Arthropoda	Insecta		Trichoptera		Calamoceratidae			Caddis Flies	x				1	1					1		1								1	5	7
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies	x				1	1	1			1			1			1		1			1	8	4
Arthropoda	Insecta		Trichoptera		Hydrobiosidae			Caddis Flies	x			1	1		1					1										4	8
Arthropoda	Insecta		Trichoptera		Hydropsychidae			Caddis Flies	x			1	1	1			1	1				1								6	6
Arthropoda	Insecta		Trichoptera		Hydroptilidae			Caddis Flies	x			1	1	1	1	1		1	1			1		1	1	1		1	1	13	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies	x			1	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	16	6
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies	x			1							1											2	8
Arthropoda	Arachnida		Acarina	Hydracarina				Freshwater Mites																				1	1	2	6
Arthropoda	Crustacea	Branchiopoda	Diplostraca	Cladocera				Water Fleas						1	1			1	1			1						1	1	7	*
Arthropoda	Crustacea	Copepoda	Calanoida		Centropagidae			Copepods																							*
Arthropoda	Crustacea	Copepoda	Cyclopoida		Cyclopidae			Copepods						1				1	1			1					1	1	1	7	*
Arthropoda	Crustacea		Amphipoda		Ceinidae			Side Swimmers																				1	1	2	2
Arthropoda	Crustacea		Decapoda		Atyidae			Freshwater Shrimp				1		1	1	1						1	1							6	3
Arthropoda	Crustacea		Decapoda		Parastacidae			Yabbies					1		1	1	1			1	1	1	1	1	1	1	1			12	4
Arthropoda	Ostracoda							Seed Shrimps										1	1			1					1	1	1	6	*
Annelida	Hirudinea				Erpobdellidae			Leeches																					1	1	1
Annelida	Hirudinea				Richardsoniadidae			Leeches															1							1	4
Annelida	Oligochaeta							Freshwater Worms					1	1			1	1	1		1	1		1	1	1	1	1	1	13	2
Cnidaria	Hydrozoa				Hydridae			Hydra																							3
Mollusca	Bivalvia				Sphaeriidae			Pea Shells					1	1				1		1	1			1				1	1	8	5
Mollusca	Gastropoda				Ancylidae			Freshwater Limpets				1						1		1								1		4	4
Mollusca	Gastropoda				Lymnaeidae			Freshwater Snails				1			1		1	1		1		1								6	1
Mollusca	Gastropoda				Physidae			Freshwater Snails					1	1				1	1	1	1	1					1	1	1	10	1
Mollusca	Gastropoda				Planorbidae			Freshwater Snails					1	1						1										3	2
Platyhelminthes	Turbellaria		Tricladida		Dugesiidae			Flatworms										1										1	1	3	2
Chordata	Amphibia							Tadpoles				1					1			1	1			1			1	1		7	*
Chordata	Osteichthyes				Eleotridae			Gudgeon								1														1	*
Chordata	Osteichthyes				Eleotridae		*Philypnodon grandiceps*	Flathead Gudgeon				1		1	1							1			1					5	*
Chordata	Osteichthyes				Galaxiidae		*Galaxias olidus*	Mountain Galaxias												1		1								2	*
Chordata	Osteichthyes				Poeciliidae		*Gambusia holbrooki*	Eastern Gambusia					1	1	1	1		1	1		1	1		1	1	1				11	*
Chordata	Osteichthyes				Salmonidae		*Salmo trutta*	Brown Trout														1								1	*
								Total number of invertebrate taxa per site:				22	22	25	26	10	20	20	19	27	24	27	12	25	17	22	26	23	25	64	
Notes:	* represents those taxa for which SIGNAL-2 scores are not available							Site SIGNAL2 Scores:				4.65	4.14	4.00	4.22	3.75	3.89	3.63	4.60	4.40	4.64	3.90	3.92	4.00	3.75	3.90	4.04	3.84	3.91		

Plate 1: Coxs River upper site CR2 Autumn 2011.

Plate 2: Site CR2 looking upstream Spring 2011.

Plate 3: Looking downstream CR4 Autumn 2011.

Plate 4: Looking downstream CR4 Spring 2011.

Plate 5: Looking upstream from Maddox Lane site CR4 Autumn 2011.

Plate 6: Looking upstream at CR4 Spring 2011.

Plate 7: Looking downstream at CR4 Autumn 2011.

Plate 8: Looking downstream at CR4 Spring 2011.

Plate 9: Looking downstream at CR5 Autumn 2011.

Plate 10: Looking downstream at CR5 Spring 2011.

Plate 11: Looking downstream past Main St bridge at CR5 Autumn 2011.

Plate 12: Looking downstream at CR5 Spring 2011.

Plate 13: Looking across the upstream end of culvert at WCup in Spring 2011.

Plate 14: Looking downstream from the culvert WCup Spring 2011.

Plate 15: Looking upstream from weir at WC1 Autumn 2011.

Plate 16: Looking upstream at WC1 Spring 2011.

Plate 17: Looking downstream at WC1 Autumn 2011.

Plate 18: Looking downstream at WC1 Spring 2011.

Plate 19: Looking upstream at WC2 Autumn 2011.

Plate 20: Looking upstream at WC2 Spring 2011.

Plate 21: Looking downstream at WC2 Autumn 2011.

Plate 22: Looking downstream at WC2 Spring 2011.

Plate 23:Looking upstream at WC3 Spring 2011.

Plate 24: Site WC3 channel Spring 2011.

Plate 25: Looking downstream from downstream end of site Spring 2011.

Plate 26: Indistinct channel at NCup Spring 2011.

Plate 27: Looking upstream at undercut banks at NC1 Spring 2011.

Plate 28: Looking upstream at NC1 Spring 2011.

Plate 29: Looking upstream at NCdn Autumn 2011.

Plate 30: Looking downstream at NCdn Autumn 2011.

Plate 31: Looking downstream at NCdn Spring 2011.

Plate 32: Pool at downstream end of site NCdn Spring 2011.

Plate 33: Looking downstream at PFup Autumn 2011.

Plate 34: Site PFup looking downstream Spring 2011.

Plate 35: Looking downstream from downstream end of site PFup Autumn 2011.

Plate 36: Looking downstream from at site PFup Spring 2011.

Plate 37: Looking upstream from upstream end of site at PFdn Spring 2011.

Plate 38: Looking downstream at PFdn Spring 2011.

Plate 39: Looking upstream at rail crossing over PFdn pool Autumn 2011.

Plate 40: Looking upstream at PFdn Spring 2011.

Plate 41: Looking downstream at PFdn Autumn 2011.

Plate 42: Looking downstream from PFdn towards Coxs River Spring 2011.

ANNEXURE B

AQUATIC ECOLOGY

SAMPLING FIELD NOTES,

SITE PHOTOGRAPHS

&

SAMPLING DATA

WESTERN COAL SERVICES UPGRADE PROJECT

AUTUMN 2012

Table A1 Field Comments – Autumn 2012 Aquatic Ecology Monitoring Sites		
Date	Site	Comments
29/5/12	CR2	Site water levels and pool dimensions generally consistent with former surveys, though some parts of channel have increased in depth since Spring 2011 survey. Water clear and flowing through site length. Maximum pool depth to 1.4m, average depth 0.6m. Indications of high flow event to +1.5m on bank. The edge habitats sampled were similar to previous occasions and consisted of edge grasses, detritus, submerged jointed rush (*Juncus articulatus*), curly pondweed (*Potamogeton crispus*) and cumbungi (*Typha sp*) stands. Substrate unchanged, consisting of unconsolidated and mobile sandy sediments with finer muddy deposits in localised channel areas with lower flow and at creek crossing. Relatively few areas of detrital build up. Rubble and cobble sized rock fragments at crossing. Bank erosion prevalent throughout site length. Cattle access available throughout entire site length, with stock adjacent site during sampling. Filamentous green algae abundant throughout site.
30/5/12	CR4	Water level a little higher than recent surveys- around 10-15cm above pipes at outlets. Water moderately clear and flowing through site. Maximum depth to 1.4m. Evidence of flows to +1.8m above current water level. Edge habitats similar to former sample occasions, which consisted of submerged bank vegetation including jointed rush and charophytes, detritus and undercut banks. Channel substrates made up of cobbles and boulders, with varying amounts of sandy and muddy deposits in areas of lower flow. Substrate and submerged surfaces smothered in cream- brown coloured flocculant along edge areas, with moderate amounts of silt also. Filamentous green algae present in small amounts.

28/5/12	CR5	Site water levels seemingly a little higher than recent surveys. Water cloudy and flowing throughout site length, with abundant suspended particulate matter in water column. Maximum depth to 1.3m. Substrate and submerged surfaces smothered in cream-brown coloured flocculant. Only very few areas previously occupied by curly pondweed were observed (small amounts along pool edge areas and water turbidity could be limiting observations). Some of the cumbungi and river clubrush (*Schoenoplectus validus*) stands have been scoured out since previous sample. The edge habitats sampled consisted of undercut banks, logs, cumbungi, river clubrush and trailing bank vegetation. Substrate was similar to previous samples and consisted of soft muddy sand within the pool area upstream of the bridge which extends into bedrock, boulders, rubble and cobbles at the downstream end. Filamentous green algae abundant, smothering substrate and all submerged surfaces and moderate amounts of silt present.
28/5/12	WCup	Site water levels and pool dimensions similar to Spring 2011 survey. Water very turbid with no visible flow. Maximum depth to 1.2m. The edge habitats sampled included cumbungi, trailing bank vegetation and undercut banks. Substrate consisted mostly of soft sandy sediments with sections of firm clayey sediments. Filamentous green algae present in small amounts.
30/5/12	WC1	Site water levels similar to former samples. Water clear and flowing throughout site length. Maximum depth between 0.8 and 1.0m. Evidence of high flows to +1m to 1.5m above current water level. Edge trailing bank vegetation, detritus, undercut banks and charophytes sampled as edge habitats, also as per previous surveys. Substrate flat bedrock with some gravel, sand and larger boulder fragments. Most of the substrate was smothered with a combination of silt and fine algae. Filamentous green algae present in moderate to abundant amounts. Dead yabbie *Cherax destructor* and flathead gudgeon *Philypnodon grandiceps* observed in site, and deformed mountain galaxias *Galaxias olidus* observed.

30/5/12	WC2	Site water levels similar to former samples. Water very clear and flowing throughout site length. Maximum observed depth 0.8m. Evidence of high flows to +1m to 1.5m above current water level. Edge habitat consisted mostly of jointed rush, detritus and undercut banks small amounts of trailing bank vegetation. Pine needles detritus present throughout site length on substrate and along pool water edges. Very small amounts of cumbungi and tall spikerush (*Eleocharis sphacelata*) observed. Substrate as before, consisting of flat bedrock with gravel, sand and larger boulder fragments. Moderate amounts of silt smothering substrate, and orange-white precipitate smothering all submerged surfaces throughout site length. Orange staining and seepage entering site through channel wall along northern bank. Filamentous green algae present in moderate amounts, and abundant in some isolated areas. Very few animals retained in sampling. An almost dead mountain galaxiid was observed (scales missing).
30/5/12	WC3	Water levels and pool dimensions similar to Spring sample. Water very clear and flowing through site length. Maximum depth to 1.0m, average depth 0.4m. Evidence of high flows to +1m to 1.5m above current water level. Similar habitats to WC1 and WC2, which consisted of undercut banks, detritus and trailing bank vegetation. Red scum on water surface. Substrate smothered in silt and filamentous green algae. Substrate flat rock rubble with some gravel, sand and larger boulder fragments. Filamentous green algae present in moderate amounts.
29/5/12	NCdn	Water Levels and flow higher than previous two seasonal surveys. Water clear and with higher than normal flow, and flowing throughout site length. Maximum creek width 4m, average width 1.5m, maximum depth to 1.0m, average depth 0.4m. Edge habitats similar to previous sample occasions, with most of the site length supporting adequate edge habitats as per AusRivAS protocol. The edge habitats sampled included willow tree roots, jointed rush, detritus, trailing bank vegetation and *Carex appressa*. The pool substrate was fine sand mostly firm, with some sections that contained softer finer sediments. Very few areas of detritus build up in main pool basins. Filamentous green algae present in moderate amounts.

31/5/12	PFup	Site pool dimensions, aquatic habitats and water levels similar to previous sample occasions. Water clear and flowing through site. Maximum depth ~1.5m. Evidence of high flows to +2m above current water levels (which spilled over to floodplain). The edge habitats that were sampled include undercut banks, willow roots, curly pondweed, detritus and trailing bank vegetation. The channel substrates consisted mostly of soft muddy sediments in pool basins and firm sandy sediments with some larger rock fragments in the shallower areas. Filamentous green algae present in small amounts.
31/5/12	PFdn	General pool dimensions, water levels and habitat availability consistent with previous sample occasion, although some of the channel area at the downstream end off the site has become more channelized (steepening of instream banks). Water clear and flowing through site. Maximum depth to 1.0m. Evidence of high flows to +2m above current water levels. Willow trees and blackberry have been removed from riparian areas on upstream side of rail crossing. The edge habitats sampled were undercut banks, curly pondweed, detritus and trailing bank vegetation. Substrate consisting of rock rubble with sections of very soft fine muddy sand deposits and some cobble banks. Filamentous green algae present in moderate to abundant amounts.

Appendix Table A-2 Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor			AU12	AU12	AU12	AU12	AU12	AU12	AU12	AU12	AU12	AU12
	Category	**Value**	CR2	CR4	CR5	WCup	WC1	WC2	WC3	NCdn	PFup	PFdn
1	Land-use pattern beyond immediate riparian zone											
	Undisturbed native vegetation	4										
	Mixed native vegetation and pasture/exotics	3								3		
	Mainly pasture, crops or pine plantation	2	2	2	2	2	2	2	2		2.5	2
	Urban, some vegetation	1										
	Industrial, little vegetation	0										
2	Width of riparian strip-of woody vegetation											
	More than 30 m	4									4	
	Between 5 and 30 m	3							3			
	Less than 5 m	2		2	2	2	2	2		2		2
	No woody vegetation	1	1									
	No Vegetation	0										
3	Completeness of riparian strip of woody vegetation											
	Riparian strip without breaks in vegetation	4										
	Breaks at intervals of more than 50 m	3									3.5	
	Breaks at intervals of 10-50 m	2			2	2			2			
	Breaks at intervals of less than 10 m	1		1			1	1		1		
	No riparian strip at all	0	0									0.5
4	Vegetation of riparian zone within 10 m of channel											
	Native tree and shrub species	4										
	Mixed native and exotic trees and shrubs	3			3	3	3	3	3		3	
	Exotic trees and shrubs	2		2						2		2.5
	Exotic grasses/weeds	1	1									
	No vegetation at all	0										
5	Stream bank structure											
	Banks fully stabilized by trees, shrubs, concrete	4										
	Banks firm but held mainly by grass and herbs	3								3	3.5	
	Banks loose, partly held by sparse grass, rubble	2		2	2	2						2
	Banks unstable, mainly loose sand or soil	1	1.5				1	1	1.5			
	Banks actively eroding	0										
6	Bank undercutting											
	None, or restricted by tree roots or man-made	4										
	Only on curves and at constrictions	3								3		
	Frequent along all parts of stream	2	2	2	2	2					2	2
	Severe; bank collapses common	1					1	1	1.5			
	Total bank collapse	0										
7	Channel form											
	Deep; width:depth ratio less than 8:1	4	4	4					4	4	4	
	Medium; width:depth ratio 8:1 to 15:1	3			3	3	3	3				3.5
	Shallow; width:depth ratio greater than 15:1	2										
	Artificial; concrete or excavated channel< 8:1	1										
	Artificial; concrete or excavated channel > 8:1	0										
8	Riffle/pool sequence											
	Frequent alternation of riffles and pools	4									4	
	Long pools with infrequent short riffles	3			3	3						
	Natural channel without riffle/pool sequence	2								2		
	Artificial channel; some riffle/pool sequence	1	1	1.5			1	1	1			1
	Artificial channel; no riffle/pool sequence	0										
9	Retention devices in stream											
	Many large boulders and/or debris dams	4										
	Rocks/logs present; limited damming effect	3			3	3					3	3
	Rocks/logs present but unstable; no damming	2		2								
	Stream or channel with few or no rocks/logs	1	1							1.5		
	Artificial channel; no retention devices	0					0	0	0			
10	Channel sediment accumulations											
	Little or no accumulation of loose sediments	4										
	Some gravel bars but little sand or silt	3		3	3	3	3	3				
	Bars of sand and silt common	2	2						2	2	2.5	2.5
	Braiding by loose sediment	1										
	Complete in-filled muddy channel	0										
11	Stream bottom											
	Mainly clean stones with obvious interstices	4										
	Mainly stones with some cover of algae/silt	3		3							3	3
	Bottom heavily silted but stable	2			2	2	2	2	2			
	Bottom mainly loose and mobile sandy sediment	1	1							1		
	Bottom mainly loose and mobile muddy sediment	0										
12	Stream detritus											
	Mainly unsilted wood, bark, leaves	4										
	Some wood, leaves, etc. with much fine detritus	3		3	3	3					3	
	Mainly fine detritus mixed with sediment	2	2						2	2		2
	Little or no organic detritus, mainly sandy	1					1	1				
	No organic detritus, mainly mud	0										
13	Aquatic vegetation											
	Little or no macrophyte or algal growth	4										
	Substantial algal growth; few macrophytes	3	3		3	3.5	3	3	3.5	3.5		
	Substantial macrophyte growth; little algal growth	2		2							2	
	Substantial macrophyte and algal growth	1										1
	Total cover of macrophytes plus algae	0										
	RCE Score		21.5	29.5	33.0	33.5	23.0	23.0	27.5	30.0	40.0	27.0
	RCE %age		41.3	56.7	63.5	64.4	44.2	44.2	52.9	57.7	76.9	51.9

Appendix Table A-3 Site Field Water Quality Readings Autumn 2012										
Site	Date	Time	Depth	Temp	Cond	Sal	DO	DO	pH	Turb
			M	°C	µS/cm	ppt	%sat	mg/l	Units	ntu
CR2	29/05/12	16:01	0.1	7.69	542	0.29	92.2	9.7	7.99	2.9
CR2	29/05/12	16:01	0.7	7.68	559	0.29	92.3	9.7	7.99	2.5
CR3	31/05/12	15:58	0.5	8.54	616	0.32	91.5	9.4	7.05	10.7
CR4	30/05/12	15:11	0.1	8.57	640	0.33	90.9	9.3	7.15	11.6
CR4	30/05/12	15:11	0.5	8.57	644	0.33	90.9	9.3	7.15	11.8
CR4d/s	28/05/12	16:26	0.1	8.92	721	0.37	99.0	10.1	7.40	28.5
CR4d/s	28/05/12	16:27	0.4	8.92	748	0.39	98.7	10.1	7.35	27.1
CR5	28/05/12	15:05	0.1	9.62	700	0.36	98.2	9.8	7.14	27.0
CR5	28/05/12	15:05	0.3	9.61	704	0.36	98.2	9.8	7.13	27.2
CR5	28/05/12	15:05	0.9	9.62	729	0.38	98.3	9.9	7.14	27.3
WCup	28/05/12	13:56	0.1	9.49	314	0.17	91.5	9.2	7.48	317.0
WCup	28/05/12	13:56	0.7	8.59	331	0.18	93.0	9.6	7.51	413.6
WC1	30/05/12	10:51	0.1	6.66	283	0.16	95.5	10.3	7.33	3.1
WC1	30/05/12	10:51	0.2	6.66	283	0.16	95.3	10.3	7.33	3.2
WC2	30/05/12	12:27	0.1	9.49	1451	0.75	92.1	9.2	7.14	2.4
WC2	30/05/12	12:27	0.3	9.49	1459	0.75	92.6	9.3	7.14	1.4
WC3	30/05/12	12:59	0.1	8.21	623	0.32	104.1	10.8	7.64	3.6
WC3	30/05/12	12:59	0.3	8.10	638	0.32	104.5	10.9	7.65	2.8
NCdn	29/05/12	14:30	0.1	9.53	61	0.05	89.4	9.0	6.33	6.1
NCdn	29/05/12	14:30	0.3	9.53	61	0.05	89.4	9.0	6.24	6.0
PFup	31/05/12	12:47	0.1	8.28	441	0.23	84.9	8.8	7.22	2.2
PFup	31/05/12	12:47	0.5	8.27	447	0.24	85.0	8.8	7.21	2.0
PFdn	31/05/12	11:13	0.1	7.79	475	0.25	87.4	9.2	7.20	2.4
PFdn	31/05/12	11:13	0.3	7.79	484	0.25	87.4	9.2	7.20	1.4
Note:	CR4d/s recorded at Brays Lane crossing over Coxs River									
	CR1 seepage recorded from seepage water entering CR1 from eastern bank									

Appendix Table A-4 Centennial West Aquatic Ecology Monitoring Macroinvertebrate & Fish Results - Autumn 2012

Phylum	Class	Sub-Cl	Order	Sub-Order	Family	Sub-F	Genus/spp	Common name	Description	Life Stage L	N	A	Sample Date and Sample Site 29/05/12 CR2	30/05/12 CR4	28/05/12 CR5	28/05/12 WCup	30/05/12 WC1	30/05/12 WC2	30/05/12 WC3	29/05/12 NCdn	31/05/12 PFup	31/05/12 PFdn	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles		x		x	1	1	1	1	1		1	1	1	1	9	2
Arthropoda	Insecta		Coleoptera		Elmidae			Riffle Beetles		x		x								1			1	7
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles		x		x	1		1								2	4
Arthropoda	Insecta		Coleoptera		Hydraenidae			Scavenger Water Beetles				x			1								1	3
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles		x									1				1	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges		x			1						1				2	4
Arthropoda	Insecta		Diptera		Chironomida		Chironominae	Bloodworms		x			1		1	1	1	1		1	1	1	8	3
Arthropoda	Insecta		Diptera		Chironomida		Orthocladiinae	Bloodworms		x			1	1	1		1		1	1	1		7	4
Arthropoda	Insecta		Diptera		Chironomida		Tanypodinae	Bloodworms		x			1		1	1				1			4	4
Arthropoda	Insecta		Diptera		Dixidae			Mensicus Midges		x						1							1	7
Arthropoda	Insecta		Diptera		Simuliidae			Black Flies		x			1	1			1			1	1	1	6	5
Arthropoda	Insecta		Diptera		Tipulidae			Crane Flies		x			1		1	1				1			4	5
Arthropoda	Insecta		Ephemoptera		Baetidae			Mayflies			x		1	1	1	1	1	1		1	1	1	9	5
Arthropoda	Insecta		Ephemoptera		Caenidae			Mayflies			x		1	1	1	1	1	1			1	1	8	4
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies			x		1	1	1	1	1	1			1	1	8	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Water Boatmen					1	1	1	1	1	1	1	1	1	1	10	2
Arthropoda	Insecta		Hemiptera		Nepidae			Needle Bugs								1							1	3
Arthropoda	Insecta		Hemiptera		Notonectidae			Backswimmers					1			1				1			3	1
Arthropoda	Insecta		Hemiptera		Veliidae			Small Water Striders					1										1	3
Arthropoda	Insecta		Lepidoptera		Pyralidae			Moths		x				1									1	3
Arthropoda	Insecta		Megaloptera		Sialidae			Alderflies		x											1		1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Aeshnidae			Dragonflies		x				1		1		1					3	4
Arthropoda	Insecta		Odonata	Epiproctophora	Gomphidae			Dragonflies		x				1			1	1	1	1			5	5
Arthropoda	Insecta		Odonata	Epiproctophora	Hemicorduliidae			Dragonflies		x							1			1			2	5
Arthropoda	Insecta		Odonata	Epiproctophora	Libellulidae			Dragonflies		x									1				1	4
Arthropoda	Insecta		Odonata	Epiproctophora	Synthemistidae			Dragonflies		x									1	1			2	5
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae			Dragonflies		x							1	1					2	9
Arthropoda	Insecta		Odonata	Zygoptera	Coenagrionidae			Damselflies		x					1			1		1	1	1	5	2
Arthropoda	Insecta		Odonata	Zygoptera	Megapodagrionidae			Damselflies		x							1	1			1		3	5
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies		x			1										1	7
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies			x										1		1	8
Arthropoda	Insecta		Plecoptera		Notonemouridae			Stoneflies			x		1	1						1			3	6
Arthropoda	Insecta		Trichoptera		Calamoceratidae			Caddis Flies		x											1		1	7
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies		x				1	1	1					1	1	5	4
Arthropoda	Insecta		Trichoptera		Hydrobiosidae			Caddis Flies		x				1	1			1	1	1			5	8
Arthropoda	Insecta		Trichoptera		Hydropsychidae			Caddis Flies		x				1	1			1	1		1	1	6	6
Arthropoda	Insecta		Trichoptera		Hydroptilidae			Caddis Flies		x			1	1	1		1	1	1	1	1	1	9	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies		x			1	1	1	1	1	1	1	1	1	1	10	6
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies		x			1										1	8
Arthropoda	Arachnida		Acarina	Hydracarina				Freshwater Mites						1									1	6
Arthropoda	Crustacea	Branch	Diplostra	Cladocera				Water Fleas								1					1	1	3	*
Arthropoda	Crustacea	Copepo	Cyclopoida		Cyclopidae			Copepods					1	1		1				1	1	1	6	*
Arthropoda	Crustacea		Amphipoda		Ceinidae			Side Swimmers													1	1	2	2
Arthropoda	Crustacea		Decapoda		Atyidae			Freshwater Shrimp					1	1	1	1	1	1	1		1		8	3
Arthropoda	Crustacea		Decapoda		Parastacidae			Yabbies					1		1	1	1	1	1	1	1		8	4
Arthropoda	Ostracoda							Seed Shrimps												1			1	*
Annelida	Hirudinea				Erpobdellidae			Leeches							1								1	1
Annelida	Oligochaeta							Freshwater Worms					1		1	1	1		1	1	1	1	8	2
Mollusca	Bivalvia				Sphaeriidae			Pea Shells							1			1			1		3	5
Mollusca	Gastropoda				Ancylidae			Freshwater Limpets										1			1	1	3	4
Mollusca	Gastropoda				Lymnaeidae			Freshwater Snails										1			1		2	1
Mollusca	Gastropoda				Physidae			Freshwater Snails							1						1	1	3	1
Mollusca	Gastropoda				Planorbidae			Freshwater Snails						1				1					2	2
Chordata	Amphibia							Tadpoles												1			1	*
Chordata	Osteichthyes				Eleotridae			Gudgeon							1				1		1	1	4	*
Chordata	Osteichthyes				Eleotridae		*Philypnodon grandiceps*	Flathead Gudgeon									1						1	*
Chordata	Osteichthyes				Galaxiidae		*Galaxias olidus*	Mountain Galaxias									1	1	1				3	*
Chordata	Osteichthyes				Poeciliidae		*Gambusia holbrooki*	Eastern Gambusia						1	1		1	1					4	*
Chordata	Osteichthyes							Fish eggs									1	1			1	1	4	
								Total number of invertebrate taxa per site:					23	20	23	19	17	20	15	22	27	18	53	
Notes:	* represents those taxa for which SIGNAL-2 scores are not available							Site SIGNAL2 Scores:					4.27	4.58	3.91	3.94	4.47	4.50	4.33	4.25	4.08	3.75		

Plate 1: Looking upstream from crossing in Coxs River upper site CR2 Autumn 2012.

Plate 2: Site CR2 looking downstream Autumn 2012.

Plate 3: Looking upstream at CR4 Autumn 2012.

Plate 4: Looking downstream from road crossing at CR4 Autumn 2012.

Plate 5: Edge habitats smothered in flocculant at CR4.

Plate 6: Looking downstream toward Main St bridge at CR5.

Plate 7: Looking downstream through Main St bridge.

Plate 8: Upstream side of Castlereagh Highway culvert at WCup.

Plate 9: Downstream side of culvert at WCup.

Plate 10: Looking downstream at WCup.

Plate 11: Looking upstream at WC1.

Plate 12: Looking downstream at lower end of WC1.

Plate 13: Deformed mountain galaxias from WC1.

Plate 14: Looking upstream from upstream end of WC2.

Plate 15: Looking downstream at WC2.

Plate 16: Looking upstream at WC3.

Plate 17: Looking downstream at WC3.

Plate 18: Looking downstream from downstream end of WC3.

Plate 19: Looking upstream at NCdn.

Plate 20: Looking downstream at NCdn.

Plate 21: Looking downstream from lower end of NCdn.

Plate 22: Looking downstream at Pipers Flat Creek site PFup.

Plate 23:Looking upstream at PFup.

Plate 24: Looking downstream at PFup.

Plate 25: Looking upstream from track crossing at PFdn.

Plate 26: Looking downstream from track crossing at PFdn.

Plate 27: Looking upstream through rail bridge at PFdn.

Plate 28: Looking downstream from rail bridge at PFdn.